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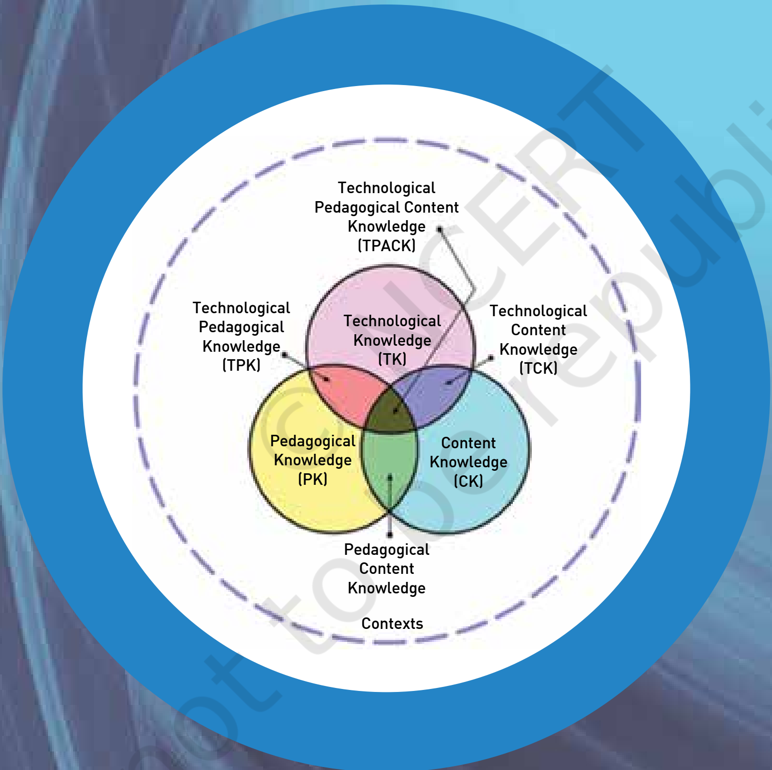

TPACK with its Components

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EDITORIAL

In this issue, we are excited to share with you five interesting articles which focus on different aspects of teaching-learning in science.

The first article is a first-hand study that was conducted via workshops on Argument-Driven Inquiry (ADI) in physical and biological sciences in both rural and urban schools. This study, which modified the ADI pedagogy for the Indian context, found that it could be a very useful strategy if judiciously amalgamated with the ongoing pedagogy within the constraints of time, space, and infrastructure.

The use of technology in the teaching-learning process cannot be overemphasised. However, the use of technology per se will not enhance learning. Therefore, several frameworks have been introduced, and Technological Pedagogical Content Knowledge (TPACK) is one such conceptual framework conceived in order to make the classroom process interactive, and learning meaningful and effective. The second article presents a brief description of how to design and develop a lesson plan based on the TPACK framework.

Sustainable development is a relatively new term that became popular more recently with the document "Our Common Future," popularly known as the Brundtland Commission Report, which was brought out in 1987. However, the idea or the philosophy was already conceived and put into practice by none other than Mahatma Gandhi. The paper "Gandhi and the Idea of Sustainability—Implications for Science Education" elaborates on this and its implications in science education.

The fourth article informs how students can use graphic organisers to prepare visual representations for the purpose of remembering, clarifying, and easily relating multiple aspects of concepts and how their achievements can be enhanced in science through this. These findings were based on a study conducted among 75 students studying in Class VIII.

Last but not the least, the research paper on climate change presents a study that was conducted to find out school students' knowledge about climate change science in India. The study also attempts to find out if students having the inclination to science or manifested interest in science subjects possess more knowledge about climate—change science compared to other students.

In addition to the articles, the issue also features interesting commentaries, an interview with a remarkable teacher, a book review, and some fascinating news items from the world of science.

We hope every section of this issue will be engaging and enriching, and at the same time, it will stimulate your minds and thoughts throughout.

As always, being committed to improving the quality of the journal, we welcome any comments or suggestions for its improvement.

Happy reading!

STUDY OF EFFECTIVENESS OF THE ARGUMENT-DRIVEN INQUIRY PEDAGOGY IN SCIENCE CLASSROOMS OF INDIA

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Implementation of Argument-driven Inquiry (ADI) pedagogy in India would face many impediments due to the detrimental alliance of the curricula with its transaction time, infrastructural limitations, and the evaluation system. The teaching-learning system with the sole aim of securing high marks is more prone to rote learning. Hence, we attempted to modify the ADI according to the Indian context, and try out the pedagogy for science classrooms in Indian schools. For this purpose, studies were conducted in the form of workshops for both Physical and Biological Sciences in schools of rural and urban sectors. We have narrated the experiences gathered from the Biological Science workshops in the form of a first-hand case study in this paper. It has been observed from the studies that notwithstanding the impediments, this pedagogy can be very useful for the teachers and the all-important students if it can be judiciously amalgamated with the ongoing teaching strategies within the constraints of time, space and infrastructure.

Keywords: Argument, Inquiry, Pedagogy, Classroom, India, School, ADI

Introduction

Science is the process of generating knowledge thorough investigation into the natural world. Any investigation starts with a question. In finding a solution, we gather data, analyse, argue, and validate a hypothesis. Spirit of inquiry, collaborative work, argumentation, and communication are the fundamental forces driving the scientific community. Every school should bring these in regular practice for all its students from early childhood to develop a scientific temper.

In India, the National Curriculum Framework has set the aim for Indian science education to develop creativity, flexibility, and inventiveness in every student of India (National Council of Educational Research and Training, 2005). However, still, we are far from achieving the goal (National University of Educational Planning and Administration, 2014). NCERT formed a "National Focus Group on Teaching of Science" according to their report published in 2006 "... science education, even at its best, develops competence but does not encourage inventiveness and creativity..." (Kumar, et al., 2006). In the last 40 years, lots of researches on science education have come up with the best possible recommendations (Driver, 1975; Fraser, 1998; Hoidn, 2017; Kremer, et al., 2013; Kumar, et al., 2006; K. Kumar, et al., 2001; Larkin, et al., 1980; Lederman, 1992; Metcalfe, 2017; National Council of Educational Research and Training, 2005; National University of Educational Planning and Administration, 2014; Sampson, et al., 2010, 2015; Sarukkai, 2014; Sullivan, et al., 2017). However, India's real classroom situation remains largely unchanged (Chandran, 2014; Joy, 2014a; Ministry of Human Resource Development, 2016a; Sarangapani, 2014; Sarukkai, 2014; UNESCO Institute for Statistics Database. UIS. Stat., 2018). Various science education researchers, including (Duschl, 2008; Duschl and Osborne, 2002), have argued for shifting the model of classroom instruction away from the one-way transmission of ideas to models that *inter alia* lay stress on knowledge construction and validation through inquiry, provide increased opportunities to perceive natural phenomena, inspire engagement in critical thinking, and involvement in sharing those ideas with groups. These group activities target creating a classroom community to help students understand scientific explanations. However, in reality, teachers in Indian schools very seldom conduct experiments in classrooms; and even if it is ever done, the experiments are found to emerge mainly from the textbooks overlooking the needs of students, who end up as mere followers (Chandran, 2014; Sarangapani, 2014). They either follow or watch whatever they are shown. To conduct experiment-based learning in the classroom, the teachers and students need enough space and time to plan an experiment, design its structure, discuss the idea, record data, analyse; and all these pose significant problems (Chandran, 2014; Cheney, et al., 2006; Joy, 2014a; Kumar, et al., 2006; Muralidharan and Kremer, 2008; Sarangapani, 2014; Sarukkai, 2014) in case of overcrowded classrooms of Indian schools (Asian Development Bank, 2018; Cheney et al., 2006; Ministry of Human Resource Development, 2016b, 2016a; National University of Educational Planning and Administration, 2014; National University of Educational Planning and Administration, and Department of School Education and Literacy, Ministry of Human Resource Development, Government of India, 2016; UNESCO Institute for Statistics Database. UIS.Stat., 2018).

A well-known fact is, the practice of collaborative study, inquiry-based pedagogy, logical argumentation, and participation of students in setting goals to making decisions are a few of those crucial factors which play vital roles in gaining better student outcomes (Driver, 1975; Duschl, 2008; Duschl and Osborne, 2002; Kumar, et al., 2006; Lederman, 1992; Wellington, 1981). The USA, UK, and other developing countries have already implemented "inquiry," and "discovery" approaches in their curricula since the 1960s, but those also have their limitations. They faced logical, psychological, and logistical problems at the time of implementation (Driver, 1975; Kumar, et al., 2006; Wellington, 1981). Overall, the nature of problems is uniform, with minor accompanying regional variations. Students are still facing problems in connecting observation with inference (Carey, et al., 1989; Sampson, et al., 2015), and this situation is much prevalent in Indian schools. Therefore, a socio-culturally diverse country like India needs a learner-centric pedagogy to sustain its education system. That pedagogy should comprise the essence of a logical blend of a fresh approach with several other inquiry-based pedagogical approaches (Joy, 2014b; Kumar, et al., 2006). In this context, a pedagogy like Argument-Driven

Inquiry or ADI (Sampson, et al., 2010) seems indispensable because it has an inherently balanced approach targeting the overall development of students.

In recent days, several attempts are being made to write the textbooks with an inquiry-based approach, but ultimately the inclination remains towards problem-solving rather than creating inquisitiveness among the students (NCERT, n.d.). A balanced pedagogy like Argument-Driven Inquiry (ADI) is still not practised in Indian classrooms. No research data are found claiming prior use of ADI pedagogy in the Indian education system. For the first time, we are customising the ADI pedagogy according to the Indian context. Many alternations and modifications have been made in this process but without affecting the essence established by Sampson et al., (2010). This paper will delve into,

- introduction of ADI and its contextualisation.
- methodology for implementation of ADI in Indian classrooms.
- a small-scale deployment of the pedagogy.
- a forerunner initiative of a qualitative study of the effects of ADI based on that small-scale deployment in the real classroom of the Indian school.

Materials and Methods

Teaching-learning is a very complex and context-dependent process because of spatial and temporal differences in the condition of classrooms, the mindset of students and teachers, cultures and ethnicities, socio-economic structures, and the curricula too; so one needs to describe it adequately to develop the understanding (Kumar, et al., 2006). Hence, a descriptive or qualitative approach might be the best way to deliver a comprehensive idea of the overall situation (Berliner, 2007).

ADI and its Modification

The Argument-Driven Inquiry or ADI pedagogy was first developed and reported by Victor Sampson, et al. (Sampson, et al. 2010); later, National Science Teaching Association (NSTA) published many books (Sampson, et al. 2015) which they are using as guides towards implementing the pedagogy in classrooms of USA. According to Sampson et al., (2010), this pedagogy was planned "...to change the nature of a traditional laboratory instruction, so students have an opportunity to learn how to develop a method to generate data, to carry out an investigation, use data to answer a research question, write, and be more reflective as they work...". In addition, it creates an opportunity for students to take part in scientific argumentation and peer review process during a lab.

However, implementing the ADI pedagogy as it is, suggested by NSTA, might not befit the context of Indian classrooms because:

1. To date, there is very little provision for laboratory work in curricula of many Indian educational boards up to the 10th standard; even if it is there in some instances but rarely are brought into practice (Chandran, 2014; Sarangapani, 2014) due to several limitations discussed earlier in the introduction (Chandran, 2014; Cheney, et al., 2006; Joy, 2014a; Kumar, et al.,

2006; Muralidharan and Kremer, 2008; Sarangapani, 2014; Sarukkai, 2014).

2. There is a vast difference prevailing between rural and urban schools. Students from rural schools have different natural, social, economic, and infrastructural experiences than their urban counterparts.

3. Only one-third of secondary schools have an organised science laboratory facility in India (The National University of Educational Planning and Administration and Department of School Education and Literacy, Ministry of Human Resource Development Government of India, 2016).

Science education in most Indian secondary schools is limited to what the teacher preaches and explains in the classroom and demonstrates by performing experimental activities using very inexpensive tools. In comparison, almost 70 per cent of Indian secondary schools have computer facilities and a good percentage of qualified teachers (National University of Educational Planning and Administration and Department of School Education and Literacy, Ministry of Human Resource Development, Government of India, 2016). Considering these scenarios, at first, a few significant changes have been made to the basic structure of the pedagogy, such as:

- We conceptualised the foundation of ADI on logical analysis of theories and left scopes for designing experiments using inexpensive devices in several cases.
- Curriculum aligned probing questions were made by ensuring the following characteristics:

1. Neither the questions nor the answers are addressed directly in their textbooks.
2. The question must be devoid of any ambiguity.
3. The question should have a concrete answer.
4. The question should not lead to an erudite discussion.
5. To solve those problems, students have to develop a strong analytical ability; they have to go through a series of logical analyses by concatenating several concepts that remain fragmented during a one-way classroom transaction.

- Further, those probing questions were presented in videos, graphics, or pictorial stories to the students. While doing so, our prime concern was to ensure the involvement of students. Therefore, the contents of videos and other forms of inputs were designed by aligning with their prior experiences and knowledge.
- Omitted the last stage or stage 7, namely "Double-Blind Group Peer Review," prescribed by NSTA at page number 13 of their guidebook by (Sampson, et al., 2015).

Intentional omission of that peer review stage was done as we were faced with the stark reality that the students, the infrastructure, and the curriculum of Indian schools are not in conformity with the spirit behind handling the same unbiasedly. However, apart from this, it was strongly felt that if we had tried to introduce something very complex or any idea alien to them at the very beginning, then that would have been received with a strong inhibition, and there were chances of students getting intimidated.

A complete outline of all the structural and instructional modifications that we made to ADI compared to the prescribed format by NSTA is presented in Fig. 1.

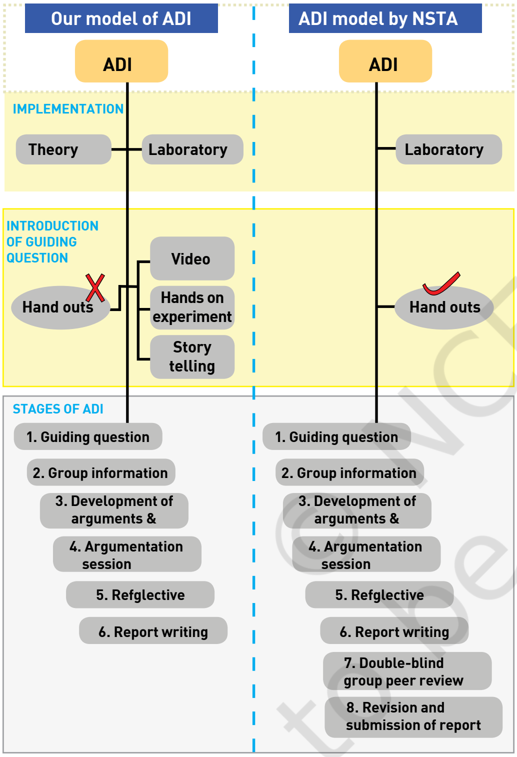

Fig. 1. Outline of the ADI model developed and implemented here (Left one) as compared to the ADI model prescribed by NSTA (Right one)

Participants

The study was carried out in two separate locations involving two separate groups of pupils belonging to two discrete categories. Each group comprised 48 students from six separate schools and a few trainee- teachers for overall monitoring of the process. Programmes were conducted under the overall guidance of experts from the research team. For the ease of further communication, we will denote the groups as 'SGp X' and 'SGp Y.' All the participants willingly took part in this experiment.

SGp X

Participants of this group belonged to urban or semi-urban areas. They were from families with a decent economic background, had private tutors, and had easy access to modern technologies and gadgets like television, computer, the internet, smartphones, etc. Moreover, they were blessed with well-educated predecessors in their families. In addition, pupils of this group belonged to different private schools with developed infrastructure, organised laboratories, and adequate teachers.

SGp Y

Participants of this group hailed from remote villages. They were from families with extremely weak economic backgrounds, and could not afford the facilities like private tutors and other educational materials. They had minimal access to modern technologies and gadgets like television, computer, the internet, smartphones, etc. They rarely had any educated elder members in their families; most were first-generation learners. Students of this group came from different public schools with nominal infrastructures, lacking organised laboratory facilities and adequate number of teachers.

Table 1
Selection criteria for experiment group SGp X and SGp Y

Groups / Selection Criteria	SGp X	SGp Y
Place of living	Urban or Semi-urban	Rural
Family income per year (INR)	≥200000	≤200000
If having private tutors at home ≥2	Yes	No
If 1st or 2nd generation learner	No	Yes
Having any of these two at home 1. Television, 2. Computer, 3. Smartphone	Yes	No
Having any access to at least 14 hrs of internet facility	Yes	No
Type of school	Private	Public
School has more than 20 teachers	Yes	No
Classrooms have audio-visual facilities like projector, etc.	Yes	No
School has well-organised laboratory facilities	Yes	No

Sampling of the student population

Forty-eight participants of each group were selected from Class IX. Initially, we prepared a list of schools from the district Paschim Medinipur, West Bengal, India. Schools were selected randomly from each of the categories. After contacting the schools, we randomly selected six willing schools for the study. Each school selected eight students of Class IX as participants. Then these 48 students, along with their respective class teachers, were invited to a venue selected for the study. After that, we again mixed them and randomly selected eight students to form one mixed population group. Thus, six groups of randomly selected populations were formed. Two separate studies were carried out in two separate locations for SGp X and SGp Y, respectively.

Tasks

At first, after psychological relaxation through a few fun activities, a video was played on the screen.

- The video contained many interesting facts about Photosynthesis and its relation with the existing living world; how these complex aerobic multicellular organisms evolved because of Photosynthesis.
- The visual had a subtle clue about the relationship between Photosynthesis, respiration, and growth.
- The video ended with one probing question or guiding question on the screen, "Between Photosynthesis and Respiration, which one is a comparatively slower process in a plant?" which they had to solve in groups.

Participants had to conclude, called the Claim, based on some evidence. Then, finally, they had to make an argumentation board putting their Claim, evidence, and justification of the evidence on it as prescribed by NSTA (Sampson, et al., 2015). The task was the same for both the SGp X and SGpY groups.

Interestingly, there was a strong initial tendency of school-wise polarisation among the students, but it gradually subsided. We considered this tendency shift to be the first step towards imbibing ADI pedagogy by the students.

Data Acquisition and Analyses

Studies with SGp X and SGp Y were conducted in two separate locations and dates. First, the whole event was video-recorded. Later, those videos were analysed to gather every piece of important information. Finally, analyses were done in terms of their interaction and responses.

The argumentation boards made by the groups were analysed. Each SGp X and SGp Y comprised six sub-groups, and each sub-group created an argumentation board. Evaluation of boards was done based on three criteria.

Criterion 1: Percentage of Clue-based evidence

We counted the total number of evidence (E) in each argumentation board, then counted the number of evidence established on the analytical base of the Clue (E_C), placed within the video, and converted the number in percentage (CE%).

$$CE\% = \frac{\sum E_C}{\sum E} x\,100............(1)$$

Criterion 2: Percentage of original evidence

Out of the total evidence (E), we identified those evidence representing an original thought and named those as Original Evidence (OE). This Original Evidence represented the ideas, which were neither a part of the video nor written in the books. Here we considered all the ideas that came from a unique analytical thought process, irrespective of themselves being conceptually correct, partially correct, or incorrect. We did so to understand their internal drive to find a unique solution to a problem. The reason behind the correctness of the idea might have depended on several factors, and we tried to address a few of these factors of interest with the qualitative approach later, but here Original Evidence (OE) had been converted to percentage using the following formula:

$$OE = \sum E - \sum E_C$$

$$OE\% = \frac{\sum OE}{\sum E} x\,100............(2)$$

Criterion 3: Graphical presentation of the idea (G_i)

The third criterion measured their ability to represent an idea or complex thought intuitively and simplified with graphs or diagrams. There we took a 3-point scale where one indicates "Bad or No Graphics," two indicates "Moderate," and three indicates "Good." That means each group could have a score (G_S) out of 3 or maximum (G_{max}) based on this 3-point scale. Finally, the score was converted into a percentage (G_i%) using the following formula:

$$G_i\% = \frac{\sum G_S}{\sum G_{max}} x\,100............(3)$$

Results and Discussion

Focus areas of the experiment

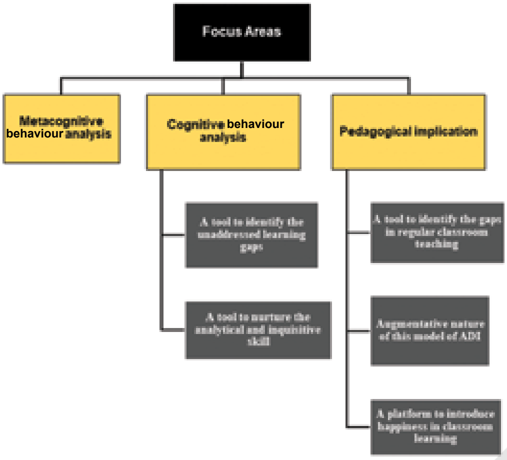

Fig. 2. Focus area of the study

Metacognitive behaviour analysis

The scope and practice of group activities are very limited in regular classrooms of Indian schools. Those are mostly practised in the playground or physical education classes but rarely in science classes, so the students are not familiar with the system (Chandran, 2014; Sarangapani, 2014). From the video content analysis, it was clear that students initially felt very uneasy in SGp X and SGp Y. Initially, they started working individually or in tiny groups within the activity group of eight pupils. With time they got habituated and started working as a single complete group. During the practice of ADI pedagogy, over time, both the groups were found to open up and get involved in group activities overcoming all the intrinsic impediments. This could be sensed from one of the participant's feedback items (transcribed from Online Resource 1OR_Feedback: https://doi.org/10.6084/m9.figshare.9995828)

"At first, we were hesitating as we were from different schools. We were kind of an introvert and not mingling with one another, but when we started talking, we saw that pupils have different ideas and concepts on the same topic."

Schools are where students spend most of their time in a day— so achieving our target of equity and equality in education (Kumar, et al., 2006; National Council of Educational Research and Training, 2005; National University of Educational Planning and Administration and Department of School Education and Literacy, Ministry of Human Resource Development, Government of India, 2016) we should adopt such a pedagogy in the classrooms which are not only effective in developing optimum scientific skills and aptitude but also efficient enough to ensure the overall development of next-generation learners of India. The study showed the effectiveness of ADI pedagogy in this context, though on a very small scale. During their feedback, participants from the group SGp X said (transcribed from Online Resource 1OR_Feedback: https://doi.org/10.6084/m9.figshare.9995828)

Participant 1 : "Here, working in the group increased our team spirit. It is very new to us; we did not do this before."

Participant 2 : "I not only learned Photosynthesis or respiration, but I have learned to bring scientific temper within me. I have also learned to write scientifically and to read scientifically.".

Cognitive behaviour analysis

A tool to identify the unaddressed learning gaps

Claims made by all the groups of both SGp X and SGp Y were correct, and so we analysed every evidence (see Fig. 3; Fig. 4; Fig. 5; and Online Resource 2OR_ADI_Boards: https://doi.org/10.6084/m9.figshare.12054090) put in the argumentation board by student groups and identified a few statements which were carrying signs of unique approaches towards the solution to the problem. We marked every piece of evidence with a unique approach, though that may be conceptually right or wrong. The key reason behind the consideration was to gauge their internal drive for taking a unique approach toward solving a problem. As an exhibit, the excerpt presented by Group 2 of SGp X is mentioned below (see Fig. 3)

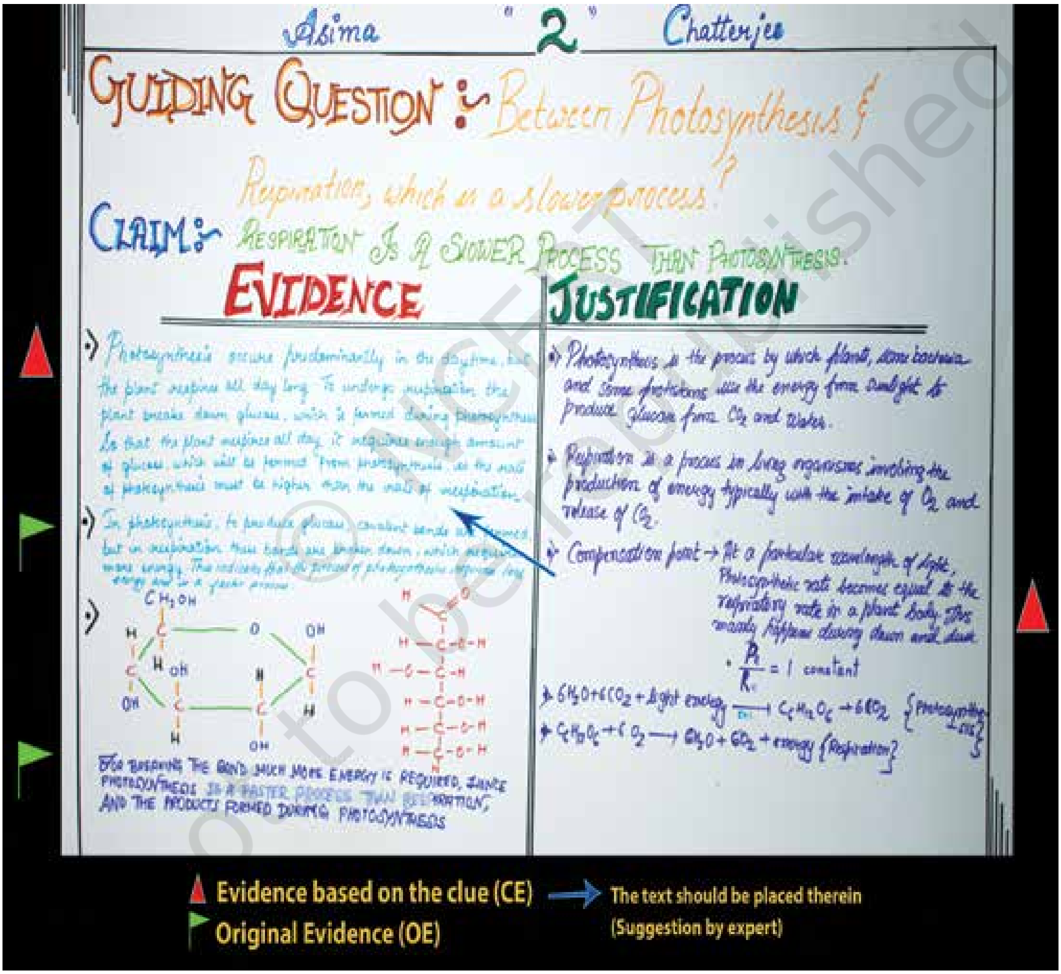

Fig. 3. Argumentation board made by Group 2 of SGp X.
(The board has been annotated, and the annotation legend is on the board)

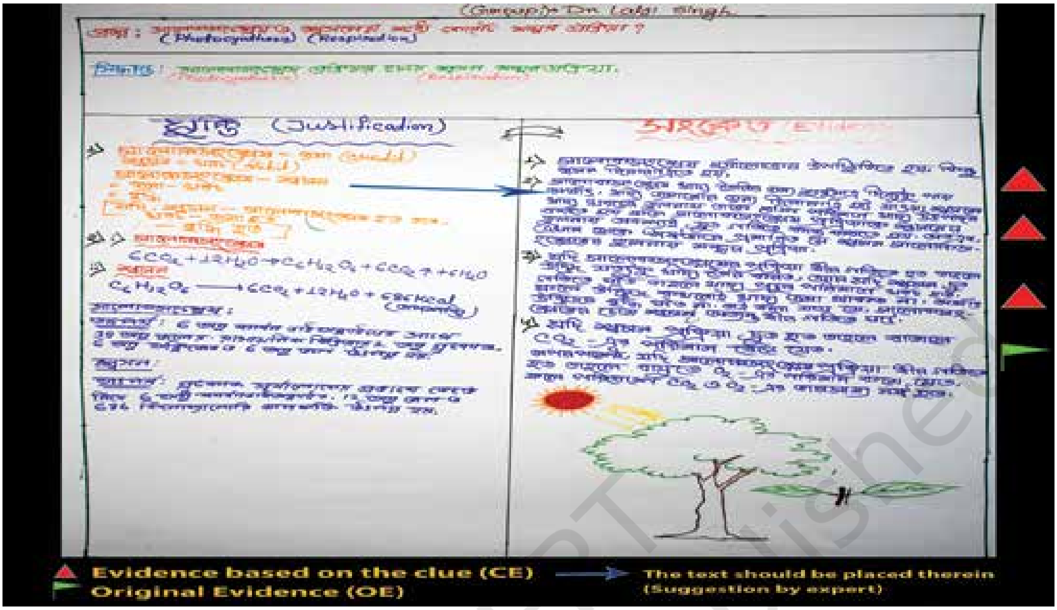

Fig. 4. Argumentation board made by Group 6 of SGp Y. (The board is written in the Bengali language as participants were from Bengali medium schools. The board has been annotated, and the annotation legend is on the board)

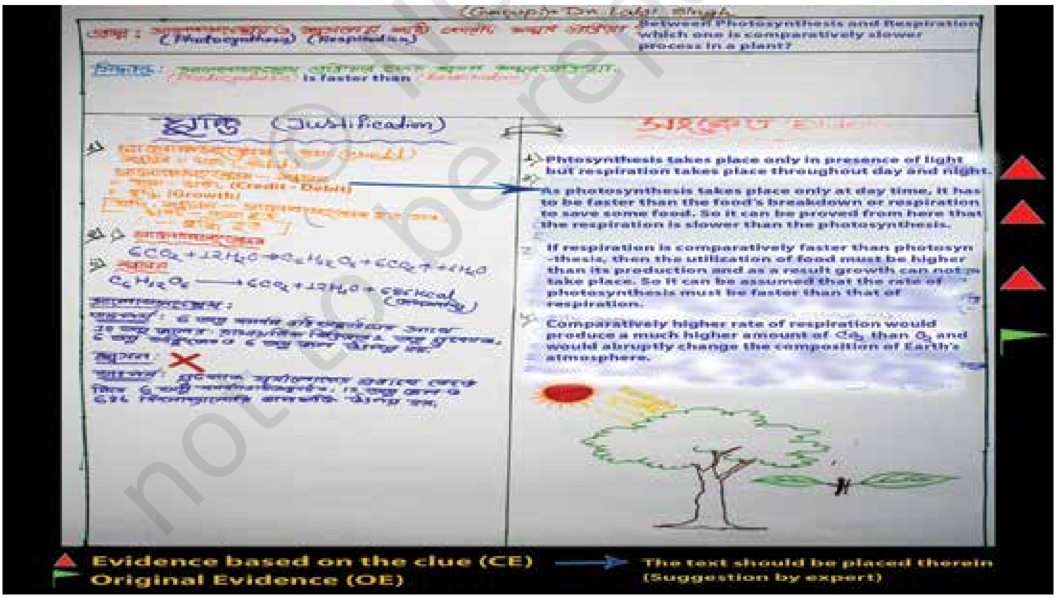

Fig. 5. Transcribed argumentation board made by Group 6 of SGp Y. This has been transcribed in English as the original board was made in Bengali. The transcript has been edited using Adobe Photoshop CS4 (The original board has been cited as Fig. 4.)

"In Photosynthesis, covalent bonds are formed to produce glucose, but in respiration, these bonds are broken down, which requires more energy. This indicates that the process of Photosynthesis requires less energy and is a faster process." (Sic)

This statement is evidence of their endeavour to keep no stone unturned within the limitations of their reach and exert maximum effort to analyse all the pieces of information they had gathered. Similarly, the statement has another exciting story to tell. The group had gone through 'Bonds and their nature' in the classroom, and they tried to use that knowledge to solve the problem. Nevertheless, it is evident from the statement that they had wrong concepts about the chemical reaction and interaction of bonds; otherwise, they could have understood that breaking of bond releases nearly the same amount of energy trapped during its formation. They also did not have a rational idea about the processes of making and breaking glucose in plants. These conceptual gaps remained unidentified and unaddressed, and might have continued to do so until they went through the process of ADI during this study. So, this pedagogy could be used frequently in classrooms as a formative assessment to identify the gaps of teaching-learning. According to one participant (transcribed from Online Resource 1OR_Feedback: https://doi.org/10.6084/m9.figshare.9995828):

"We had lots of misconceptions which cleared after exchanging our thoughts with other group members and participants, and getting proper criticism from them." (Sic).

Again, this pedagogy could fill up those gaps. To do so, the teachers should move strategically with an element of creativity and modification of the system, as we know that erroneous learning could be turned into beneficial learning if followed by corrective feedback. For example, according to (Metcalfe 2017), the error committed with high confidence could be corrected more readily, and the lesson could be more permanent than low-confidence errors. Likewise, we did in the reflective discussion session.

First, the expert asked: "What is being formed during Photosynthesis?"

Participants: "Glucose"

Expert: "What is being broken down in respiration to produce energy?"

Participants: "Glucose"

Expert: "That means both are the same, so the same bonds are being produced during Photosynthesis and are being broken down during respiration. Do you agree?"

Participants: "Yes, we do."

Expert: "How can you assume that the same product carrying the same bond will require a different amount of energy and time during formation and breaking down through reverse reactions? Is it possible? What do you think?"

Participants: "No, it is not possible."

Expert: "Now, do you agree with this statement of yours - 'in Photosynthesis, to produce glucose, covalent bonds are formed, but in respiration, these bonds are broken down, which requires more energy. This shows that the process of Photosynthesis requires less energy and is a faster process." (Sic)

Participants: "No, that was a misconception."

Not only could the students benefit from it, but the teachers would also gain valuable information from errors, and error tolerance encourages students to engage in exploratory activities.

An essential lesson of ADI is that the students should not be discouraged from committing errors. On the contrary, they should realise that such errors are not mistakes, not to speak of blunders!

A tool to nurture the analytical and inquisitive skill

Curiosity is the ultimate drive behind every sort of knowledge. Curiosity generates question, and question generates knowledge. However, unfortunately, students are losing their habit of questioning. The practice of traditional one-way classroom transactions makes them mere passive listeners (Sarangapani, 2014). This study showed that ADI pedagogy could transform the current scenario of the classroom by transforming the students from passive listeners to active question raisers, and the fact was also admitted in her feedback by a teacher who took part in the study (see Online Resource 1OR_Feedback: https://doi.org/10.6084/m9.figshare.9995828). Students made several errors in due course of practising ADI pedagogy during the study. By way of committing errors, they got a stimulus to learn more; and as they learned more, they gathered more experiences, got more raw materials to enhance their analytical ability. With deep understanding, when they tried to analyse, they came up with lots of queries, which started a healthy cyclic reaction. In our study, we came across an interesting statement put by Group 4 of SGp X on the argumentation board as evidence, and it was like (see Online Resource 3OR_ADI_Board: https://doi.org/10.6084m9.figshare.12064314):"Respiration has greater numbers of steps, so phases are longer and slower than Photosynthesis,"

At the Reflective Discussion session, we performed an elementary set of low-cost experiments on displacement reaction, using (a) $CuSO_4$ solution and iron nail (b) $AgNO_3$ (aq) and NaCl (aq), to show that not all the chemical reactions take an equal amount of time to complete. Therefore, the overall reaction time of a complex biochemical process does not depend on the number of steps it involves. We also demonstrated that a reaction does not take place at the same speed in-vivo and in-vitro with the help of another simple set of experiments of Oxygen Evolution Reaction () (Ghosh and Rahaman, 2018). OER was demonstrated through in-vitro electrolysis of water and in-vivo photolysis of water within *Hydrilla sp*., (detail description of all the previous experiment set up could be found here https://doi.org/10.6084/m9.figshare.17427407.v1). Consequently, a question came from their end, and the question was, "What are the factors affecting this reaction speed in-vivo?" That is how ADI did its job. To get rid of the usual lecture method of teaching-learning, moreover making science classrooms interactive and vibrant space, schools need a pedagogy like Argument-Driven Inquiry as echoed in the feedback of participants (transcribed from Online Resource 1OR_Feedback: https://doi.org/10.6084/m9.figshare.9995828).

"We get to learn how to reach the core of a topic. In schools, we study only theories in a straightforward way; that is how our teachers taught but did not get the opportunity to analyse and connect,".....Participant: 3.

"I learned here how to ask questions and the importance of questioning. Previously I did not ask questions, or even if I asked, either the question or my way of asking was wrong. So I repent if I would have asked questions that came in my mind on those days, I would have learned more,"....Participant: 4.

Pedagogical implication

A tool to identify the gaps in regular classroom teaching

Before this experiment, their respective class teachers in their schools taught students topics like Photosynthesis and Respiration as usual. After analysing the data obtained from the experiment, we found that ADI could be used to improve the quality of classroom teaching by applying it as a tool to find the gaps therein. In the argumentation boards of the groups SGp X and SGp Y, only 33.33 and 29.17 per cent of evidence respectively represented original evidence, and the rest of the part was based on the clue shown within the video of the probing question. Therefore, from Table 2, one could understand that students had a strong dependency on what they have seen or on the information that has been supplied to them, but they could not carry out critical analysis based on those pieces of information, and a similar view could be found in Joy (2014b).

Table 2
Quantitative analysis of the Argumentation Boards made by different groups of SGp X and SGp Y

Name of Grouwps /Subgroups	SGp X					SGp Y				
	Evidence based on the clue (CE)	Original evidence (OE)	Total Evidence (E)	Graphical presentation of idea (Gi)		Evidence based on the clue (CE)	Original evidence (OE)	Total evidence (E)	Graphical presentation of idea (Gi)	
				Gs	Gmax				Gs	Gmax
Group 1	05	00	05	01	03	04	00	04	01	03
Group 2	02	02	04	01	03	03	03	06	03	03
Group 3	02	02	04	03	03	05	00	05	01	03
Group 4	03	01	04	02	03	03	01	04	02	03
Group 5	01	03	04	03	03	01	03	04	01	03
Group 6	05	00	05	01	03	03	01	04	01	03
Total (∑)	18	08	26	11	18	19	08	27	09	18
Average ± SD	3 ±1.67	1.33 ±1.21	4.33 ±0.52	1.83 ±0.98	3.00 ±0.00	3.16 ±1.33	1.33 ±1.36	4.50 ±0.84	1.50 ±0.84	3.00 ±0.00
Percentage (%)	69.23	30.77	100	61.11		70.37	29.63	100	50	

With such analysis, teachers could identify the gaps in their regular teaching, and work on developing analytical ability and critical thinking among the students. In addition, the score of 'Graphical presentation of the idea' (Table 2) could help teachers understand the usability of the concept map and other forms of graphical presentation in the classroom. Unfortunately, the current curriculum structure and the Indian schools' infrastructure have very little space for regular implementation of the Argument-Driven Inquiry pedagogy. Considering the above discussion, it can be suggested that ADI implementation can be considered intermittently for formative assessment in schools. One of the school teachers, who took part in this experimental process as a trainee, expressed a similar thought in his feedback (transcribed from Online Resource 1OR_Feedback: https://doi.org/10.6084/m9.figshare.9995828):

"We taught the meaning of Photosynthesis and the process, and we also taught respiration as another separate process in schools. However, I never thought to ask or think on such a thing that between Photosynthesis and respiration which one is slower or faster."

Augmentative nature of this model of ADI

According to the report published by the National University of Educational Planning and Administration in 2015 (National University of Educational Planning and Administration and Department of School Education and Literacy, Ministry of Human Resource Development, Government of India, 2016), only 33.89, 33.64, and 32.02 per cent of Indian higher secondary (10+2) schools have a separate room for the laboratory of physics, chemistry, and biology respectively, and the scenario must be worse in secondary schools (up to Class X) because there is minimal provision for laboratory work in the secondary curriculum throughout the nation (Joy, 2014b; Sarangapani, 2014). Theoretical study, logical analysis, and some low-cost classroom experiments are the only means for studying science subjects in India, at least at the stage of secondary education. So, sticking with the current curriculum framework, the ADI pedagogy cannot be implemented to improve the quality of experimental science in laboratories as practised in the USA (Sampson et al., 2010, 2015). Therefore, this model of ADI was designed for theory classes and from the above discussions that seemed befitting to the Indian context. Although this pedagogy could not replace the ongoing teaching process because initially, teachers have to teach the topics with the process they are used to, and then they could apply the ADI intermittently to strengthen the teaching-learning process. The teacher concerned, according to the necessity and demand of the situation, could determine the frequency of using the ADI.

A platform to introduce happiness in classroom learning

The most precious outcome of our experiment was the expression of happiness on students' faces. During analysis, the videos showed reflections of surging enthusiasm and smiling faces in every frame, and that is one of the most crucial parts amidst the crowd of tangible outcomes (Online Resources 4OR_SGp X: https://doi.org/10.6084/m9.figshare.9995918 and 5OR_SGp Y: https://doi.org/10.6084/m9.figshare.9995921). Another teacher, who took part as a trainee in one of these experimental workshops, shared one of his significant experiences after the first day of the workshop in his feedback (transcribed from Online Resource 1OR_Feedback: https://doi.org/10.6084/m9.figshare.9995828).

"When we were returning from here to our places, students were asking me eagerly, sir, when are you going to start this in our classroom?"

In every learner-centric model of education, the happiness of learners is the ultimate word. Any pedagogy or model of instruction cannot be effective if it fails to attract the learners so in this respect, the pilot run of the model of Argument-Driven Inquiry pedagogy, which has been designed for Indian schools, could be claimed as fruitful.

Conclusion

In this experiment, ADI pedagogy was redesigned to match the context of the Indian education system, and pilot runs were conducted to experience its effectiveness. Two groups of students, one from remote villages and another from urban areas, were selected to study the impact of this pedagogy on the teaching-learning process. The study found, albeit the vast difference in their experience, mindset, and institutional infrastructure, that both groups have similar gaps in understanding science. This can be attributed to the fact that they were being taught mainly through the exact traditional information-centred teaching mechanism.

This ADI pedagogy was observed to bring some visible changes within their behaviour, such as they started to inquire spontaneously and analyse critically, they gradually opened up and started interacting with each other. They were observed to collaborate to find solutions through group activity. ADI was found to be effective in identifying gaps in learning and teaching. Above all, the pedagogy was observed to bring spontaneous involvement and happiness in the teaching-learning environment. Although the ADI pedagogy cannot replace the traditional teaching system in India's science classrooms, it can be used effectively to augment the current system.

However, we have a long way to go before implementing it at every school in India. The prominent impediments in this journey are an intrinsic inhibition within the teachers and school administrators to accept something new, lack of space and time for ADI within the current curricula, lack of infrastructural support in rural schools, and most importantly, the lack of awareness among the parents of the students. Based on the outcome of the Experimental Workshop, which *inter alia*, generated tremendous enthusiasm among the students and the teachers, our current strategy would be to strike a balance between ADI and the existing teaching-learning process in the schools.

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Declarations

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Conflicts of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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DESIGNING LESSON PLAN IN SCIENCE BASED ON TPACK FRAMEWORK

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Technological Pedagogical Content Knowledge (TPACK) has been introduced as a conceptual framework based on the notion that teachers need to align and integrate content, pedagogy, and technology in their teaching practice in order to make the classroom process interactive and learning meaningful and effective. This paper presents a brief description of how to design and develop a lesson plan based on the TPACK framework in teaching science with illustrations in a systematic manner.

Keywords: TPACK, Lesson Plan, Education, Teaching Strategies.

Introduction

In traditional teaching, content and teacher played an important role, where textbooks were the only source of content. However, education in the digital era is more student-centred. Now education favours a curriculum that focuses on the enhancement of the competency of students. Although not previously considered among the traditional frameworks for research in education, in recent times, however, PCK offers a new perspective for science education research within teacher education. The notion of pedagogical content knowledge was first introduced by Shulman as a form of knowledge that connects a teacher's cognitive understanding of subject matter content, and the relationships between such understandings with the instruction teachers provide for students (Shulman, 1986:25).

Research has shown that in order to improve the quality of science education, science teachers need to possess knowledge of learners, content, pedagogy, and technology. Recently, considerable interest has surfaced in using the notion of Technological Pedagogical Content Knowledge (TPACK) (Mishra and Koehler, 2006; as a framework for the teacher knowledge required for effective technology integration because TPACK reconnects technology to curriculum content and specific pedagogical approaches. This paper discusses TPACK framework and designing a lesson plan in science based on it with an illustration.

What is TPACK?

Technological Pedagogical Content Knowledge is a framework that tries to identify the nature of knowledge required by teachers to teach effectively with technology. The TPACK framework describes how teachers' understandings of technology, pedagogy, and content can interact with one another to produce effective discipline-based teaching with educational technologies. In this framework, there are three interdependent components of teachers' knowledge: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK); when these (CK, PK, and TK) interact with each other, they form PCK, TPK, TCK, and TPACK (Fig. 1). That is, there are seven components in total. Effective integration of CK, PK, and TK by the teacher would help in meaningful classroom transactions.

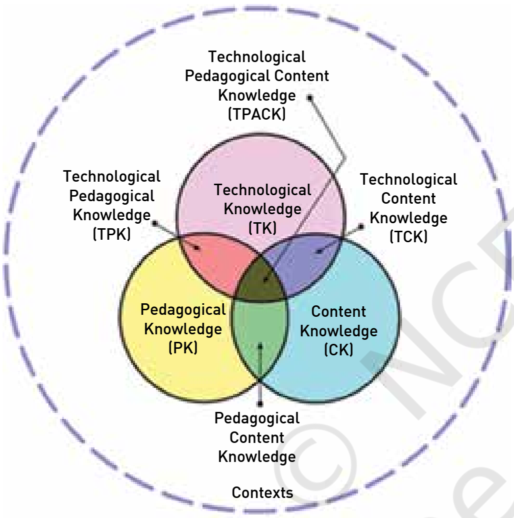

Fig. 1. TPACK with its Components

Content Knowledge (What to teach)

Teachers' knowledge of the content or subject matter (components of scientific knowledge) that has to be transacted in the classroom is called content knowledge. It includes factual knowledge and procedural knowledge. The teacher needs to analyse the content to be taught in order to understand the nature of the content.

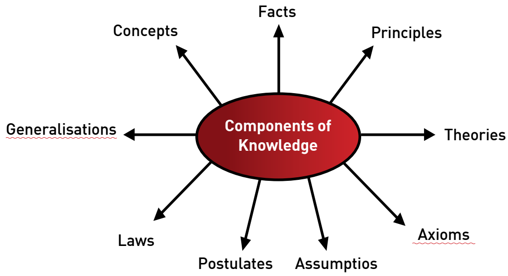

Fig. 2. Components of Knowledge

Content Analysis

The subject matter or content has to be analysed in order to understand the nature of the content and identify content categories or components of scientific knowledge from the chosen content. After analysing the content, the teacher understands the nature and scope of the content—whether it is descriptive, exploratory, illustrative, procedural, etc. Content knowledge includes knowledge of facts, concepts, principles, laws, theories, generalisations, etc. (Fig. 2).

Example: Content analysis of the topic Cell and its Types

The content of the lesson is exploratory in nature, wherein students can be given an opportunity to explore different types of cells. The teacher can facilitate and orient the students in handling the microscope. The content is illustrative as there is the scope of giving examples of different shapes of cells, unicellular and multicellular organisms. The content contains facts, principles, theories, concepts, and generalisations. The content may be categorised as shown in Table 1.

Table 1
Content categorisation of the topic Cell

Facts	Concepts	Theory	Generalisation
The Cell was first discovered by Robert Hooke in 1665. The nucleus was discovered by Robert Brown. Schleiden and Schwann proposed cell theory The Cell is the structural and functional unit of life	Cell Organelle Microscope Multicellular organisms Unicellular organisms	All plants and animals are composed of cells, and the Cell is the basic unit of life. All cells come from the pre-existing cells	All living organisms are made up of cells Each living cell has the capacity to perform certain basic functions that are characteristic of all living forms. Different kinds of cells perform different functions.

Pedagogical Knowledge (How to teach)

Teachers' knowledge of the learning process, the context of learning, methods/approaches/strategies/processes involved in the teaching-learning process is called pedagogical knowledge. It also includes an understanding of how students learn, planning a lesson, classroom management, and continuous comprehensive assessment of students. Once the content is analysed, it is vital to decide how to teach students. Some of the teaching strategies are given in Fig. 3.

Teaching Strategies

Expository approach (Teacher-centred)

Methods

1. Lecture Method
2. Demonstration
3. Questioning
4. Discussions
5. Memorisation
6. Drill and Practice
7. Didactic Method
8. Direct Instruction

Model

1. Concept attainment model
2. Inductive thinking model
3. Inquiry training model
4. Jurisprudential model
5. Synectics model
6. Advance organiser model

Discovery approach (Students-centred)

Methods

1. Brain-storming
2. Project Method
3. Concept-mapping
4. Collaborative Learning
5. Peer Learning
6. Socratic Method
7. Debate
8. Role Play
9. Simulation
10. Problem-solving
11. Tutorials
12. Lab Method Cooperative

Fig. 3. Teaching strategies

Pedagogical analysis

Depending upon the age, maturity, and intelligence of the students, a stage has to be set in nurturing congenial learning environment by the teachers. The teacher has to make decisions regarding whether individual or group-based learning has to take place, the method/strategy/approach/technique to be adopted, and assessment techniques to be used before the commencement of classroom instruction.

Example: Pedagogical analysis of the topic 'Cell & Cell theory'

To teach 'Cell & Cell' theory, the following pedagogical processes can be taken up:

- Concept attainment model to help the student attain the concept of Cell
- Inductive method to arrive at the statements of Cell theory
- Lab method to show the main parts of the Cell
- Group work and Album making
- Development of Rubric to assess the process of learning

Technological Knowledge

Teachers' knowledge of tools, resources, teaching-learning materials, and their use contextually in the classroom is called technological knowledge. Understanding when, which and how, technology promotes the learning process among the students and would improve the teaching-learning process. Out of many technologies available, the teacher has to determine the ones for the lesson, keeping into consideration affordances and constraints. In addition, the teacher must understand the purpose of using or integrating technology while teaching, which includes:

(a) **Substitution:** Instead of a chart, slides or documents may be shown. In other words, the technology here is not added on but is used as another medium of presentation.

(b) **Modification:** Instead of using papers/letters, the ideas can be shared on google docs wherein there is a mutual exchange in different times and spaces.

(c) **Augmentation:** In this case, the technology can enhance the concept, and augments learning among the students.

(d) **Redefining:** This is the highest level of integration wherein technology is used for transforming learning.

The exemplar resources/materials/tools that can be used in the teaching-learning process are given in Figs. 4 and 5.

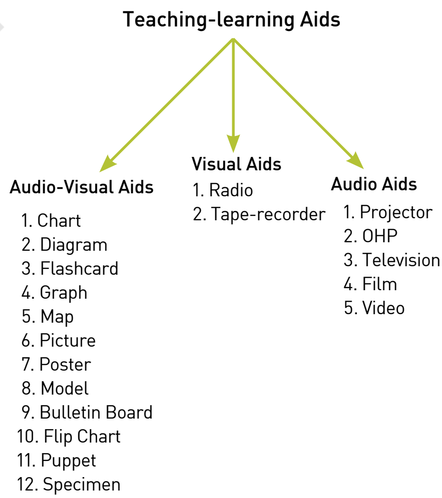

Fig. 4. Teaching-learning Aids

ICT Tools

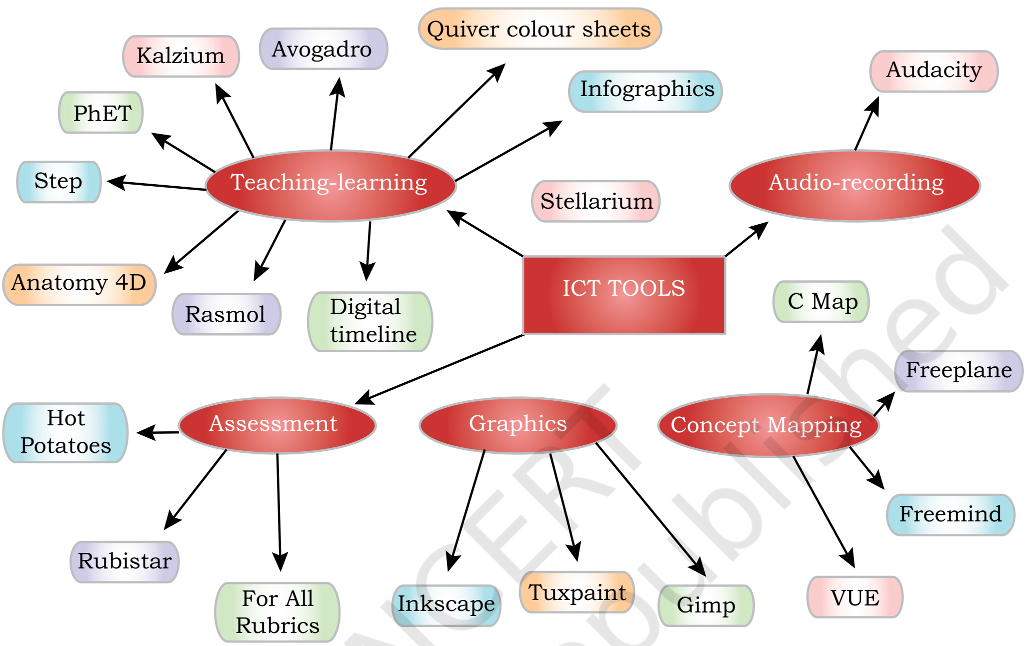

Fig. 5. ICT tools that can be used for teaching

Pedagogical Content Knowledge (PCK)

According to Shulman (1986), PCK is the notion of transforming the subject matter for teaching. This occurs as the teacher interprets the subject matter, finds multiple ways to represent it, adapts, and tailors the instructional materials to alternative conceptions and students' prior knowledge. In addition, PCK includes conditions that promote learning and links curriculum, assessment, and pedagogy (Koehler and Mishra, 2009). In other words, PCK is the specialised knowledge of a teacher that helps him/her decide how to teach the given topic to a group of students, and which materials to use to facilitate learning among the students. This knowledge is enhanced with the teaching experience of teachers.

Example: Cell & its types

An Illustration of PCK is represented in Table 2.

Table 2
Forms of Knowledge and Pedagogical Interventions

Forms of knowledge				Pedagogical Intervention
Factual	Conceptual	Procedural	Meta Cognitive	
Recalls that cell is the structural and functional unit of life			Associates honeycomb compartments with the cells	Allows the students to explore the cells under the microscope (draw the diagram in their notebooks)
	Describes cell theory Generalises that each cell has the capacity to perform certain basic functions that are characteristics of all living forms Differentiates unicellular and multicellular organisms			Uses charts models and encourages the students to discuss the shape, size, and functions of the cells Using the inductive thinking model, the students may be encouraged to arrive at the concepts and differentiate them
		Encourages the students to observe the cell under a microscope using core and fine adjustments		Encourages the students to observe and identify the organisms under the microscope
	Analyses the relationship between the shape and size of the cell with that of function			Encourages students to observe the organisms under the microscope and discuss with one another
	Develops a rubric along with the students and assess the album			Motivates students to participate actively in their group work
	Prepares an album on the life history of scientists Robert Hooke and Schleiden and Schwann			

Technological Content Knowledge (TCK)

Teachers' knowledge of the application of technologies and their suitability for teaching the content chosen or subject matter constitutes Technological Content Knowledge. In other words, TCK is the teachers' understanding of how the subject matter or knowledge is constructed and which technologies are best suited for addressing the same, and even understanding how the content dictates the use of technology.

Example: Cell & its types

- **Cells:** Observation of slides under a Microscope
- **Shapes and sizes of the cells:** Using charts, models, slides
- **Structure of a Cell:** Quiver colour sheets
- **Rubric:** Rubistar
- **Concept map on Cell:** VUE/Free mind
- **Life history of the scientist:** Digital timeline, Digital storytelling
- **Unicellular and multicellular organisms:** PowerPoint presentation, movie maker

Technological Pedagogical Knowledge (TPK)

TP describes teachers' understanding of technologies and their use in the teaching-learning process, pedagogical affordances, and the challenges/constraints. With this knowledge, the teacher can choose the tools that match the students' age, maturity, and other student-related aspects, along with pedagogical interventions that are developmentally appropriate.

Example: Cell & its types.

- **Cells:** Observation of slides under Microscope – Lab method
- **Shapes and sizes of the cells:** Using charts, models, slides – Inductive method
- **Structure of a Cell:** Quiver colour sheets – Group work
- **Rubric:** Rubistar – Group work
- **Concept map on Cell:** VUE/Free mind – The teacher can develop the map with the help of students or use a concept map while developing a lesson
- **Life history of the scientist:** Digital timeline, Digital storytelling - Presentation
- **Unicellular and multicellular organisms:** PowerPoint presentation, movie maker – Inductive thinking model / Concept attainment model of teaching

Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) is best explained in the following lines of Koehler and Mishra (2009):"Underlying truly meaningful and deeply skilled teaching with technology, TPACK is different from knowledge of all three concepts individually. Instead, TPACK is the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn, and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones".

Example: Cell & its types.

in an appropriate context for the students. Technology is integrated with content and pedagogy as it can be used for substitution, modification, augmentation, and redefining. In other words, the whole purpose of integration

Table 3
TPACK format for the topic Cell and its types

Content	Pedagogical interventions	Technological interventions	Assessment
The cell is the structural and functional unit of life Associates the honeycomb compartments with the cells	Allows the students to explore the cells under the Microscope (draw the diagram in their notebooks)	Uses Microscope Colour and scan Quiver colour sheets	Quiz (Hot potatoes)
Describes cell theory Generalises that each Cell has the capacity to perform certain basic functions that are characteristics of all living forms, Differentiates unicellular and multicellular organisms	Uses charts and models and encourages the students to discuss the shape, size, and functions of the cells Motivates the students to develop concept maps Uses the Inductive Thinking Model to arrive at the concepts	Charts, models, PPTs Freemind / VUE PPTs	Concept map for assessment
Life history of scientists	Group work Prepares an album on the life history of scientists Robert Hooke and Schleiden and Schwann Create Rubric for assessing the album	Digital storytelling/ timeline Rubistar	Presentation by students

To develop a lesson based on TPACK, one has to determine the context, content and pedagogy; reflect on PCK; determine technology; reflect on TCK and TPK; develop classroom processes based on TPACK in a sequential manner. An illustration is presented in Table 3.

To sum up, it is necessary that the teacher needs to be resourceful in terms of content and pedagogy, and integrate technology is to enhance the quality of learning by making it enjoyable, meaningful, and outcome-based learning.

An Exemplar Lesson

Class: IX

Subject: Science

Topic: Cell and Cell theory

Content: Cell, Cell theory, Microscope, Unicellular and Multicellular organisms, Life history of scientists

Technology integration: Charts, Models, Videos, PPTs, Microscope, Rubistar, Quiver colour sheets, Hot potatoes, digital storytelling or timeline, Freemind or VUE

Class demographics: Total no. 35, Boys: 20, Girls: 15; Students are from rural and urban areas; No CWSN

Learning goals: At the end of the instruction, the students:

- identify cells.
- generalise that Cell is the structural and functional unit of life.
- explain cell theory.
- differentiate unicellular and multicellular organisms.
- create an album on the contribution of the scientist.
- design a rubric to assess the album.

Pedagogical interventions/activities

Filling quiver colour sheets, observing cells under Microscope, concept attainment model, group work for designing rubrics and developing an album, using charts and models are the pedagogical interventions or activities that can be carried out for teaching the selected content.

Procedure

After setting an ambiance for learning, the teacher may tap students' previous knowledge of characteristics of living things and create readiness among them. For example, an activity may be conducted wherein students explore the structure of Cells by observing onion peel and cheek cells or any other under a microscope and draw a microscopic view of cells (Figs. 6 and 7). If that is not possible, the teacher can use quiver color sheets. The students may be encouraged to fill the quiver colour sheets of plant and animal cells, and scan and observe the cells. Further, they may be asked to describe the cells observed in their own words.

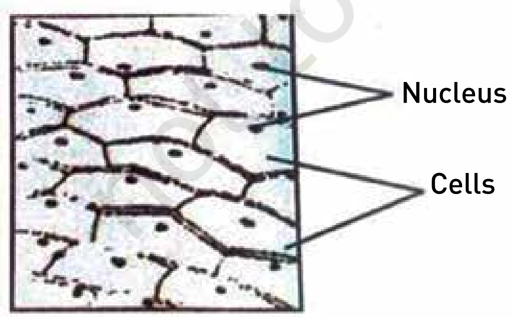

Fig. 6. Cells of Onion peel

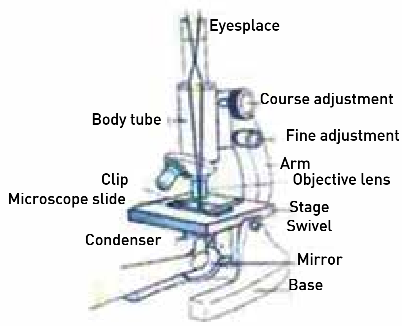

Fig. 7. Parts of a Compound Microscope

The teacher can further use videos to explain the concept of cell theory given by Schleiden and Schwann. Finally, a discussion can take place showing charts and models regarding the different shapes, sizes, and functions of the cell. Based on this discussion, the teacher can encourage the students to generalise that each cell has the capacity to perform certain essential functions that are characteristics of all living forms.

The teacher may use open software like Freemind / VUE to show concept maps to students, for which a laptop or a PC with a projector will be required as shown in Fig. 8.

the concept of unicellular organisms and multicellular organisms using PowerPoint presentations or pictures, or images. These teaching models help the students inform and attain concepts through a variety of examples.

Group work can be carried out in which students need to prepare an album on the life history of scientists Robert Hooke and Schleiden and Schwann. For this work, students may take the help of digital storytelling/timeline. The album prepared in the group will be assessed with the rubrics developed in Rubistar.

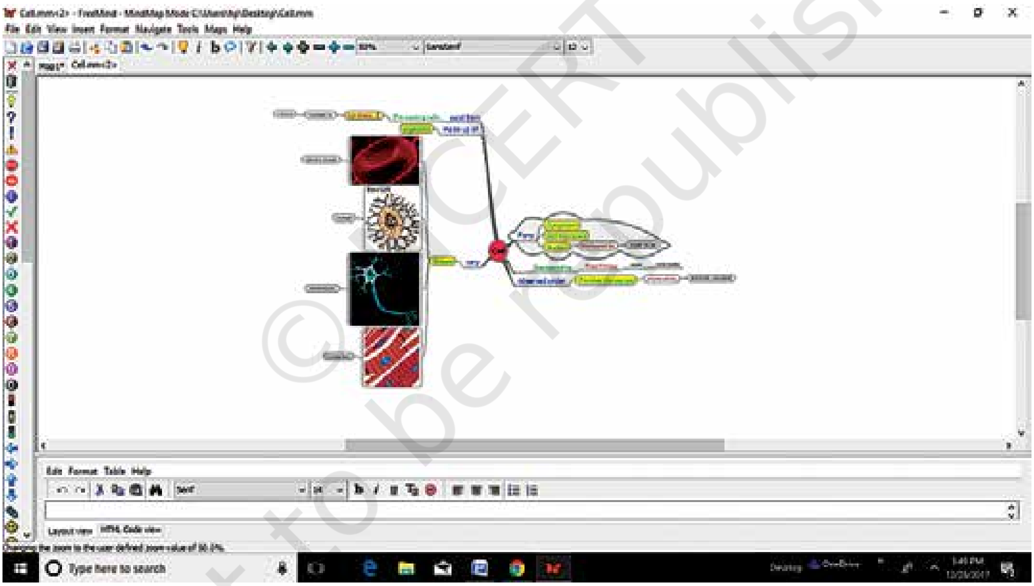

Fig. 8. Freemind software can be used to construct concept maps

Using hot potatoes, the quiz can be conducted in the class to recall the largest, longest, smallest cells, etc.

Teachers may use the Reception or Selection strategy of the Concept Attainment Model of teaching so that students can attain

Conclusion

This framework considers the different types of knowledge needed; it becomes a great possibility of integrating technology into the teaching-learning process. It further impacts both teachers' professional development and students' learning. Because it considers the different types of knowledge needed and how teachers could cultivate this knowledge. The TPACK framework thus becomes a productive way to consider how teachers could integrate educational technology into the classroom. In other words, it is imperative that the teacher understands the aspects mentioned above and that the class is driven in an integrated way. Technology has become an increasingly important part of the teaching-learning process, especially in understanding complex concepts and helping in collaboration with peers.

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GANDHI AND THE IDEA OF SUSTAINABILITY– IMPLICATIONS FOR SCIENCE EDUCATION

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The principles of Sustainable Development (as highlighted in the Brundtland Commission*, 1987) entail the conservation of resources for the current and future generations without disturbing the ecological balance. The present paper discusses the role and relevance of Gandhian education philosophy and his vision of a School (at Sevagram Ashram) for sustainable living. The paper further delineates the scope of Gandhian education philosophy and ideals in the present-day context of school education and integrates his philosophy within the prescribed school curriculum. A case of a Class VI science textbook has been taken as an example to review and analyse the curriculum in the light of Gandhian principles and ideas of sustainability for school education. The paper also provides suggestions for further integration of Gandhian values of sustainability and sustainable development within the school curriculum. Educational implications can be drawn for science education in general, as well as for in-service and pre-service science teachers, teacher educators, and science curriculum developers.

Keywords: Sustainable Development, Ecology, Science, Society, Science education, Sustainability.

Introduction

Gandhian Philosophy and principles have inspired millions across the ages, not just for nation-building and resilience but also in spheres such as Education, the employment sector, economy, and industry. However, thinking about the current pace and means of development in the country, it largely appears antithetical to the ideals and values embedded in Gandhian Philosophy and ideology.
As a result of this, we are a witness to a development that is lop-sided and focused mainly on economic and material gains rather than based on human values, conservation of the environment, and ethics. Such a model of development may be a boost for an economy but can never be long-lasting as it is detrimental to the health of our environment and the fabric of our society. Gandhian principles are based on self-sufficiency, non-violence, truth, and care, cutting across all organisms and the environment.

The Gandhian idea of Education has always been inspirational and pragmatic not just for India but also for the World. Gandhian Philosophy and his ideology have been emulated in Education, development, nation-building, economics, societal fabric, lifestyle, and character building. The values inherent

* The Brundtland Commission 1987 emphasised upon the judicious utilisation of environmental resources such that they fulfill the needs of the present generation and do not compromise on the needs of future generations as well. This is the principle of 'sustainable development' which was the major recommendation of this report.

in Gandhian Philosophy have the power of transforming the World, which we have been a witness to, especially when it comes to the Indian Freedom Movement and the struggle for the rights of South African people. Gandhiji had never tried to influence or ask the people to follow him or his ideals; instead, the people themselves got motivated to adopt them. This is the sign of a true leader, who himself is a model of all the ideals he believes in rather than insisting others follow them. Gandhiji was an epitome of truth, ahimsa (non-violence), honesty, virtue, and peace, and he strived for these ideals for his entire life. In one of the books he wrote, 'my life is my message,' clearly depicts the thought process of his evolution from an ordinary human being to an extraordinary Mahatma. His experiments in Education are somewhat influenced and abridged from the socio-political turmoil that our country was going through during the freedom struggle. His principles in Education were primarily derived from his own experiments and thoughts, initially, at the Tolstoy's farm (in South Africa), also known as the *Satyagraha* institution, where the inmates practiced Satyagraha, truth, and non-violence. Some of the inmates from the farm were Indians and hence returned to India, where Gandhiji established an Ashram at Kochrab, Ahmedabad, in 1915. The Ashram's life was not easy or leisurely as the inmates were expected to practice self-restraint, celibacy (*Brahmacharya*), truth, non-violence (love), peace, offer prayers, use swadeshi products, cleanliness, and kindness. Gandhian ideas are truly apt even today for building a peaceful and harmonious society and for establishing World religion.

Gandhiji had always promoted village industries and propounded a 'craft-centred' Education System for a self-reliant society, and rejected the use of any foreign products as that would devalue our national products and labour. In Ashrams, spinning and weaving were among the chief activities that every ashramite was supposed to contribute. Spinning meant spinning the wheel (*Charkha*) for making cloth that is indigenous (*Khadi*). Besides, *Charkha* spinning was considered a meditative practice where 3H (head, heart and hand) are actively involved, unlike the English Education System, which aims to develop 'head' only. The significance of village industries in the context of India was put in a paragraph in *Harijan*.

"I would say that if the village perishes, India will perish too. It will be no more India. Her mission in the World will get lost. The revival of the village is possible only when it is no more exploited. Industrialisation on a mass scale will necessarily lead to the passive or active exploitation of the villagers as the problems of competition and marketing come in. Therefore, we have to concentrate on the village being self-contained, manufacturing mainly for use. Provided this character of the village industry is maintained, there would be no objection to villagers using even the modern machines and tools they can make and can afford to use. Only they should not be used as a means of exploitation of others." (Harijan, 29-08-1936, p. 226)

The National Curriculum Framework (NCF-2005) envisages the ideals of the Gandhian system of Education, taking as it is from *Nai Talim* (1937). Mahatma Gandhi visualised Education as a means to awaken the nation's conscience to injustice, violence, and inequality entrenched in the social order. *Nai Talim* emphasised the self-reliance and dignity of the individual, which would form the basis of social relations characterised by non-violence within and across society. Gandhiji recommended using the immediate environment (context of the learner), including the mother tongue (language) and work, as a resource for socialising the child into a transformative vision of society. He dreamt of an India where every individual discovers and realises her or his talents and potential by working with others towards restructuring the World, which continues to be plagued by conflicts between nations, within society, and between humanity and nature (NCF-2005). The idea of *Sarvodaya* propounded by Gandhiji is a sustainable ideal as it subsumes the welfare of all, including the environment, and shuns the role of any external power or discriminatory practice and self-centred pursuits for luxury and material gains.

Gandhiji was a great environmentalist, too, as he always promoted homemade (nation-made) products as opposed to foreign products because they are not meant to suit our body, mind, and environment, and are bound to cause peril. He was against the idea of indiscriminate industrialisation and aping the west. He was also wary of the fact that injudicious use of resources would lead to their depletion and extinction, especially when he said, "the World has enough for everyone's need but not for everyone's greed," pointing toward the exploitative tendency of human beings towards nature and its resources. This is the central idea of sustainable development, as stated in the Brundtland Conference report,

"Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."(World Commission on Environment and Development, 1987)

The NCF position paper on 'Habitat and Learning' also emphasises the role of Education in promoting sustainable development.

"Education is becoming increasingly central to the development process. It has to help raise awareness and build the capacity of communities to elaborate a vision and participate in the pursuit of environmentally and socially sustainable development." (NCERT, 2006).

The present paper delves into Gandhian ideas and philosophy of a sustainable society and sustainable living. The paper also analyses the present NCERT Science textbooks at the upper primary level from the lens of the Gandhian idea of sustainability and provides suggestions for better integration within the subject and topics given in the textbook.

Gandhian Idea of Sustainable Development

Sustainable Development refers to the principle of meeting human development goals while simultaneously respecting, protecting, and sustaining the ability of natural systems to provide natural resources and ecosystem services to all the people indiscriminately and equitably. In such a society, the integrity of the natural systems is maintained and nurtured. Sustainable Development can be defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland Report, 1987).

Gandhiji always advocated a minimalistic and straightforward lifestyle, which helped reduce waste and serve the poor in the country. He believed in equality and equitable distribution of resources. Gandhiji emphasised the idea of living in harmony with nature and that nature can provide for everyone's needs but not for everyone's greed (Vijayam, 2004). His idea of *Sarvodaya* emphasised welfare and self-sufficiency for each and every individual, for which he always promoted the idea of village and cottage industries. Besides generating employment for millions of workers, the village industries also promote the use and marketing of nation-based products as opposed to foreign materials. Gandhiji was wary and opposed to too much mechanisation by industries, as that would reduce the value of manual labour and affect the livelihood of many people (Gandhi, 1960). Instead, Gandhiji promoted the wielding of *Charkha* by every individual and every household as a symbol of peace, prosperity, freedom, and self-sufficiency.

"I... claim for the *Charkha* the honour of being able to solve the problem of economic distress in a most natural, simple, inexpensive, and businesslike manner. The *Charkha*, therefore, is not only not useless... but it is a useful and indispensable article for every home. It symbolises the nation's prosperity and, therefore, freedom. It is a symbol not of commercial war but commercial peace. It bears not a message of ill-will towards the nations of the earth but of goodwill and self-help. It will not need the protection of a navy threatening a world's peace and exploiting its resources, but it needs the religious determination of millions to spin their yarn in their own homes as today they cook their food in their own homes. I may deserve the curses of posterity for many mistakes of omission and commission, but I am confident of earning its blessings for suggesting a revival of the *Charkha*. I take my all on it. For every revolution of the wheel spins peace, goodwill, and love. Moreover, with all that, inasmuch as the loss of it brought about India's slavery, its voluntary revival with all its implications must mean India's freedom." (Young India, 08-12-1921).

The idea of the 'Spinning Wheel' and *Khadi* can also be understood as a means to generate self-employment and dignity of labour. It also helps in conserving a nation's resources and builds cooperation among its people. Gandhiji compared the 'Spinning Wheel' to a life-giving Sun, a precursor to promoting and reviving other handicrafts. Gandhiji was a great supporter of 'Vegetarianism,' and a vegan diet excluding all animal flesh and animal products, and provided a moral basis for the same (Gandhi, 1959). He also argued for animal rights and taking good care of animals in the animal houses (*Gowshalas*).

Looking at the current pace and means of development, adhering to Gandhian ideals and ways of living becomes indispensable and can only provide an alternative path that is less destructive to the environment. It is clear that environment and development can no more be viewed dialectically as both are deeply related to each other and are indispensable for sustainable living. Post-Independence development is often viewed from an anthropocentric viewpoint that needs to be realised in terms of a country's material gains and economic growth, but less viewed from a holistic and integrated perspective, including the social, political, cultural, economic, environmental, and ethical standpoints. The recent environmental crises such as depletion of natural resources, global warming and climate change, dwindling biodiversity, soil erosion, and land desertification result from the lop-sided model of development that needs to be combated equally by developed and developing nations. The present Education System also contributes to harbouring a self-centred and competitive mindset of the people. Thus, there is a need to revamp our Education System and base it on the Gandhian values and ideals for a better tomorrow, and conserving our environment.

Methodology

The present paper involves a critical content analysis of the Class VI NCERT Science textbook with respect to the integration of Gandhian values of Sustainability. The textbook chapters have been analysed keeping in view the following parameters:

- Topics/content in the textbook that caters to the idea of 'sustainability' or 'sustainable development.
- Integration of Gandhian values of Sustainability (refer to Table 1) within the Science Textbook of Class VI
- Treatment/presentation of these values in the textbook
- Pedagogical implications for transacting content/topics related to Sustainability in the classroom
- Suggestions for further value addition in the textbook

Integration of Gandhian Ideals in School Curriculum — Content Analysis of Class VI NCERT Science Textbook

Sustainable living is one of the critical elements of the Gandhian philosophy that understands that all live in harmony with nature. Sustainability is also in each of the SDGs (Sustainable Development Goals) for a better world. The Gandhian idea, "Be the change you wish to see in the world," emphasises the value of individual responsibility in changing the current world order and aiming for a better tomorrow. National Education Policy (NEP) 2020 also emphasises instilling the value of sustainable development and living for global citizenship. The policy also reinstates the integration of environment awareness and principles of sustainable development within the teacher education curriculum to sensitise the pre-service teachers toward sustainable development (p. 23). In the light of the above framework, a case example of a Class VI NCERT Science textbook has been taken to understand the integration of the Gandhian idea of 'sustainability' within the curriculum. Class VI Science textbook has been selected as a sample for developing a framework to integrate Gandhian Philosophy and ideals at other levels.

A critical analysis of NCERT Science textbooks from Classes VI – VIII was carried out to identify the topics and areas where Gandhian values and his idea of sustainable development can be integrated. The matrix (refer to Table 1) presents the Gandhian values found in the literature that can be mapped to the current science curriculum at the elementary school level. The matrix can help the teachers identify the Gandhian values and ideals that they can integrate with their science curriculum topics. For instance, when a teacher is teaching animal kingdoms and the classification of species, at the same time, she can also talk about taking care of animals, especially stray animals, by giving them food and comfort. This will help develop sensitivity among students toward animals in their neighbourhood and develop a feeling of care for them.

A case of Class VI NCERT Science textbook is taken as a case example to explain the process of integrating Gandhian values and ideas within the curriculum (refer to Table 2). The pedagogy easily integrated with Gandhian values could role-play, storytelling approach, field study, watching documentaries and report writing, etc. In addition, Gandhiji emphasised the working of the head, heart, and hand for holistic learning and Education. Therefore, teachers need to integrate all the three elements (cognitive, affective and conative) into their teaching-learning processes.

Table 1
Matrix representing Gandhian values mapped to curricular topics

Skill and manual labour (hands-on activities and Experiments)	**Peace (collaborative work in doing science experiments and projects)**	**Harmony (group activities and Discussion)**	**Moral development (case studies and storytelling)**
Truth (reporting the results of experiments)	Animal care (Species diversity and animal classification)	Environment Ethics (air pollution, water pollution, use of plastics, e-waste, industrialisation)	Character development (helping others learn science concepts, scientific temper)
Non-violence (tolerance for others' views and opinions, animals' rights, human rights)	Sustainability (conservation of resources)	Simplicity (polluting less, reducing carbon footprints)	Lifestyle (healthy diet, regular exercise, reliance on organic products)
Charkha (hands-on science activities and experiments)	Employment (green economy and green jobs)	Self-sufficiency (training in skills such as coding, experimentation, artificial intelligence, etc.)	Equity (contribution of rich and poor in the share of Carbon footprints and Carbon emissions)

Self-restraint (adopting a balanced and healthy lifestyle)	Equality (science education for all students irrespective of their caste, class, gender and socioeconomic status)	Freedom (conduct innovative science experiments and projects, report and share the findings)	Conservation of resources (judicious utilization of natural resources)
Sarvodaya or Social Welfare (science and scientific practices for community welfare)	*Swaraj* or decentralised power (democratic practice in science to arrive at logical solutions to given problems)	3Rs- Reduce, Reuse and Recycle (waste management, conservation of resources)	*Swadeshi* or local goods (developing technology locally in the country and promoting skill development in the country)

BOX 1: Classroom Discourse on Conservation of Resources

Teacher: Which is your favourite dish?

Student 1: I like dal

Student 2: I like rice with sambar

Student 3: I like cauliflower vegetable

Student 4: I like scrambled egg

Teacher: Do you know from where these food items come?

Student 4: From a poultry farm

Student 5: From daily store

Student 6: From the fields

Student 7: From grocery shops

Teacher: Yes, you are right; our food grains come from the fields while eggs come from the poultry farm. But, do you know who grows the food grains for us and takes care of the poultry?

Student 1: The farmers grow the food grains for us

Student 3: The animal breeders take care of the poultry farm in producing eggs

Teacher: Do you know some people cannot get enough food? What could be the reasons for it?

Student 4: Food items might be costlier for them to purchase

Student 6: They might not be having jobs to earn money and buy food

Student 8: They are not able to avail of the Govternment's subsidized ration scheme

Student 10: There might be too many members in a family to feed and not enough resources

Teacher: Yes, you all are right; there could be different reasons for people not being able to feed themselves and their families adequately, but one of the primary reasons is 'Poverty.' This could lead to malnutrition and many deficiency diseases.

However, is there any way through which we can help in reducing the shortage of food and solve the problem of hunger?

Student 2: By reducing wastage of food

Student 4: By buying food only as much as we want and not hoarding food items

Student 5: By donating excess food to people who cannot afford

Teacher: You are right! We should conserve the resources and utilise them judiciously to make them available and accessible to everyone. This is also known as the concept of Sustainability.

While teaching about food and its sources, a teacher can refer to the NCERT Science textbook of Class VI (p. 2, Activity 3 and Table 1.3) and can initiate a discussion around the quality of food items, problem of food scarcity, and hunger in the country, working of the PDS (Public Distribution System), issue of access to quality food by the poor, and malnutrition. A discussion could be initiated in this regard (refer to Box 1).

Another example from the same textbook is the chapter 'Fibre to Fabric' and the importance of hand-woven fabrics and *Charkha*. Here, the teacher can discuss the process of making fabric from fibre and how *Charkha* became a national movement in India, leading the country toward self-sufficiency in terms of cloth making. The following excerpt from the Class VI NCERT textbook (refer to NCERT Science textbook for Class VI, p. 21) can be taken as a starting point for initiating the Discussion.

"Use of *Charkha* was popularised by Mahatma Gandhi as part of the Independence movement. He encouraged people to wear clothes made of homespun yarn termed as *Khadi* and shun imported cloth made in the mills of Britain. To popularise and promote *Khadi*, the Government of India constituted a body called *Khadi* and Village Industries Commission in 1956." (NCERT Science Textbook for Class VI, 2006)

Here, teacher can actually begin with the activity of making a model of *Charkha* in the classroom and ask the students to do the same. This will help understand the working of *Charkha* and the coordination of their head, heart & hand (3 'H'). The storytelling method can also be integrated by narrating the story of *Charkha* (refer to Box 2) while teaching about the process of making fabric from fibre.

Box 2: The Story of *Charkha*

Charkha or the spinning wheel is one of the essential landmarks in India's freedom struggle initiated by Mahatma Gandhi.

During the rule of the East India Company, the British used to ship raw material (cotton) from India to England and then used to sell the finished products (fabric) in India at exorbitant prices that led to enormous losses for Indian farmers and commoners. At this time, Mahatma Gandhi introduced the 'Swadeshi' movement by taking up *Charkha* and asking Indians to weave their cloth. This cloth woven from the spinning wheel came to be known as *Khadi* or *Khaddar*. This marked the beginning of the Indian Spinning Industry.

Source: https://commons.wikimedia.org/wiki/File:Charkha_kept_at_Gandhi_Ashram.jpg

In Mahatma Gandhi's view, *Charkha* constitutes a movement that will revive the cottage industry in India, which will alleviate poverty. The message of the spinning wheel is to replace the spirit of exploitation with the spirit of service. Weaving *Khadi,* according to Gandhiji, is an honourable occupation to earn bread and has a far greater value as an instrument of winning *Swaraj* through non-violent means.

There are many other chapters in the textbook where Gandhian values of Sustainability could be integrated (refer to Table 2). However, it is essential to note here that there could be varied pedagogical approaches to integrate the Gandhian values seamlessly within the curriculum. A teacher needs to be cognisant of the relevant examples, activities, and contexts for developing an integrated lesson plan with Gandhian values. Educators could be engaged with sustainability education much more by incorporating examples from local culture, natural resource issues, and economic possibilities for connecting their students more deeply with their community and place (Smith, 2010). Sustainability education needs to be dealt with holistically while adopting an interdisciplinary approach that includes concepts, evidence, controversy, values, and devising solutions to complex problems (Hill, 2005; Summers et al., 2005). Students can also be encouraged to take up short-term projects to deal with an issue related to sustainability.

They can also document certain traditional practices and folklores that inherently promote sustainable development. Sustainability education should pervade all aspects of school education, be it curriculum, pedagogy, physical surroundings, and infrastructure, as well as partnerships with the local community. The approach to be adopted for integrating sustainability education includes intra-subject delivery, cross-curricular delivery, and the organization of special events (Buchanan, 2012).

Table 2
Content Analysis of NCERT Science Textbook of Class VI for the integration of Gandhian Values

Chapter No. and Title	Topic/Task/ Figure/ Exercise (page no.)	Content/ Theme	Gandhian Values integrated	Suggestions for value addition (based on Gandhian idea of Sustainability
1. Food— where does it come from	Food materials and sources (p. 2) Table 1.3 Things to think about (p. 7)	Sources of different food materials, both plants and animals Does everyone around you get enough food to eat? If not, why?	Harmony & tolerance Equity and equality	The Gandhian value of giving importance to 'vegetarianism' and including more cereals and pulses in our diet can be integrated here. Likewise, the ethic of conservation of plants and animals can also be integrated here as the need to take care of animals in breeding houses. The question integrates the value of the equitable distribution of resources (food items) for sustainable living and eradicating hunger.
3. Fibre to Fabric	3.4 (spinning cotton yarn) p 21 Project (p. 24)	Spinning of fibres into yarn Visit a nearby handloom or powerloom unit and observe the weaving or knitting of fabric.	*Charkha* and the value of self-sufficiency	The section talks about the Gandhian *Charkha* movement in India. He also emphasised the value of wearing homespun cloth *Khadi* and shunned the use and buying of foreign fabric. A field visit to a nearby *Khadi* Industry can be organised where the students get an idea about the process of spinning and the fabric of *Khadi*.

5. Separation of substances	5.1 (Methods of separation)	Handpicking, threshing, winnowing, sieving, sedimentation	These manual methods generate employment for village people and help them attain self-sufficiency	The Dandi March (salt satyagraha) can be included under the evaporation/sedimentation of salt as a movement to make India self-sufficient and independent.
7. Getting to know plants	Fig. 7.13 (p. 57)	Watering and tending of plants	Taking care of plants	Students can be encouraged to plant more trees to preserve the environment and generate awareness about cutting down trees.
14. Water	Table 14.1 (p. 136) Boojho: Regions having a low supply of water (p. 137) Paheli: two glasses of water are required to make one page of a book (p. 137)	Estimation of the amount of water used by a family in a day Unequal distribution and availability of water	Conservation of water Equitable distribution of resources Conservation of resources	The activity helps give an idea about the total water consumed and wasted in a day. It can help develop sensitivity among the learners towards the conservation of resources such as water. A discussion can be initiated on these points in the class to emphasise upon judicious utilisation of resources.
16. Garbage in, garbage out	A step towards cleanliness (p. 155) Fig. 16.2 16.2 Vermicom posting (p. 158)	Government of India *Swachh Bharat* mission Managing garbage	Cleanliness and hygiene Value of manual labour and clean environment	The chapter emphasises the Gandhian ideal of cleanliness and how to make our surroundings clean.

Discussion

The importance of sustainability in education and curriculum has been greatly emphasised Worldover (Jones, Selby, and Sterling, 2010; Ryan, Tilbury, Corcoran, Abe, and Nomura, 2010; Velazquez, Munguia, and Sanchez, 2005). The present study provides a perspective on Gandhian values of Sustainability and sustainable development. Gandhiji always emphasised a closer integration of schools and community to develop the sociological aspect of a child's nature and encourage a cooperative mindset (Bala, 2005). Thus, teaching science integrated with Gandhian values for sustainable living will help mobilise the communities toward the idea of 'sustainability' and sustainable living. The Gandhian idea of sustainable development aims at reviving the traditional and indigenous knowledge systems such as cloth-making using *Charkha*, making 'salt' by using traditional methods of separation, which help generate employment opportunities for the rural poor. This helps in reducing the gap between the rich and the poor. There could be many such case examples and anecdotes from the Gandhian era that could be added to the textbook or curriculum to emphasise the idea of 'sustainability.' Gandhiji always stressed skill-based and experiential learning rather than rote memorisation of concepts (Sykes, 1988). Therefore, science teaching and learning in schools need to reorient itself toward skill-based learning and preparation for the nation's future workforce. This has been highlighted by National Education Policy (NEP)-2020* and is one of the sustainable development goals (SDGs) for a self-reliant India.

The Gandhian idea of sustainable development and value framework can be integrated into many topics of science and technology for developing an interdisciplinary perspective among learners as well as inculcating values through science. For instance, while teaching the topic, 'Garbage in, Garbage out', the values of cleanliness and hygiene can be integrated through various activities.

Gandhian ideals, such as, democracy, equality, honesty, cooperation, and care for living beings constitute the core values for human beings and for building responsible citizenship. These ideals, when integrated with the curriculum through various activities and collaborative projects, help in nurturing such values among students. The Gandhian ideology of promoting the local handicrafts and cottage industries helps generate rural employment and sustainable living without polluting the environment. The skill of making cloth on a *Charkha* is a natural way of cloth weaving and fabric production and is sustainable too. Similarly, the value of conservation of natural resources such as water, coal, petroleum, etc., also helps build a sustainable future. Integrating the Gandhian idea of sustainability and sustainable development provides an interdisciplinary perspective to science teaching and learning. Science need not be taught as an objective and value-free subject; rather, values can form an integral part of science teaching and learning. Assessing the impact of new technology on society and the environment provides an interdisciplinary perspective to science teaching and learning; for instance, Genetically Modified crops and

*The original reference was Draft NEP-2019 but by the time of publication of this issue, NEP-2020 was published and hence modified accordingly.

their production in India have been a reason for great debate and furore owing to their unforeseen impact on the soil, environment and human body, and also being a reason for farmer distress in India.

The present study highlighted the significance of Gandhian values in the science curriculum through science textbooks. A critical content analysis of the Class VI NCERT Science textbook revealed the integration of Gandhian values of Sustainability infused seamlessly in different chapters and topics. However, there is scope for further emphasis on these values and ideals in the science curriculum. The role of the teacher is also predominant in modeling such values for sustainability as well as in designing activities based on 'sustainability' and 'sustainable development'. Some suggestions for additional activities within the science curriculum are provided in the paper (refer to Table 2).

Implications for Science Education

The analysis of the Class VI NCERT Science textbook reveals that the Gandhian idea of Sustainability has been integrated into a few chapters but can be emphasised more through additional activities and classroom discourses. A similar exercise can be carried out in other textbooks as well. This analysis has suggested that Gandhian ideas can be integrated into the science curriculum to provide a value-based framework and fulfil the sustainable development goals (SDGs) for Education. Gandhian Education is on the lines of sustainability education, which is also one of the essential recommendations of the National Education Policy (NEP)-2020*. The integration of Gandhian ideals within the science curriculum will not only inculcate the idea of sustainability among the young generation, but will also help in developing a value-framework for science teaching and learning. This would help in character development and nation building as emphasised by various national education policy documents such as National Education Commission (1964–66), National Education Policy (1986), etc. The students will be able to appreciate their own culture, its practices, and some sustainable traditional practices. Students and their teachers will also engage with the larger community outside their schools, which can benefit through certain co-designed activities and projects. The community-based approach as well as integration of head, heart, and hand envisaged by Gandhiji's Basic Education Scheme (1937) is completely aligned with the activity-based approach and problem-solving approach practised in science teaching learning till date. The teachers need to adopt more collaborative pedagogical approaches in their teaching plan so as to instill among their students a spirit of cooperation, tolerance, and peace for building a sustainable society.

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CAN GRAPHIC ORGANISERS ENHANCE SCIENCE ACHIEVEMENT IN SCHOOL STUDENTS?

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Graphic organisers are teaching and learning tools that show the organisation of concepts as well as relationships between them in visual formats. The objective of the study was to find out the effectiveness of graphic organisers on science achievement. In this study, three groups pre-post test experimental design was adopted. Ten mini-lessons on the graphic organiser were conducted for the experimental group for 12 days. Science achievement test with four multiple-choice options was used. A total of 75 students was selected and divided into three groups of 25 each, viz., control, module, and experimental based on the group mean of the pretest. The t value calculated between the pre-test and post-test mean of the module group was found to be significant (5.97) and the effect size was found to be very large (1.716). The t value calculated between the pre-test and post-test mean of the experimental group was found to be significant (21.64) and the effect size was found to be huge (4.866). Today, most of the concepts are overlapping and need multiple perspectives to understand but through graphic organisers, students can prepare visual representations that can be used for remembering, clarifying, and easily relating to multiple aspects of the concepts.

Keywords: Learning strategy, visual representations, biology learning, Cohen's d effect size, experimental design

Introduction

In today's educational scenario, getting a job or cracking entrance exams is not as easy because the competition has become too high. The students have to learn a vast number of concepts. The teachers in that situation must orient students towards learning strategies to learn fast, accurately, and remember for a more extended period. One such way is through the usage of graphic organisers in learning. According to Ausubel's theory, meaningful learning occurs when an individual's existing knowledge interacts with new information in a non-arbitrary way. Ausubel (1960) found that meaningful learning of verbal material could be enhanced by using an advance organiser. An advance organiser is a tool that is presented prior to the material to be learned and that helps learners organise and interpret new incoming information. Advance organisers in cognitive instruction promote the learning and retention of new information. It is vital to link old information with something new. They help students recognise that the topic they are beginning to learn is not totally new and provide teaching explanations that include concepts. This study aims to develop a self-learning environment and retention of concepts using graphic organisers. In this study, the learners must be aware of graphic organisers. The learners should know the uses of graphic organisers; in turn, they should choose the correct graphic organisers for the concepts, prepare graphic organisers for the given concept in science, learn science concepts through prepared graphic organisers and score well on the achievement tests.

Graphic organisers will help in learning as well as retention of science concepts. A graphic organiser is a strategy for science instruction that teachers can use to help students record information from direct observation as well as from reading to create a descriptive model of an organism or a phenomenon. Advance organisers have also been presented graphically. They are also called graphic advance organisers in some research. Graphic organisers are teaching and learning tools that show the organisation of concepts as well as relationships between them in a visual format. While advance organisers are being used at the beginning of the lesson, graphic organisers can be used in any process of the lesson with different aims. They can be used as a teaching tool throughout a lesson or for review at a later time. Being visual is so crucial in graphic organisers, but advance organisers can be visual or solely prose. Graphic organisers can help students organise their knowledge and encourage them to become actively engaged during the discussion of the topic and its concepts. Moreover, students will find it helpful in many competitive exams for jobs, entrance exams for higher education, etc. Therefore, using the graphic organiser can assist in making the topics more understandable for the students and retain concepts for a more extended period.

The prevalent theory behind the use of graphic organisers comes from the cognitive psychology literature. Based upon research by Ausubel (1963, 1968) and Ausubel et al. (1978), cognitive psychology is the learning that takes place by the assimilation of new concepts and propositions into existing concepts and propositional frameworks. Ausubel's theory of meaningful versus rote learning suggested that meaningful learning intentionally attempts to integrate new information, uses a more extensive network, and creates more means of recovery. Graphic organisers were first reported by David Ausubel in 1969 in his glossary; he states that graphic organisers are like a bridge that links the gap between the learner's prior knowledge and what they have to learn (Culbert et al., 1998).

Graphic organisers are an attribute of organising thoughts. The users may use graphic organisers to visually depict an idea through sequences or charts. Graphic organisers are the visual representation of knowledge that structures information by arranging important aspects of a concept or topic into a pattern using labels. Their primary function is to help present information in concise ways that highlight the organisation and relationships of concepts. Simply stated, a graphic organiser is a "visual representation of knowledge" regarding a certain concept (Bromley, DeVitis, and Modlo, 1999). More specifically, graphic organisers are arranged in a way that best shows the interrelatedness of pieces of information presented (Horton, Lovitt, and Bergerud, 1990). Graphic organisers are also known as key visuals, cognitive organisers, or advance organisers that are formatted for organising information and ideas graphically or visually. Just as cooperative learning groups make student thinking audible, graphic organisers make student thinking visible. Students can use graphic organisers to generate ideas, record and reorganise information, and see relationships. They demonstrate not only what students are thinking but also how they think as they work through learning tasks. Examples of graphic organisers include tree charts, fishbone charts, flow charts, T-charts, Venn diagrams, K–W–L charts, idea builders, and mind maps.

Graphic organisers are visual depictions that resemble networks and allow students to add or modify their background knowledge by seeing the connections and contradictions between existing knowledge and new information. Graphic organisers serve as mental tools (Vygotsky, 1962) to help the students understand and retain important information and relationships. Graphic organisers provide an optional way of depicting knowledge and understanding (Sorenson, 1991), so it is particularly beneficial for students who have difficulty with expressing relationships among parts of science concepts in the written word. Students who use graphic organisers in the classroom develop their ability to use them independently as study tools for note-taking, planning, presentation, and review (Dunston, 1992).

Tandog and Bucayong (2019) reported that the integration of effective study techniques could still be a relevant education research topic if we are to consider the changing demand for skills brought about by technological advancements. Thus, graphic organiser as a teaching tool was developed and implemented to promote conceptual understanding in the solution processes of algorithmic related topics in Physical Science. Iofciu, Miron and Antohe (2011), in a study entitled "Graphic Organiser for the constructivist approach of advanced science concepts." The study revealed that retaining of information in extraordinary development of technical applications is a real challenge for science teachers and they wish to use graphic organisers to their interested students for grasping advanced science concepts. Fisher, Frey and Williams (2002) have observed positive reactions among students to the use of graphic organisers.

Banikowski and Mehring (1999) highlighted that Teachers must introduce the use of a new graphic organiser to ensure its effectiveness in the classroom. Consistency across subject areas is another important element that ensures successful independent student practice of organising techniques in the classroom. The review of related literature demonstrates that graphical visualisation provides a framework to systematise ideas, facts, and concepts that promotes the development of higher-order thinking skills and facilitate effective student learning.

Objective of the study

To find out the effectiveness of graphic organisers on science achievement.

Hypotheses of the study

The following hypotheses were formulated in this research

1. There is no significant mean difference in pre-test scores of the control group, module group, and experimental group in science achievement.
2. There is a significant mean difference in post-test scores of the control group, module group, and experimental group in science achievement.

There is a significant mean difference between the pre-test and post-test scores of the control group, module group, and experimental groups in science achievement.

Experimental Research Design

To study the effectiveness of applying graphic organisers to the achievement of science, an experimental method was employed. Three groups, namely control, module and experimental groups were taken, and a pre-test was administered, followed by providing a module to the module group and treatment with a module to the experimental group, and a post-test was given to find out the effect of the module and treatment. In this study, the investigator adopted three groups — pre-test-post-test experimental design. The investigator had the study for a period of one week for the preparatory programme and 12 days for the intervention programme from January to March. As the researcher felt the urgent need for the improvement of science learning among elementary school students, the investigator prepared the module on graphic organisers that will enhance science learning among students.

Sample

Based on the group mean of the pre-test, three groups were formed, namely, the control, module, and experimental groups involving 25 students each. The study sample was the two sections of Class VIII students of Government High School, Thippirajapuram of Kumbakonam block in Thanjavur District of Tamil Nadu. The sample of the study is shown in Table 1.

Table 1
Sample groups classified based on the pre-test

S. No.	Sample groups	N	Graphic Organiser Module Provided	Intervention Given
1.	Control group	25	No	No
2.	Module group	25	Yes	No
3.	Experimental group	25	Yes	Yes

Delimitations of the study

1. The study was restricted to both sections of Class VIII students of Government high school of Tamil Nadu Thippirajapuram from the Kumbakonam block of Thanjavur District.
2. Graphic organisers are limited to 10 in number.
3. The study only concerned 75 students in Class VIII students, which were classified into three groups.
4. The focus is to apply graphic organisers shown in the given module and not create a new one.
5. Only concepts given in the Class VIII term three Tamil Nadu Government science textbooks are selected for the study.
6. The intervention programme was carried out for 12 working days.

Development and validation of science achievement test

To find out the effect of the treatment, the investigator has framed a pre-test tool and a post-test tool in Tamil. Before administering the pre-test tool, it was given to the subject experts to identify the content validity, and the reliability was also established from Cronbach's alpha. A pilot study has been conducted among 33 students of other schools Government Higher Secondary School-Aduthurai, Thiruvidaimarudur, Thanjavur district and Govt. Hr. Sec School Chettimandapam, Kumbakonam, Thanjavur district, where the intervention was not planned. Based on the students' performance in the pilot study, item analysis was done, and the pre-test tool was developed. Initially, there were 60 items, but finally, 42 test items were selected for the study based on item analysis. Finally, Cronbach's alpha was found to be 0.73, and thus the achievement test was considered reliable.

Intervention

The graphic organiser module developed by the investigator was administered in the treatment programme. The prepared module was given to the module and experimental groups except for the control group. One biology lesson was discussed and made to complete the graphic organisers for the experimental group only. The mini-lessons using graphic organisers were: Scanning, Science Vocabulary, Compare and Contrast, TimeLine, 5W1H, Science Activity, Flow Chart, Tree Chart, Concept Map, and Fish-Bone as shown in Appendix 1 were implemented for the experimental group and insisted on completing all the ten graphic organisers for one lesson (No. 7), Crop Production and Management (Biology) as shown in appendix 2. One lesson each for Physics (Unit 1 Sound) and Chemistry (Unit 6 Chemistry in Everyday Life) was chosen and given a one-week duration to prepare the graphic organisers introduced by the investigator. The same three lessons were intimated to all three groups as the portion for the post-test.

Results

After the planned intervention towards using graphic organisers in the science concepts, the post-test was conducted. The results were analysed using SPSS version 21 and were tabulated and interpreted below:

Table 2

Mean, Standard Deviation (SD), and t value of the pre-test scores in science achievement based on groups

Groups	Mean	SD	t value	df	t sig.
Control Group Pre-test	11.88	2.60	0.14	24	0.89
Module Group Pre-test	11.76	2.68			
Module Group Pre-test	11.76	2.68	0.10	24	0.92
Experimental Group Pre-test	11.68	3.12			
Control Group Pre-test	11.88	2.60	0.26	24	0.79
Experimental Group Pre-test	11.68	3.12			

Table 2 shows that there is no significant mean difference between pre-tests of the control and module group, module and experimental group, and control and experimental group.

From Table 3, it can be inferred that the module group (15.84) scored higher than the control group (12.24) in the post-test, as the t value was determined to be 5.49, which was significant at a 0.01 level. The experimental group (26.69) scored higher than the module group (15.84) in the post-test, where the t value was estimated as 18.17, which was significant at a 0.01 level. The experimental group (26.69) scored higher than the control group (12.24) in the post-test, where the t value was estimated as 17.01, which was significant at a 0.01 level.

A perusal of Table 4 shows that the t-value calculated between the mean scores of the pre-test and post-test of the control group is found to be 0.54, which is not significant even at a 0.05 level; thus, there is no need to calculate the effect size. The t value calculated between the mean scores of the pre-test and post-test of the module group is found to be 5.97, which is significant at a 0.01 level. The post-test mean (15.84) is higher

Table 3
Mean, Standard Deviation (S.D.), and t value of the post-test scores in science achievement based on groups

Groups	Mean	S.D.	t value	df	t sig.
Control Group Post-test	12.24	2.54	5.49	24	0.00
Module Group Post-test	15.84	2.03			
Module Group Post-test	15.84	2.03	18.17	24	0.00
Experimental Post-test	26.96	3.16			
Control Group Post-test	12.24	2.54	17.01	24	0.00
Experimental Group Post-test	26.96	3.16			

Table 4
Mean, S.D., t value, and correlation of the pre-test and post-test scores in science achievement based on groups

Groups	Test	Mean	S.D.	t value	df	t sig.	Cohen's d
Control Group (25)	Pre-test	11.88	2.60	0.54	24	0.60	–
	Post-test	12.24	2.54				
Module Group (25)	Pre-test	11.76	2.68	5.97	24	0.00	1.716
	Post-test	15.84	2.03				
Experimental Group (25)	Pre-test	11.68	3.12	21.64	24	0.00	4.866
	Post-test	26.96	3.16				

than the pre-test (11.76). The magnitude of the difference between the pre-test and post-test mean is estimated by Cohen's d (1.716), which is found to be very large (Sawilowsky, 2009). The t-value calculated between the mean scores of the experimental group's pre-test and post-test is 21.64, which is significant at a 0.01 level. The post-test mean (26.96) is higher than the pre-test (11.68). The magnitude of the difference between the pre-test and post-test mean is estimated through Cohen's d (4.866), which is found to be huge (Sawilowsky, 2009). Therefore, it can be inferred that the intervention of graphic organisers had a significant effect on students' achievement in science. The line graph of mean scores of pre-test and post-test in the control, module, and experimental group are shown in Fig. 1.

Educational implications

The graphic organiser is a self-learning strategy whereby students can learn independently with little guidance from the teacher. Through this, students will grasp the concepts and understand them deeply. Today, most of the concepts are overlapping and need multiple perspectives to understand. However, through the graphic organiser, students can prepare visual representations that can be used for remembering, clarifying, and easily relating to multiple aspects of the concepts they learn. The teachers just need to monitor the preparation of the visual forms by students; they have to simply monitor and guide the students wherever needed. However, once the students learn and apply graphic organisers in their academics, they can be helpful throughout their life. Many

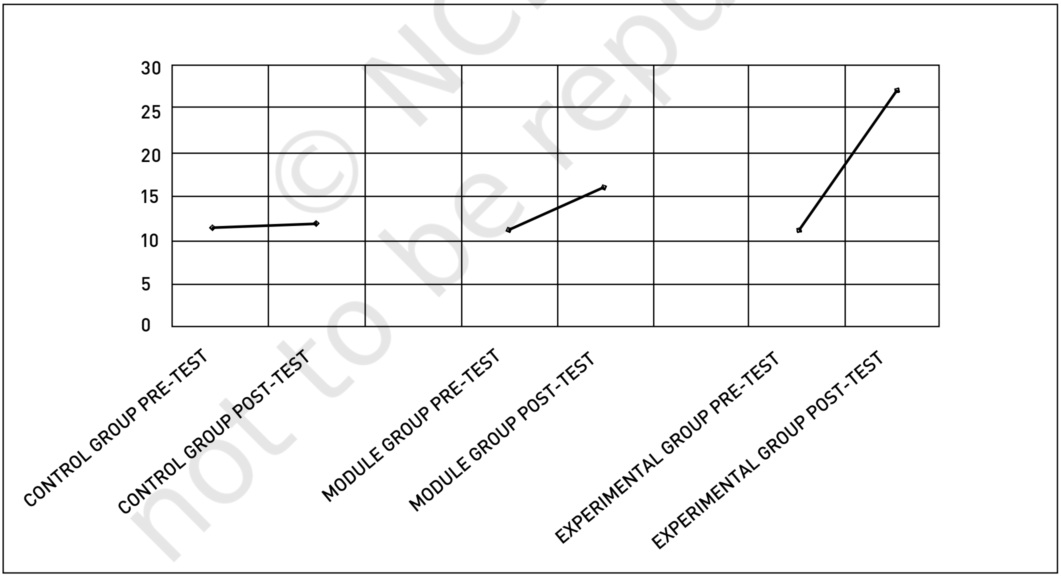

Fig. 1. Line graph showing mean scores of pre-test and post-test in the control, module, and experimental group

formats of graphic organisers are available on the internet; the teachers can adapt them according to their needs and modify them according to their concepts and students' learning levels. This graphic organiser makes students learn concepts and remember them for a more extended period. Graphic organisers can be kept for a long time for any future exams and even it will be helpful for competitive exams. Even though we have efficient modules/ books/ booklets, still academicians/ teachers must use graphic organisers efficiently for better student performance in academics.

Conclusion

This research takes the positive path in accordance with the review of related literature discussed. Graphic organisers are very effective self-learning strategies that could be used with little guidance from the teacher; the students can learn more profound concepts and remember them for a more extended period. Academicians should prepare and validate a standard module through SCERT or NCERT so that teachers can use that module in their teaching-learning process. Central and State governments should take steps to give orientation on graphic organisers to teachers. Teachers should implement these strategies in their teaching-learning process. Graphic organisers can be prepared for other subjects in other classes, and this would be helpful for competitive examinations while they are in the school itself. Teachers must implement these graphic organisers in their teaching-learning and feel the difference. This could even lessen their burden of teaching and make students remember and retain many complex or overlapping concepts for a more extended period.

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Appendix 1: Graphic Organisers as per module prepared by the investigator

1. Scanning the Chapter

Chapter: ______________________

I. Heading and Sub-heading

1	Heading
1.1	Sub-heading
1.2	Sub-heading
1.2.1	Sub (Sub-heading)

II. Science Activity

S. No.	Page No.	Activity heading	Do you know?	Whether you can do

III. Tables

S. No.	Description of the table

IV. Figures

Fig. No	Description of the figure	Do you know

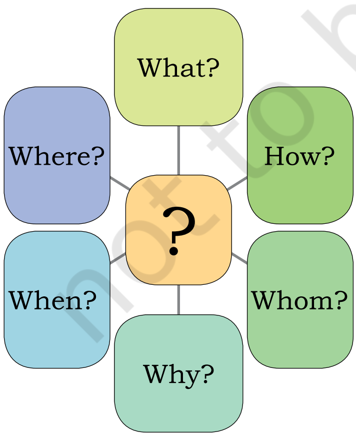
V. "Do you known?" Total numbers given in that chapter:_______

VI. "More to Know" Total numbers given in that chapter: _______

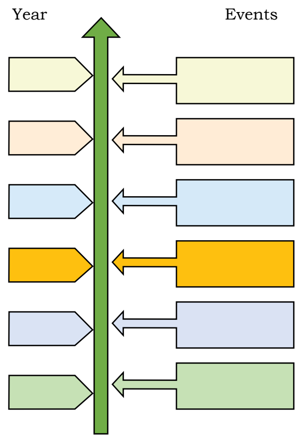
2. Science Vocabulary

S. No.	Page No.	Word	Can I define it?	What is it related to?	Definition	Whether given in book back glossary?

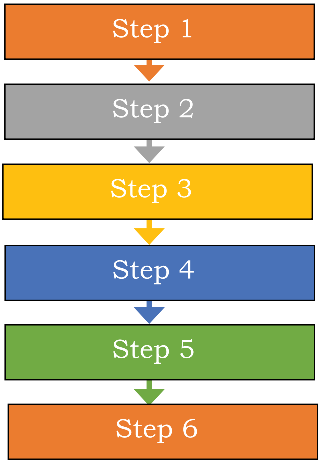
3. 5W1H



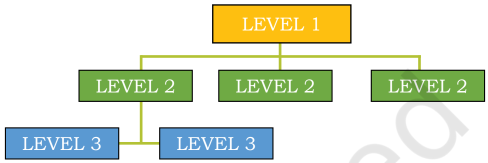
4. Time Line Chart



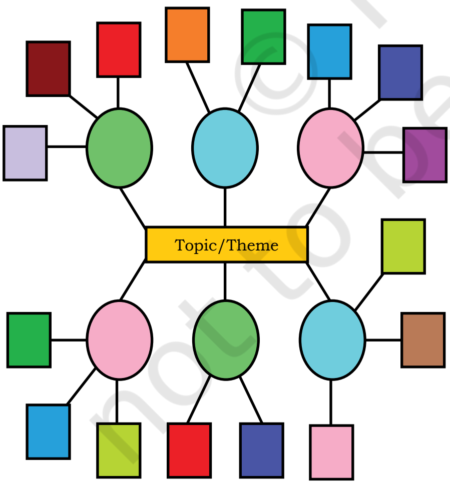
5. Flow Chart (Process)



6. Tree Chart



7. Concept Map



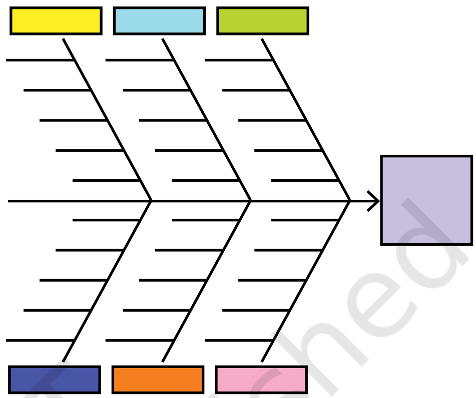
8. Science Activity

Activity title:	
Process: 1 2 3 4 5 6	**Materials Required:** 1 2 3 4 5
Questions: 1 2 3 4 5	**Answers:** 1 2 3 4 5
Inference/ Conclusion/ Summary of the activity:	

9. Compare and Contrast

S. No.	Subject 1	Subject 2
1		
2		
3		

10. Fish Bone



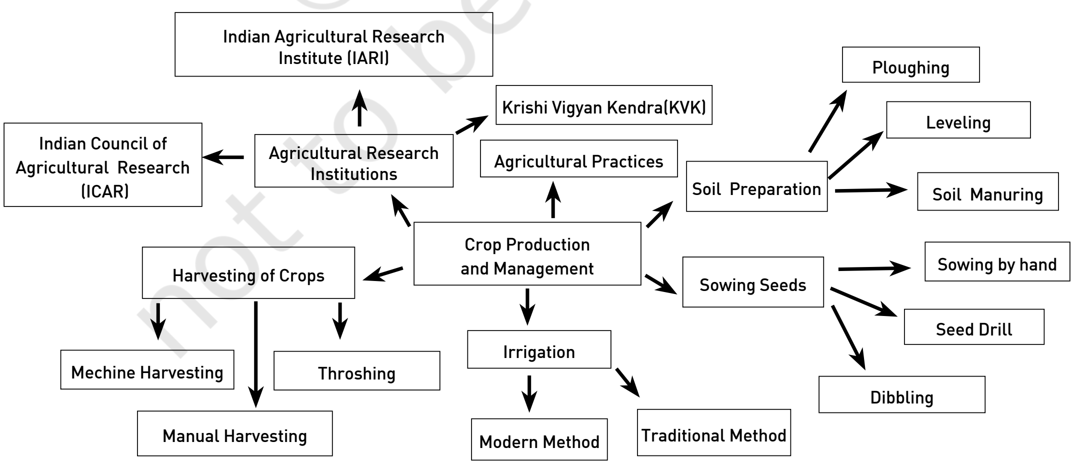
1. Scanning 2. Science Vocabulary 3. 5W1H 4. Time Line 5. Flow Chart 6. Tree Chart 7. Concept Map 8. Science Activity 9. Compare and Contrast, and 10. Fish-Bone

Appendix 2: Sample Graphic Organisers prepared by experimental group students as per module, and the instruction is given by the investigator

Vocabulary

S. No.	Page. No.	Words	You Know	Related	Meaning	Book back
1.	90	Basal Manuring	✓	Irrigation	Manuring means adding manure to the Soil	×
2.	90	Ploughing	✓	Soil enrichment	The process of loosing and turning at the Soil	✓
3.	93	Sprinkler Irrigation	✓	Proper Irrigation System to Plants	Method of applying irrigation water which is similar to natural rainfall	✓
4.	97	Mono-Culture	✓	Single pattern Crop Plantation	Planting of the same crop in the same field year after year	✓
5.	91	Dibbling	✓	Sowing in the Seed	Placement as seed material in a sarrow, pit or hole at predeter spacing mined	✓

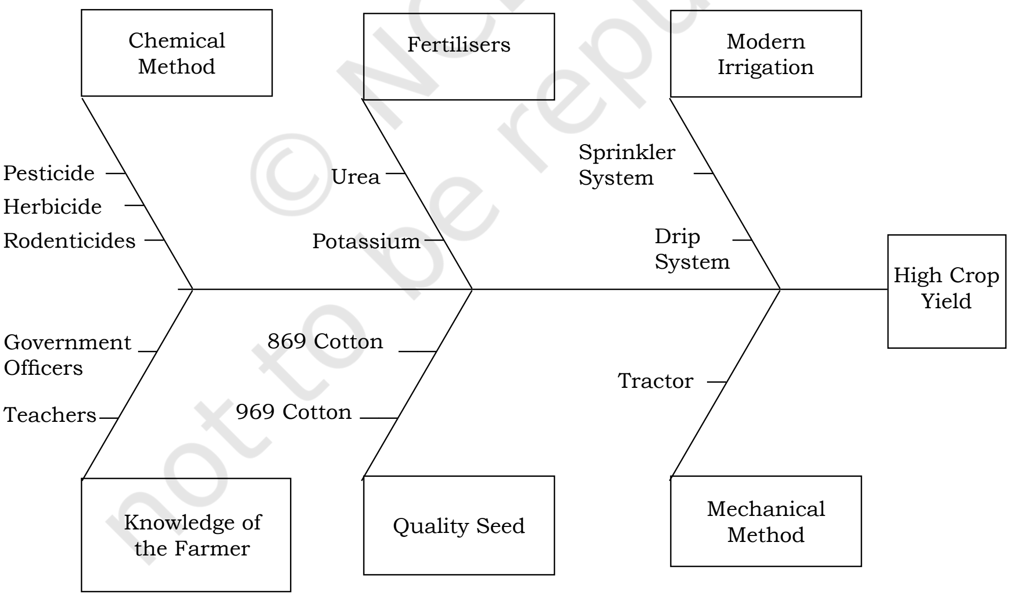
Concept Map



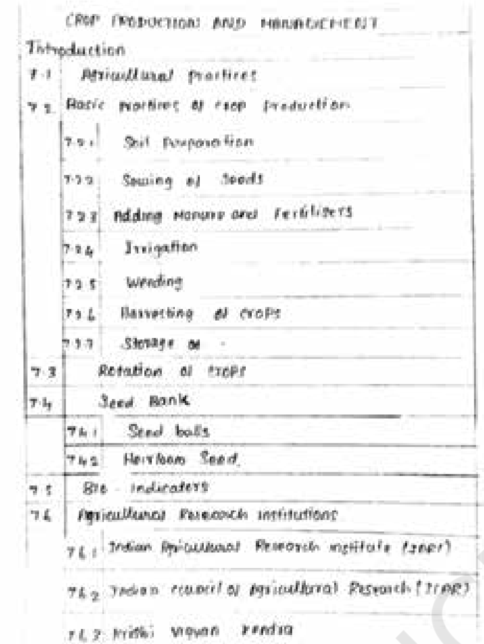
Compare and Contrast

***Kharid* Crops**	***Rabi* Crops**	***Zaid* Crops**
The crops which are sown in the rainy season are called *kharid* crops	The crops grown in winter season are called *rabi* crops	The crops which are grown in summer season are called zaid crops
Paddy, Maize, Soyabeen, groundnut and cotton.	Wheat, gram, ea, mustard, linseed	Watermelon cucumber.

Fish Bone



Scanning


CROP PRODUCTION AND MANAGEMENT
Introduction
7.1 Agricultural practices
7.2 Basic practices of crop production
7.2.1 Soil preparation
7.2.2 Sowing of seeds
7.2.3 Adding manure and fertilisers
7.2.4 Irrigation
7.2.5 Weeding
7.2.6 Harvesting of crops
7.2.7 Storage of
7.3 Rotation of crops
7.4 Seed Bank
7.4.1 Seed balls
7.4.2 Heirloom Seed
7.5 Bio - indicators
7.6 Agricultural Research institutions
7.6.1 Indian Agricultural Research institute (IARI)
7.6.2 Indian council of Agricultural Research (ICAR)
7.6.3 Krishi Vigyan Kendra

Science Activity

Activity	Required Things
Set up a compost pit within your school compound. Put all the organic wastes like food waste and plant leaf in your school campus, cover it with soil. Wait for three weeks and then you can use this as manure for the plants in your school.	1. Collected food waste 2. plant leaf 3. Crowbar

Questions	Answers
i) What constitutes organic from wastes?	Collecting food waste plants leaf.
ii) organic from wastes should be cover with?	It should be covered with soil.
iii) After how many months later does organic farm waste should be used.	Three months
iv) How does organic farm waste can be used for plants.	As fertilizer.
v) where does the organic farm waste be used for plants.	Agriculture land open spaces, and schools.

Tree Chart

- Basics of usage
  - Food crops
  - Fodder crops
  - Fibre crops
  - Oil crops
  - Ornamental crops

A STUDY OF SCHOOL STUDENTS' KNOWLEDGE ABOUT CLIMATE CHANGE SCIENCE IN INDIA

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This paper can be considered a preliminary study to have an idea about the implementation of climate change education in India. An attempt was made to assess school students' knowledge about climate change science based on ten closed statements, some of which were part of the curriculum in some way, while the rest of the statements were related to important climate change science concepts. A comparison was also made to determine if students who have manifested interest in science have more knowledge about climate change science than the rest. The findings of the study are expected to be useful for curriculum developers and other stakeholders of school education in India to prepare a robust curriculum on climate change.

Keywords: Climate change education, climate change science, students' knowledge, curriculum

Introduction

Climate change is one of the major crises the world is facing in the 21st century (Cohen and Waddell, 2009). The challenges it poses are daunting and will continue to be a threat in the coming years and decades. It is, therefore, pertinent for the world community to come together to take the right measures and initiatives to limit, if not undo, the damage that we have brought on ourselves. This is going to be a long-drawn battle that probably will not be settled in this generation, and the struggle will be carried forward for a few more generations. Indeed mitigating climate change will happen in decadal time scales (Corner et al., 2015). In such a scenario, it is imperative that we educate our children and teenagers and sensitise them towards climate change issues as they will be responsible for dealing with the environmental and societal consequences of climate change (Kuthe et al., 2019). Students do learn about climate change from their personal experiences, imbibe from parents, teachers, and peers. Apart from all these, formal education will play a crucial role in addressing a complex and complicated issue like climate change, which stretches beyond a single industry, region, culture, or field of study. It is through education that we can ensure that there is a sustainable future for us. Although in a different context, what the former President of South Africa, Nelson Mandela, said is very relevant to climate change, "Education is the most powerful weapon to change the world" (Ratcliffe, S., 2017). The goal of such an education is that it should aid students in engaging in critical and thoughtful enquiry about the information they receive. It should act as an enabler to communities and individuals in making informed decisions in mitigating the climate change problem and help in responding to its impeding effects (Chang and Pascua, 2017). Nobody could have put it better than UNESCO when it dubbed education as humanity's best hope of achieving sustainable development (UNESCO, 2012).

We are aware that curriculum is an important and integral part of education. The curriculum creates shared goals between teachers and students, standardises the learning for each grade, helps plan the education process or procedure, and provides a clear path for students to progress (Williams, 2019). Therefore, the quality of education imparted will depend on how robust the curriculum is. Further, Morgan and Moran (1995) elucidate that science education makes a significant difference in literacy on climate-related issues. Climate change is a buzzword today, and hence, as mentioned above, students are also informed about climate change from various sources. Keeping in view the urgency to address issues and problems related to climate change, it is necessary to prepare our students accordingly. The first and foremost task in this direction will be to provide appropriate knowledge about climate change science since this will drive students' opinions about this phenomenon and subsequently act as a driver for climate change policy development through the expression of pro-environmental constituents and behaviours (Harker-Schuch and Bugge-Henriksen, 2013; Kuthe et al., 2019). Several studies have shown that climate change education has become part and parcel of the curriculum in schools throughout the world, in some form or other (Kastens and Turrins, 2008; Chang and Pascua, 2017), including India (NCERT, 2006; NCERT, 2007; NCERT, 2008).

Comprehensive studies have been conducted in many countries on the implementation of climate change in schools, as the one for the US by Plutzer et al. (2016). This paper aims to explore how much students in India know about the science related to climate change. The findings of the study will provide some insights which will be valuable to curriculum developers, educators, and other stakeholders in devising better educational programmes for a more meaningful climate change education.

Objectives of the Study

The present study was undertaken with the following objectives:

1. To find out whether school students have the basic knowledge about climate change science
2. To find out whether students with a manifested interest in science have better knowledge about climate change compared to other students

Review of Literature

A review of the literature reveals that many of the studies undertaken have been found to be on what students know about climate change or how aware they are. For example, Kuthe et al. (2019) studied the level of awareness using questionnaires that were administered to 760 teenagers (13–16 years old) from Germany and Austria. Shepardson et al. (2011) investigated students' conceptions of the greenhouse effect, global warming, and climate change by collecting qualitative data from 51 secondary students from three different schools in the midwest, USA. Further, Shepardson et al. (2012) also conducted a study on what secondary students should know and understand about a climate system. Other studies on this aspect were also done by Boon (2010) and Liarakou et al. (2011); what are they taught, such as a study conducted by Kastens and Turrin (2008) which identified different aspects of climate change that was included in the curriculum in 49 states in the US such as the mention of anthropogenic climate change in science education standards, burning of fossil fuels as a contributor of climate change, deforestation in the context of changes to climate or atmospheres, etc.; what they want to learn as in the case of a study undertaken by Tolppanen and Aksela (2018) wherein they conducted a qualitative content analysis to examine 355 open-ended questions which were provided by 16-19-year-olds in a study to find out what students want to learn about climate change. A study in Singapore by Chang and Pascua (2017) discussed what is taught in Economics, Social studies, and Science related to climate change. Specific to India, studies have been done on the views about global warming among secondary (Chhokar et al., 2011) and senior secondary students (Chhokar et al., 2012). Many other studies point out the misconceptions (alternative conceptions) and confusions held by students on various concepts related to climate change, such as the greenhouse effect, global warming, ozone layer depletion, ozone hole, greenhouse gases, etc. (Boyes et al.,1993; Boyes and Stanisstreet, 1993; Harker-Schuch and Bugge-Henriksen, 2013; Rajeev Gowda et al., 1997; Papadimitriou, 2004; Sulistyawati et al., 2018; Bostrom et al., 1994; Read et al., 1994; Morgan and Moran, 1995; Kempton, 1991).

Methodology

Tool used

A simple questionnaire was prepared which had besides general demographic items such as class and State/UT they belong to, ten closed items (statements) related to climate change science which are given below:

1. Global warming is caused due to increase in the size of the ozone hole.
2. The incoming solar radiation has a longer wavelength than the reflected solar radiation.
3. Carbon monoxide released from vehicular exhaust contributes to climate change.
4. Chlorofluorocarbon (CFC) and water vapour are both greenhouse gases.
5. Oceans are important carbon sinks.
6. Changes in temperature over a week are due to climate change.
7. Increase in temperature contributes to sea level rise.
8. Position of Earth with respect to the Sun contributes to climate change.
9. Tsunamis are caused by climate change.
10. Greenhouse gases in the atmosphere absorb solar radiation and cause global warming.

Considering the syllabus and textbooks prepared by the National Council of Educational Research and Training (NCERT) as reference for this study, item Nos. 1, 3, 4, 6, and 10 are part of the curriculum till

Class X in some form in the textbooks, or it is expected that teachers would introduce students to such concepts. Concepts related to item No. 1 are in Science textbooks of Class VII (NCERT, 2007, p. 216), Class VIII (NCERT, 2008, p. 61, p. 73, pp. 242–243), Class IX (NCERT, 2006, pp. 198–200) and Class X (NCERT, 2007a, p. 244, p. 249, p. 279);. Item No. 3 is in Science textbooks of Class VII (NCERT, 2007, p. 216), Class VIII (NCERT, 2008, p. 61, p. 73, pp. 242–243), Class IX (NCERT, 2006, pp. 198–200), and Class X (NCERT, 2007a, p. 249, p. 279). Item No. 4 is in the Science textbooks of Class VII (NCERT, 2007, p. 216), Class VIII (NCERT, 2008, p. 61, p. 73, pp. 242–243), Class IX (NCERT, 2006, pp. 198–200), and Class X (NCERT, 2007a, p. 249, p. 279). Item No. 6 is in the Science textbook of Class VII (NCERT, 2007, pp. 68–79), and item no. 10 is in Science textbooks of Class VII (NCERT, 2007, p. 216), Class VIII (NCERT, 2008, p. 61, p. 73, pp. 242–243), Class IX (NCERT, 2006, pp. 198–200) and Class X (NCERT, 2007a, p. 244, p. 249, p. 279). In addition, students also learn about such topics in Class XII Biology (NCERT, 2007, pp. 280-281) and in some form in Geography in different classes unto Class XII. Item Nos. 2, 5, 7, 8, and 9 have been included since these will help identify their basic understanding of climate change science. Many of the concepts related to the items have also been used by different researchers in their studies. For example, item Nos. 1 (Boyes et al., 1993; Boyes and Stanisstreet, 1993; Rajeev Gowda, et al., 1997; Papadimitriou, 2004; Harker-Schuch and Bugge-Henriksen, 2013); Item No. 2 (Shepardson et al., 2011 and Shepardson et al., 2012); Item No. 4 (Harker-Schuch and Bugge-Henriksen, 2013); Item No. 7 (Sulistyawati et al., 2018); Item No. 10 (Papadimitriou, 2004). In their study about elementary science methods, students' understanding of global climate change in the US, Lambert et al. (2012) included questions related to item Nos. 1, 2, 4, 6, 7, and 8.

Two options (Yes or No) were provided to choose their response to the items (statements).

The questionnaire was anonymous. Student participation was voluntary, and consent was obtained from all participants in this research.

Sampling

Two groups of students were considered for this study. One group included 96 students who had attended Jawaharlal Nehru National Science, Mathematics and Environment Exhibition for Children (JNNSMEE) held in Ahmadabad, Gujarat, in 2018. They were grouped as "Science" for the purpose of this study. Due to their participation in this exhibition, they were considered to have manifested interest in science. National Council of Educational Research and Training (NCERT), New Delhi, an apex body for school education in India, in collaboration with various state governments, organises this prestigious exhibition every year, where students showcase their talents in science and mathematics and their applications in different areas related to everyday life through their innovative models. However, this exhibition is open only to a select few students who have been screened from the cluster-level, block-level, district-level, and state-level exhibitions. These students answered the questionnaire in pen and paper mode. The demography of the students based on their class is provided in Table 1.

Table 1
Demography of students based on their class

Sl. No.	Class	Number of students
1.	VI	1
2.	VII	4
3.	VIII	5
4.	IX	17
5.	X	21
6.	XI	17
7.	XII	31
	Total	**96**

The second group of participants included 1817 students from different schools located in different States and UTs. Since this population of 1817 was heterogenous, i.e., a different number of students in a different class, we first used stratified sampling to divide the heterogenous population into homogenous strata class-wise, and then by applying simple random sampling from these strata using Excel, we sampled 96 students to make the number of students equal in both the groups and also in terms of the number of students from a given class as listed in Table 1. This group of students was grouped as "Others" in the study. Their response was obtained online via the Survey Planet platform (149 students participated) as well as by offline mode, which was administered in schools through different state functionaries (1668 students participated) during 2018–19.

Analysis of data

Objective 1 was inspected within each group of students, and Objective 2 was examined between the two groups of students —"Science" and "Others."

A simple statistical analysis was done to find out the performance of students in terms of correct or incorrect responses, and a T-test was employed to compare the performance of the two groups of students in the study for which online tools available on different websites were used such as in easycalculation.com and graphpad.com.

Results and Discussions

I. Results and discussions are provided herewith based on objectives. The first objective of the study was to find out whether students have the basic knowledge related to climate change science. For this, we calculated the performance of the students in terms of the number of students whose responses were correct or incorrect, as provided in Table 2 and Fig. 1.

As we can see in Table 2, except for items Nos. 2, 6, and 9, more than 50 per cent of students (Overall) responded correctly for all the items, with the percentage as high as 78.5, 80 and 78 for item nos. 3, 7 and 10, respectively.

Table 2
Knowledge of students about climate change science based on their response

Item No.	Correct response			Incorrect response		
	Science (%)	Others (%)	Overall (%)	Science (%)	Others (%)	Overall (%)
1.	80 (83)	24 (25)	104 (54)	16 (17)	72 (75)	88 (46)
2.	54 (52)	30 (31)	84 (41.5)	42 (48)	66 (69)	108 (58.5)

3.	86 (90)	64 (67)	150 (78.5)	10 (10)	32 (33)	42 (21.5)
4.	58 (60)	59 (61)	117 (60.5)	38 (40)	37 (39)	75 (39.5)
5.	74 (77)	58 (60)	132 (68.5)	22 (33)	58 (40)	80 (36.5)
6.	35 (36)	28 (29)	63 (32.5)	61 (64)	68 (71)	129 (67.5)
7.	81 (84)	73 (76)	154 (80)	15 (16)	23 (24)	38 (20)
8.	65 (68)	69 (72)	134 (70)	31 (32)	27 (28)	58 (30)
9.	42 (44)	41 (43)	83 (43.5)	54 (56)	55 (57)	109 (56.5)
10.	83 (80)	73 (76)	156 (78)	13 (20)	23 (24)	36 (22)

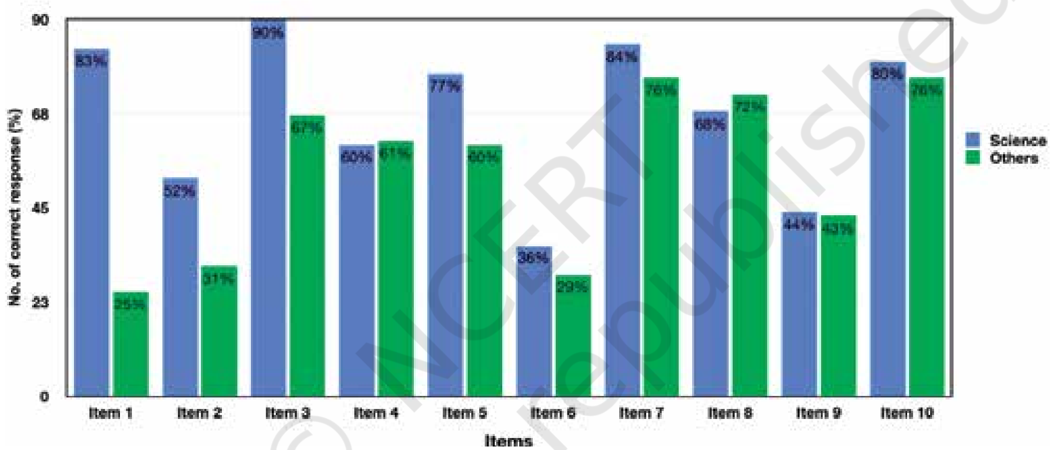

Fig. 1 Item-wise comparison of students' response

The low percentage of the correct answer of Overall students for item no. 1 (54%) with an even lower percentage (25%) amongst "Others" is found to be in line with the previous studies (Boyes et al., 1993; Boyes and Stanisstreet, 1993; Rajeev Gowda et al., 1997, Leiserowitz, 2006; Grant and Featherstone, 2009; Boon, 2010; Liarakou et al., 2011; Shepardson et al., 2012; Lambert et al., 2012; Harker-Schuch and Bugge-Henriksen, 2013; Tolppanen and Aksela, 2018). In most cases, this is largely attributed to the misconception held by students that the ozone hole lets more radiation from the sun to enter the atmosphere, thereby warming the Earth, or due to the trapping of solar radiation by the ozone layer, which causes global warming (Koulaidis and Christidou, 1999). Since the concept related to the item is expected to have been studied by students as part of their curriculum, a correct response would have been expected, which is not the case. However, the performance of the Science group was found to be very good, with 83 per cent having correctly answered. This could be due to a clearer understanding of the concept due to their natural inclination to Science.

For item no. 2, only 41.5 per cent of students (Overall), 52 per cent (Science), and 31 per cent (Others) gave the correct answer. This could be because most students are unfamiliar with the concept since it is not part of their curriculum. A study conducted by Papadimitriou (2004) found that none of the students in his study made any connection with the long-wave radiation emitted from the Earth's surface when describing the process of the greenhouse effect. This explains the importance of having a clear idea about various radiations in order to understand climate change. Shepardson et al. (2011, 2012) also found a lack of understanding about different radiations amongst secondary students in their study to prepare a climate system framework. Boyes and Stanisstreet (1997, 1998), in their studies among the 13-14-year-olds, also found a stark lack of clarity about UV-rays and heat rays. Koulaidis and Christidou (1999) also found a lack of clarity on the part of students about the nature of radiations, although the participants of their study belonged to 11–12 years. The lack of understanding about the types of radiations and their role in the greenhouse effect was also pointed out by Lambert et al. (2012) in their study about elementary science methods students' understanding of global climate change in the US. This reveals the need to include basic concepts of the electromagnetic spectrum, their source (active and passive) as well as wavelength with more thrust in the curriculum.

Students performed well for item no. 3 as we look at the number of students who responded correctly (Overall = 78.5%; Science = 90%; Others = 67%). This could be attributed to their exposure to this concept at some point in their curriculum. Earlier studies have not specifically focused on this concept while conducting studies on school students' knowledge about climate change.

For item no. 4, students were found to perform decently considering the number of students who responded correctly (Overall = 60.5%; Science = 60%; Others = 61%). Again, this could be attributed to their exposure to this concept at some point in their curriculum. Earlier studies (Harker-Schuch and Bugge-Henriksen, 2013; Boon, 2010; Lambert et al., 2012) have also included this aspect, and it was observed that students lacked clarity regarding the types of greenhouse gas and their role in the greenhouse effect or global warming.

Similarly, students have performed well for item no. 5 with the correct response in the order of Overall = 68.5%; Science = 77%; Others = 60%). Although this is not directly part of their curriculum, it is likely that students have been exposed to this concept from other sources such as print and electronic media (Carbon Sources and Sinks, National Geographic Society, n.d.), talks by scientists, and public conversations.

Item no. 6 is fundamental to understanding climate change. Yet it is discouraging to find that the least number of students responded correctly of all the items (Overall = 32.5%; Science = 36%; Others = 29%). As is evident from the result, Science students performed equally poorly. The result is more surprising because this concept is dealt with in detail in the curriculum in Class VII based on the NCERT syllabus and textbook. It is also disappointing because this concept is fundamental if one has to understand climate change. However, this confusion was also observed even amongst student-teachers (Lambert et al., 2012).

Although item no. 7 is not directly part of the curriculum, most of the students responded correctly (Overall = 80%; Science = 84%; Others = 76%). Similar results are found in a study conducted amongst adolescents in Indonesia (Sulistyawati et al., 2018). Boon (2010), Shepardson et al. (2011), and Liarakou et al. (2011) also found similar results but with varying degrees. This could be because of the popularity of the idea of sea level rise with climate change. However, Lambert et al. (2012) found a lack of clarity amongst student-teachers on the cause of sea level rise.

Most of the students responded correctly (Overall = 70%; Science = 68%; Others = 72%) for item no. 8. Although this is not directly part of the curriculum in terms of climate change, students study about the position of the sun, rotation, and revolution of the Earth in Geography through which they would have gained some idea. In one of their questions to find out the cause of changing seasons on Earth from student-teachers, Lambert et al. (2012) also found similar results (94%), indicating that natural reasons for climate change are a relatively easy concept to grasp.

For item no. 9, less than 50 per cent of students responded correctly (Overall = 43.5%; Science = 44%; Others = 43%). This could be because the concept is not part of the curriculum. However, this observation to relate Tsunamis with climate change is not uncommon. Lambert et al. (2012) also found in their study that many student-teachers had also linked the two phenomena. That "Tsunamis are caused by climate change" could also be considered a misconception held by students.

Of all the items in the questionnaire, maximum number of students responded correctly to item no. 10 (Overall = 78%; Science = 80%; Others = 76%). This could be because the concept is included at some stage in the curriculum. Whatever the reason for their knowledge, it is an important finding because at least we can conclude that students know that greenhouse gases are responsible for global warming. The concept related to this was also included by Papadimitriou (2004) in a study related to climate change.

As we observed in the result, students generally have some knowledge about climate change science, although a much better performance would have been encouraging. The fact that students did not have extensive knowledge about climate change science could be because the existing curriculum is not robust enough to drive students to be climate literate. It is important to mention here that the existing NCERT syllabus (NCERT, 2005; NCERT, 2005a) and textbooks were prepared from 2006 to 2008 (NCERT, 2006; NCERT, 2007; NCERT, 2007a; NCERT, 2007b; NCERT, 2008). The focus on climate change then and now has changed drastically, with tremendous attention shifting towards climate change today. In addition, the major misconceptions that seem to exist among Indian students based on the result are a major concern. However, such misconceptions are commonly found to exist amongst students globally, as we have discussed in some cases earlier. Curriculum developers and other stakeholders may take note of such misconceptions so that the resources that are developed address those concerns or that teachers are prepared accordingly. Besides such items, which indicate misconceptions, the remaining items included in the questionnaire are equally important to be addressed in the curriculum since they are crucial for understanding climate change science. As mentioned earlier, appropriate knowledge and views about climate change are crucial for the expression of pro-environmental constituents and behaviours amongst students (Harker-Schuch and Bugge-Henriksen, 2013; Kuthe et al., 2019).

II. The second objective was to find out whether students from "Science" (students with a manifested interest in Science) have better knowledge about climate change compared to "Others" (randomly selected students from different states and UTs).

For this, we performed a t-test to compare the response of the two groups of students— "Science" and "Others."

The null hypothesis for this study is that the two groups of students have equal knowledge about climate change science. The alternative hypothesis is that both groups of students have different knowledge about climate change science.

Level of significance: α=0.05

We found the p-value of the t-test to be 0.0501, which is slightly more than α=0.05 (i.e., $p \rightarrow .05$) (Table 2). This means that the null hypothesis cannot be rejected, i.e., the difference in the knowledge about climate change science in both the groups of students—"Science" and "Others" is not quite statistically significant.

It can be concluded that "Science" students (students with a manifested interest in science) do not have better knowledge about climate change science compared to "Others" students.

It was expected that the performance of "Science" students would be better and statistically significant compared to students from the group "Others" because "Science" students have manifested interest in science, and hence one would expect them also to show an inclination to learn about climate change science. However, the result from the study did not validate the same. This also indicates, to some extent, that the source of information whatsoever for all the students on climate change may be similar. Unfortunately, there are limited research on the sources of information from where students or teachers learn about climate change. Nevertheless, we can list some general sources of information such as the Internet; government sources; mass media (print and electronic); and professional development courses, and most importantly, for students, it is the teachers who serve as the major source of information. Therefore, teachers play an important role in transmitting information, knowledge, and skills related to climate change, and rightly so, teachers have been described as 'gatekeepers of information (Kunkle and Monroe, 2019). Consequently, it becomes important to understand teachers' source of information since this will impact their interaction with students. It is also crucial for teachers to have expertise in the subject since this will help them filter information appropriately, which are available on different platforms or sources (McNeal et al., 2017). At the same time, there is a need to re-visit the curriculum content with regard to climate change.

Table 2
T-test to compare the response of the two groups of students—"Science" and "Others"

Variable	Mean	Standard Deviation	SEM	95% Conf. Interval
Science	5.75	1.49385	0.1524654	-0.0001999 0.8335399
Others	5.33333	1.43392	0.1463488	
Mean (diff) = Mean (Science - Others) = 0.4166700				
t = 1.9716				
Df = 190				
Standard error of the difference of means of samples = 0.211				
P value = 0.0501				

Conclusion

The present paper can be considered a preliminary study to assess the implementation of climate change education in India. From the study, we can conclude that climate change education is undoubtedly part of the curriculum, but much is wanting for its effective and meaningful implementation. The study also revealed that the greenhouse effect and global warming have been included in several places in the curriculum from Class VI to XII. However, the result revealed that inclusion of the concept did not lead to an understanding of the concept. This is despite the fact that most students who participated in the study belonged to higher classes (above Class VIII) and, therefore, have been introduced to climate change-related concepts over the years in their curriculum. It is worth mentioning here that in many instances, the concepts were merely included as a passing statement and, therefore, are left to the mercy of the teachers to teach the way she/he best perceives. In addition, many important concepts related to climate change that were included in the study are yet to find a place in the curriculum. Therefore, the first step in the direction of climate change education will begin with the systematic inclusion of appropriate concepts and contents in the curriculum in different classes and subjects. Towards this end, the development of appropriate resources which are contextualised, relevant and relatable to students will be crucial. Along with this, the preparation of teachers and their professional development must also be prioritised, which caters to climate change education. Moreover, the National Education Policy-2020* also focuses on, and is committed to, achieving the different targets of Sustainable Development Goals (SDGs), of which, climate is a major area with direct relation to Goal 13: Climate Action and also linked with all other SDGs as well. The role of curriculum developers, policymakers, teacher educators, teachers, and other stakeholders will be indispensable for its successful implementation.

*The original reference was Draft NEP-2019 but by the time of publication of this issue, NEP-2020 was published and hence modified accordingly.

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COMMENTARY: ROLE OF SCIENCE IN CURRICULUM

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NEP-2020* inculcates within the curriculum the very essence of toy-based pedagogy. Play, as an activity, has always been an essential and integral part of human culture. The child's involvement with play is vital in early childhood as this has a significant bearing on the child's physical, psycho-emotional, social, and cognitive development (Rensickand Ocko, 1990). In addition, toys are the carrier of the cultural heritage of any country, and the local heritage connects the student to their soil and thus induces the spirit of patriotism within. The role of introducing toy-based pedagogy in the upcoming NCF, as envisioned in NEP 2020, will change the way toys have been perceived and will find their proper place in the curricula.

The teachers, by virtue of using the toys as learning resources and developing them into pedagogical practices, should slowly introduce the student to the ethos of Indian culture. The developmental level of the child, the interest the child has in the toy, the availability of the toy and the impact of cultural beliefs are key factors that aid in the selection of toys (DuBois, 1997). This, in turn, will inculcate creativity and problem-solving skills. Using analogy, puzzles, and games to teach science and mathematics are a few exemplars that should find their place within the lesson plan. The use of indigenous local toys will bring out the local traditions and essence of the background in which the student develops and will always reflect their personality. Play-based learning promotes academic readiness and outcomes (Hirsch-Pasek and Golinkoff, 2008). It also adds to sustainability as going local with crafted local toys will curtail the use of plastic toys and avoid adverse environmental repercussions.

The development of toy-based pedagogy should be seen in all four aspects of science, social science, mathematics and language. In addition, one may embed it within the existing tools and techniques of delivery by inducing critical thinking, decision-making and problem-solving within them. However, research has shown that the traditional approaches to professional experience generally provide insufficient integration of theory and practice, and have been criticised for resulting in a lack of classroom readiness in early career teachers (Allen and Wright, 2014; Craven et al., 2014). Therefore, the

*The original reference was Draft NEP-2019 but by the time of publication of this issue, NEP-2020 was published and hence modified accordingly.

teacher Education Curriculum Framework must reframe itself to accommodate the vision of the upcoming NCF, and pre-service teachers must learn the art of embedding, which will allow rethinking, restructuring, and reimaging of the curricula through the created pedagogy.

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COMMENTARY: REVISITING THE MENTAL HEALTH OF SCHOOL STUDENTS

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Students often consider the classroom as a site of intellectual competition, and every success fuels their drive to excel further. However, there have been mixed views regarding the role of competition in motivating students in the classroom (Cropper, 1998). Extrinsic motivation driven by a scheme of rewards and incentives can lead to mental stress and even be detrimental to the expression of ingenuity. Parents, in their quest for getting the best out of their children, generally resort to making comparisons, and unintentionally aggravate mental pressure in the process. Rather than merely egging students on to obtain higher grades than their peers, a shift to a more holistic approach involving all-round development of their personality is the need of the hour.

In this context, it is very interesting to note that the National Education Policy-2020* emphasises on the adoption of alternate approaches to make the learning process "holistic, integrated, enjoyable, and engaging."

Research has shown that schools can be ideal sites for delivering mental health interventions (Shoshani and Steinmetz, 2014). The role of a teacher as a facilitator serves to kindle the intrinsic motivation of a student by involving them in activity-based and problem-solving approaches to learning. Additionally, participation in co-curricular activities can de-stress students to a great extent and make a positive contribution to their subjective well-being (Vetter et al., 2019).

Rather than mechanically preparing students to secure high-paying jobs, thrust should also be given to imbibing and practising human values that would equip students with self-confidence and the capacity to manage themselves better. Striving to create intelligent students with a sound body and a sound mind would be a more sustainable roadmap towards a bright future for our country. There is a lot to ponder over the statement – 'Education must be for life and not merely for a living.'

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COMMENTARY: EXPECTATIONS IN THE NEW SCIENCE CURRICULUM

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Science is a discipline that intends to develop scientific knowledge, scientific temper, and scientific attitude among all its stakeholders. In order to develop these, the Science curriculum should be such that the children are given ample scope to learn Science not only through textbooks but through the usage of various modes of classroom transaction focusing on activity-oriented experiential learning. It was found that 'in order to help students learn science meaningfully; teachers should ensure that learning is constructive' (Glynn and Duit, 1995) and different dimensions of constructivist teaching, learning, and supervisory practices have different effects on student achievement.' (Zeigler, 2000). Science, being a dynamic and ever-changing one, the textbooks should have the scope for incorporating up-to-date concepts and contents. The textbook should have basic science contents along with advanced developments to make them prepared to face the world around them.

The contents in Science textbooks should be such that they can be easily transacted by taking relevant examples from the context of the child and with ample scope for designing and using different improvised experimental apparatus and instruments. Apart from the textbooks, competencies of the teacher and their attitude toward Science play a very crucial role in imparting scientific temper and scientific attitude in students along with scientific knowledge. Science learning should be encouraged through the usage of different activity-oriented pedagogies focusing on constructivist pedagogy. The curriculum should have the scope for developing various process skills in Science along with values and ethics. Further, the assessment should primarily be formative and focus on learners' needs and requirements. The Science curriculum should have mostly practical components in order to make Science learning joyful, meaningful, and interesting for the children.

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INTERVIEW WITH RAHUL S. CHATTERJEE

Rahul S. Chatterjee is an Assistant Lecturer *in Physics at Shillong Jail Road Boys' Higher Secondary School with 27 years of teaching experience. A National Teacher Awardee, 2020, Chatterjee is also the recipient of the prestigious Fulbright Scholarship program in 2012. He was also selected in 2019 to visit CERN in Geneva, Switzerland, as part of The High School Teacher Program. Chatterjee has actively contributed to the development of e-content in Science for NCERT over the years.*

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What made you choose Physics as your subject?

I was always interested in knowing the "why" and the "how" behind things. So, from a very young age, I would open up all kinds of mechanical things like toys and clocks, and try to figure out how they worked. Of course, I did not understand much, but the curiosity set in. My parents and my paternal uncle recognised this penchant and bought me toys that would help me understand the mechanics of things, like Mechanical Builder sets; sets that used the property of levers, etc.

Added to this was the fact that I have two elder sisters, the first-born being five years older than me. When she would study, I would often go around to see what she was studying. The diagrams in her science book intrigued me. I would ask her about them, and she was the first to tell me about mirrors and lenses, light and sound! Those interactions opened a whole new world for me. I had started experimenting with mirrors and magnifying glasses.

Later, when I was in Class IX, the bearer brought a notice to the class that in the evening, from 4 PM that day, a Geological Survey of India scientist, who had just returned from Antarctica, would give a popular talk and show his slides at a local college. (There were no computers in the '70s, and presentations were made with specially prepared slides from negatives of photographs, all stacked up one behind the other and then projected on a screen one after another). I still remember rushing home from school, taking permission from my mother and directions, pen and paper, and landing up at the place on time to be able to see the presentation from close quarters. The evening's presentations started with a short presentation on Venus. That was the day, that was the moment I got hooked on astronomy and astrophysics, which remains my passion even up to today. The pictures from Antarctica were beautiful, but Venus was intriguing! An atmosphere of sulphur-dioxide; if it rains, it will rain sulphuric acid! This information was just too exciting to not follow up. However, back in the day, getting information was a challenge. The only reliable places were my school library and the State Library. Both became my treasure hunting places.

So, either just the right events fell onto my platter and made me take up Physics or, among all the things that were happening around me, I naturally gravitated towards wanting to know more, understand more, and hence Physics. I think it was the latter more than the former.

What and who motivated you to become a teacher?

I realised I had a knack for teaching and that teaching helped me understand better when I started helping my younger sister. The more I taught, the more I began to enjoy it. Gradually, the neighbourhood children began coming to me for help, saying it helped them. That is when I realised teaching should be a career choice for me.

According to you, what does it mean to be a teacher?

Being a teacher is a whole lot of responsibility and challenge. It is not just about going to class and imparting a lesson. That even a robot would be able to do. A teacher is expected to understand every child individually and know their strengths and weaknesses. Understand that there are bad days for a child just as there are bad days for the teacher. This understanding of a child is pertinent because it is expected of a teacher to build the little soul into a confident, optimistic, honest, hardworking individual who will become an asset to society. Just think of the unsaid expectations from a teacher for a moment. They are huge! Teachers are expected to do things that parents cannot, yet teachers do. Moreover, teachers do it for not one or two children, but for a class full of students, year after year!

Thus, to be a teacher, the individual must have various talents and qualities. A teacher has to be able to teach oration, drama, music, art, craft, sports, storytelling, and you name it! Can you show me another job that requires that many skills of any single individual? And all of this is beyond what is considered the core area, teaching the subject.

How have you been able to bring about improvement in the teaching-learning of Physics? Kindly share some innovations that you have made in terms of teaching methods of teaching-learning materials.

All I can say is I have tried. I realised that no one approach is the ideal approach. People learn differently. So there must be multiple ways of giving the same information. The different approaches I have taken are (a) designing new experiments and repeating standard experiments, to demonstrate a phenomenon or a concept, (b) showing pictures/videos again to illustrate a point, (c) making my own videos when I felt the necessity, (d) writing popular science articles for All India Radio and asking my students to tune in and also sharing the script later with the class, (e) delivering popular lectures, mainly on astronomy and astrophysics, and (f) inviting national level scientists to my school to deliver lectures.

From your years of experience, what do you think is the best way to motivate students and nurture their talents to become their best version?

Students are most motivated when they see a passionate teacher; a teacher who loves one's subject, and the love is absolutely evident. Nothing great has ever been done in the world without passion. A teacher's passion is infectious. It positively influences students like nothing else can. And if a teacher is not passionate about one's subject, what is the person doing there?

"A teacher is a student for life." What have you learned from your students?

The most valuable lesson for a teacher is 'how do students learn?'. Among the many different things that I have learned, the most important is when and how do they learn best. The more I invest myself in them, the more they learn. Among the other things, the important lesson I have realised is that each student is different, with different talents, aspirations, and dreams. And a good teacher has to cater to each and every one of them.

What has been your most touching experience so far as a teacher?

I am most touched when old students get in touch after many years, and they say things like it was because of me that they have been able to do this or that, or when some students, who are now abroad, invite me to their homes and tell me that I am welcome to stay with them if I visit their country...

Kindly suggest some areas where you think your district/ state/ country needs attention concerning science education, in general, and education in particular.

The first and foremost thing to be done is to recruit teachers who are passionate about teaching. Secondly, improve the service conditions of teachers across the board so that better talent is attracted to the profession. Thirdly, the government must spend more on science education to be able to implement a more hands-on pragmatic approach, as is the requirement in National Education Policy 2020*.

*The original reference was Draft NEP-2019 but by the time of publication of this issue, NEP-2020 was published and hence modified accordingly.

Do you also make an effort to popularise physics or physics learning in your community? If so, kindly elaborate.

Yes, I have been associated with science popularisation for over thirty years now. I have been a regular contributor to the Science Magazine Programme and Popular Science Programme of All India Radio (AIR) Shillong and North Eastern Service, AIR, Shillong. Other than that, I write freelance for different newspapers on popular science topics. I also have a blog on astronomy and astrophysics articles. In addition, I deliver popular lectures, mainly on Astronomy and Astrophysics, and have travelled to different parts of the country to deliver lectures. I also conduct science quizzes from time to time and hold hands-on sessions on teaching/learning physics through experiments.

What are your top two regular practices that have helped you stay motivated?

Starting the day by listening to or reading about a success story and choosing good friends who push me and keep me motivated.

BOOK REVIEW

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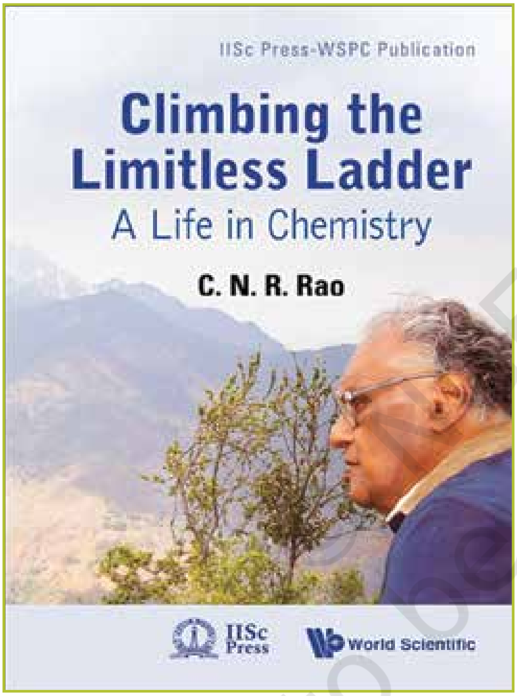

- Book name: Climbing the Limitless Ladder: A Life in Chemistry
- Author: C. N. R. Rao
- Publisher : World Scientific Publishing Co and IISc Press
- Language : English
- Paperback : 232 pages
- ISBN-10 : 9814307858

"Climbing the limitless ladder: A life in Chemistry" is a brutally honest autobiographical account of doing scientific research in India. It provides insight into the making of a scientist from a developing country. It narrates the author's early years to his academic adventures, his journey from Bangalore to where he goes on a "pilgrimage for knowledge" to Banaras for Postgraduate studies, then to Purdue University, Indiana, USA, for a Doctoral research program to taking up a research associate position at the University of California, Berkeley, USA where he developed critical thinking and problem solving, honed his analytical and scientific skills, and evolved his writing and communication which matured and defined him as a scientist, and finally to his return to his country and his engagements thereafter.

The book offers many lessons to young and aspiring scientists. The paramount lesson to draw from the life of C N Rao is that in Science, it is not enough if you are good at the subject and at the lab. To make a mark in research and academics, one should get many things right. Firstly, one should try to have the right mentor. Second, one should learn to collaborate. Third, one becomes visible in the community of scientists through research publications, reviews, and books—Roa has to his credit, a whopping 1400 research papers and 43 technical books on a wide range of topics. The book also includes a few of his select essays and papers. There is also a letter to a young scientist at the end.

The book has also brought out a few more aspects of being a good scientist–be able to win grants, pitch for a cause to philanthropists, and try to be a member of the right platforms and academies.

For an extremely focused scientist of his calibre, if you expect the book to be dull and dry, you are definitely mistaken. On the contrary, the book is as entertaining as educational. His uncanny ability to recollect does not fail when he brings to life many of the funny anecdotes at several sections in the book.

Charismatic. Hard-working. Humble. Compassionate. Pioneer. Dedicated. Trailblazer Visionary. Poster Boy of Indian Science. This book has brought out all of these qualities and many more of C N Rao very nicely. This autobiography provides an insight into the feeling of how, in spite of the many limitations, one can try to climb the limitless ladder of excellence. This book is, therefore, a gift to humanity and a treasure for eternity.

SCIENCE NEWS

Exploring why males are larger than females among mammals

Date: April 8, 2020
Source: Wiley
Summary: In most animals, females are larger than males, but in most mammals, males are larger than females. A new analysis examines the potential drivers of these differences.

In most animals, females are larger than males, but in most mammals, males are larger than females. A new analysis published in Mammal Review examines the potential drivers of these differences.

In most animals, females are larger than males, but in most mammals, males are larger than females. A new analysis published in Mammal Review examines the potential drivers of these differences, calling into question the theory that only sexual selection is at play in mammals— that males compete to mate with females, and bigger males are more likely to win.

The analysis suggests that, alongside sexual selection, natural selection may be an evolutionary driver of sexual size differences in mammals. Males and females may have evolved to differ in size so that they could exploit resources such as food.

Warming climate is changing where birds breed

Migratory behaviour and winter geography drive differential range shifts of eastern birds in response to recent climate change.

Date: May 26, 2020
Source: S.J. and Jessie E. Quinney College of Natural Resources, Utah State University.
Summary: Spring is in full swing. Trees are leafing out, flowers are blooming, bees are buzzing, and birds are singing. But a recent study found that those birds in your backyard may be changing right along with the climate.

Spring is in full swing. Trees are leafing out, flowers are blooming, bees are buzzing, and birds are singing. But a recent study published in Proceedings of the National Academy of Sciences found that those birds in your backyard may be changing right along with the climate.

Clark Rushing, Assistant Professor in the Department of Wildland Resources and Ecology Center, Quinney College of Natural Resources at Utah State University, and colleagues at the US Geological Survey wanted to know how climate change has already affected where birds breed. They used data from the Breeding Bird Survey — one of the oldest and longest citizen-science programs in the world— to conduct their research. "Thousands of devoted volunteers, cooperators, and a joint US-Canadian wildlife management team have contributed to the success of the surveys for the last 54 years," said Andy Royle, a USGS senior scientist and co-author of the study. "The Breeding Bird Survey is fundamental to our understanding and management of wild bird populations in North America."

The research team combined Breeding Bird Survey data with powerful computer models to discover changes in breeding range for 32 species of birds found in eastern North America. What they found is surprising.

Some birds' ranges are expanding. Birds that both breed and winter in North America are extending their ranges north to take advantage of new, warm places to breed. These birds are also maintaining their southern ranges. These results bring hope that some bird populations such as Carolina wrens and red-bellied woodpeckers, may be resilient to future climate change.

Some birds' ranges are shrinking. Neotropical migratory birds breed in North America during the summer and migrate to the Caribbean, Central America, and South America for the winter. Neotropical migrants include many species that people love and look forward to seeing each spring such as buntings, warblers, orioles, and flycatchers. The team's research shows that these birds are not expanding north, and their southern ranges are shrinking.

To make matters worse, over the past 50 years, Neotropical bird populations have decreased by about 2.5 billion individuals. Rushing explained, "There's a real risk that, if these declines continue at their current pace, many species could face extinction within this century. Neotropical migrants are vulnerable to future climate change, putting them at risk of greater declines."

Neotropical migrants already fly thousands of miles each year to breed, so why can't they go just a bit farther as the climate warms? The researchers suspect the conditions where the birds live during the winter might make this impossible. Migrations require immense reserves of energy, so migratory birds need high-quality winter habitat with abundant food and moisture. Unfortunately, many habitats in the Caribbean, Central America, and South America are being degraded. It is possible that Neotropical birds can't store enough energy during the winter, so they simply can't extend their journeys any farther.

"That's just one explanation," concluded Rushing, "and it highlights how little we know and how much more research is needed." And what the team does know wouldn't have been possible without the help of devoted citizen scientists.

Healthy eating behaviours in childhood may reduce the risk of adult obesity and heart disease

Date: May 11, 2020
Source: American Heart Association
Summary: Encouraging children to make their own decisions about food, within a structured environment focused on healthy food choices, has been linked to better childhood nutrition and healthier lifelong eating behaviours. Parents and caregivers can play a significant role in creating an environment that helps children develop healthier eating behaviours early in life, which can reduce the risk for overweight, obesity and cardiovascular disease as adults.

How children are fed may be just as important as what they are fed, according to a new scientific statement from the American Heart Association, "Caregiver Influences on Eating Behaviors in Young Children," published today in the Journal of the American Heart Association.

The statement is the first from the Association focused on providing evidence-based strategies for parents and caregivers to create a healthy food environment for young children that supports the development of positive eating behaviours and the maintenance of a healthy weight in childhood, thereby reducing the risks of overweight, obesity and cardiovascular disease later in life.

Although many children are born with an innate ability to stop eating when they are full, they are also influenced by the overall emotional atmosphere, including caregiver wishes and demands during mealtimes. If children feel under pressure to eat in response to caregiver wants, it may be harder for them to listen to their individual internal cues that tell them when they are full.

Allowing children to choose what and especially how much to eat within an environment composed of healthy options encourages children to develop and eventually take ownership of their decisions about food and may help them develop eating patterns linked to a healthy weight for a lifetime, according to the statement authors.

"Parents and caregivers should consider building a positive food environment centered on healthy eating habits, rather than focusing on rigid rules about what and how a child should eat," said Alexis C. Wood, PhD, the writing group chair for the scientific statement and assistant professor at the US Department of Agriculture/Agriculture Research Services Children's Nutrition Research Center and the Department of pediatrics (nutrition section) at Baylor College of Medicine in Houston.

The statement suggests that parents and caregivers should be positive role models by creating an environment that demonstrates and supports healthy food choices, rather than an environment focused on controlling children's choices or highlighting body weight. Parents and caregivers should encourage children to eat healthy foods by:

- providing consistent timing for meals;
- allowing children to select what foods they want to eat from a selection of healthy choices;
- serving healthy or new foods alongside foods children already enjoy;
- regularly eating new, healthy foods while eating with the child and demonstrating enjoyment of the food;

- paying attention to a child's verbal or non-verbal hunger and fullness cues; and
- avoiding pressuring children to eat more than they wish to eat.

Wood noted that some parents and caregivers may find it challenging to allow children to make their own food decisions, especially if the children become reluctant to try new foods and/or become picky eaters. These behaviours are common and considered normal in early childhood, ages 1 to 5 years, as children are learning about the tastes and textures of solid foods. Imposing rigid, authoritarian rules around eating and using tactics such as rewards or punishments may feel like successful tactics in the short term. However, research does not support this approach; rather, it may have long-term, negative consequences. An authoritarian eating environment does not allow a child to develop positive decision-making skills and can reduce their sense of control, which are important developmental processes for children.

In addition, the authoritarian approach has been linked to children being more likely to eat when they are not hungry and eating less healthy foods that are likely higher in calories, which increase the risk of overweight and obesity and/or conditions of disordered eating.

On the other hand, an indulgent approach, where a child is allowed to eat whatever they want, whenever they want, does not provide enough boundaries for children to develop healthy eating habits. Research has also linked this "laissez-faire" approach to a greater risk of children becoming overweight or having obesity.

Research does suggest that some strategies can increase children's dietary variety during the early years if they are "picky" or "fussy" about foods. Repeatedly offering children a wide variety of healthy foods increases the likelihood they will accept them, particularly when served with foods they prefer. In addition, caregivers or parents who enthusiastically eat a food may also help a child accept this food. Modeling eating healthy foods - by caregivers, siblings and peers— is a good strategy for helping children to be open to a wider variety of food options.

"Children's eating behaviours are influenced by a lot of people in their lives, so ideally, we want the whole family to demonstrate healthy eating habits," said Wood.

It is important to note that not all strategies work for all children, and parents and caregivers should not feel undue stress or blame for children's eating behaviours. "It is very clear that each child is an individual and differs in their tendency to make healthy decisions about food as they grow. This is why it is important to focus on creating an environment that encourages decision-making skills and provides exposure to a variety of healthy, nutritious foods throughout childhood, and not place undue attention on the child's individual decisions," concluded Wood.

Caregivers can be a powerful force in helping children develop healthy eating habits, and yet their role is limited by other factors. The statement authors encourage policies that address barriers to implementing the statement's recommendations within the wider socioeconomic context, including social determinants of health such as socio-economic status, food insecurity and others. While efforts that encourage caregivers to provide a responsive, structured feeding environment could be an important component of reducing obesity and cardiometabolic risk across the lifespan, they note that they will be the most effective as part of a multi-level, multi-component prevention strategy.

More berries, apples and tea may have protective benefits against Alzheimer's

Study shows low intake of flavonoid-rich foods linked with higher Alzheimer's risk over 20 years.

Date: May 5, 2020
Source: Tufts University, Health Sciences Campus
Summary: Older adults with low intake of foods and drinks containing flavonoids such as berries, apples, and tea, were more likely to develop Alzheimer's disease and related dementias over 20 years, compared with people who consumed more of those items, according to a new study.

Older adults who consumed small amounts of flavonoid-rich foods such as berries, apples and tea, were two to four times more likely to develop Alzheimer's disease and related dementias over 20 years compared with people whose intake was higher, according to a new study led by scientists at the Jean Mayer USDA Human Nutrition Research Center on Aging (USDA HNRCA) at Tufts University.

The epidemiological study of 2,800 people aged 50 and older examined the long-term relationship between eating foods containing flavonoids and risk of Alzheimer's disease (AD) and Alzheimer's disease and related dementias (ADRD). While many studies have looked at associations between nutrition and dementias over short periods of time, the study published today in the American Journal of Clinical Nutrition looked at exposure over 20 years.

Flavonoids are natural substances found in plants, including fruits and vegetables such as pears, apples, berries, onions, and plant-based beverages like tea and wine. Flavonoids are associated with various health benefits, including reduced inflammation. Dark chocolate is another source of flavonoids.

The research team determined that low intake of three flavonoid types was linked to higher risk of dementia when compared to the highest intake. Specifically:

- Low intake of flavonols (apples, pears and tea) was associated with twice the risk of developing ADRD.
- Low intake of anthocyanins (blueberries, strawberries, and red wine) was associated with a four-fold risk of developing ADRD.
- Low intake of flavonoid polymers (apples, pears, and tea) was associated with twice the risk of developing ADRD.

The results were similar for AD.

"Our study gives us a picture of how diet over time might be related to a person's cognitive decline, as we were able to look at flavonoid intake over many years prior to participants' dementia diagnoses," said Paul Jacques, senior author and nutritional epidemiologist at the USDA HNRCA. "With no effective drugs currently available for the treatment of Alzheimer's disease, preventing disease through a healthy diet is an important consideration."

The researchers analysed six types of flavonoids and compared long-term intake levels with the number of AD and ADRD diagnoses later in life. They found that low intake (15th percentile or lower) of three flavonoid types was linked to higher risk of dementia when compared to the highest intake (greater than 60th percentile). Examples of the levels studied included:

- Low intake (15th percentile or lower) was equal to no berries (anthocyanins) per month, roughly one-and-a-half apples per month (flavonols), and no tea (flavonoid polymers).
- High intake (60th percentile or higher) was equal to roughly 7.5 cups of blueberries or strawberries (anthocyanins) per month, 8 apples and pears per month (flavonols), and 19 cups of tea per month (flavonoid polymers).

"Tea, specifically green tea, and berries are good sources of flavonoids," said first author Esra Shishtar, who at the time of the study, was a doctoral student at the Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy at Tufts University in the Nutritional Epidemiology Program at the USDA HNRCA. "When we look at the study results, we see that the people who may benefit the most from consuming more flavonoids are people at the lowest levels of intake, and it doesn't take much to improve levels. A cup of tea a day or some berries two or three times a week would be adequate," she said.

Jacques also said 50, the approximate age at which data was first analysed for participants, is not too late to make positive dietary changes. "The risk of dementia really starts to increase over age 70, and the take home message is, when you are approaching 50 or just beyond, you should start thinking about a healthier diet if you haven't already," he said.

Methodology

To measure long-term flavonoid intake, the research team used dietary questionnaires, filled out at medical exams approximately every four years by participants in the Framingham Heart Study, a largely Caucasian group of people who have been studied over several generations for risk factors of heart disease.

To increase the likelihood that dietary information was accurate, the researchers excluded questionnaires from the years leading up to the dementia diagnosis, based on the assumption that, as cognitive status declined, dietary behaviour may have changed, and food questionnaires were more likely to be inaccurate.

The participants were from the Offspring Cohort (children of the original participants), and the data came from exams 5 through 9. At the start of the study, the participants were free of AD and ADRD, with a valid food frequency questionnaire at baseline. Flavonoid intakes were updated at each exam to represent cumulative average intake across the five exam cycles.

Researchers categorised flavonoids into six types and created four intake levels based on percentiles: less than or equal to the 15th percentile, 15th-30th percentile, 30th-60th percentile, and greater than 60th percentile. They then compared flavonoid intake types and levels with new diagnoses of AD and ADRD.

There are some limitations to the study, including the use of self-reported food data from food frequency questionnaires, which are subject to errors in recall. The findings are generalisable to middle-aged or older adults of European descent. Factors such as education level, smoking status, physical activity, body mass index and overall quality of the participants' diets may have influenced the results, but researchers accounted for those factors in the statistical analysis. Due to its observational design, the study does not reflect a causal relationship between flavonoid intake and the development of AD and ADRD.

Today's atmospheric carbon dioxide levels greater than 23 million-year record

Date: June 1, 2020
Source: Geological Society of America
Summary: A common message in use to convey the seriousness of climate change to the public is: 'Carbon dioxide levels are higher today than they have been for the past one million years!' This new study used a novel method to conclude that today's carbon dioxide (CO2) levels are actually higher than they have been for the past 23 million years.

A common message in use to convey the seriousness of climate change to the public is: "Carbon dioxide levels are higher today than they have been for the past one million years!" This new study by Brian Schubert (University of Louisiana at Lafayette) and co-authors Ying Cui and A. Hope Jahren used a novel method to conclude that today's carbon dioxide (CO2) levels are actually higher than they have been for the past 23 million years.

The team used the fossilised remains of ancient plant tissues to produce a new record of atmospheric CO2 that spans 23 million years of uninterrupted Earth history. They have shown elsewhere that as plants grow, the relative amount of the two stable isotopes of carbon, carbon-12 and carbon-13 changes in response to the amount of CO2 in the atmosphere. This research, published this week in Geology, is a next-level study measuring the relative amount of these carbon isotopes in fossil plant materials and calculating the CO2 concentration of the atmosphere under which the ancient plants grew.

Furthermore, Schubert and colleagues' new CO2 "timeline" revealed no evidence for any fluctuations in CO2 that might be comparable to the dramatic CO2 increase of the present day, which suggests today's abrupt greenhouse disruption is unique across recent geologic history.

Another point, important to geological readers, is that because major evolutionary changes over the past 23 million years were not accompanied by large changes in CO2, perhaps ecosystems and temperature might be more sensitive to smaller changes in CO2 than previously thought. As an example: The substantial global warmth of the middle Pliocene (5 to 3 million years ago) and middle Miocene (17 to 15 million years ago), which are sometimes studied as a comparison for current global warming, were associated with only modest increases in CO2.

As many as six billion Earth-like planets in our galaxy, according to new estimates

Date: June 16, 2020
Source: University of British Columbia
Summary: There may be as many as one Earth-like planet for every five Sun-like stars in the Milky Way Galaxy, according to new estimates.

There may be as many as one Earth-like planet for every five Sun-like stars in the Milky way Galaxy, according to new estimates by University of British Columbia astronomers using data from NASA's Kepler mission.

To be considered Earth-like, a planet must be rocky, roughly Earth-sized and orbiting Sun-like (G-type) stars. It also has to orbit in the habitable zones of its star the range of distances from a star in which a rocky planet could host liquid water, and potentially life, on its surface.

"My calculations place an upper limit of 0.18 Earth-like planets per G-type star," says UBC researcher Michelle Kunimoto, co-author of the new study in The Astronomical Journal. "Estimating how common different kinds of planets are around different stars can provide important constraints on planet formation and evolution theories, and help optimize future missions dedicated to finding exoplanets."

According to UBC astronomer Jaymie Matthews: "Our Milky Way has as many as 400 billion stars, with seven per cent of them being G-type. That means less than six billion stars may have Earth-like planets in our Galaxy."

Previous estimates of the frequency of Earth-like planets range from roughly 0.02 potentially habitable planets per Sun-like star, to more than one per Sun-like star.

Typically, planets like Earth are more likely to be missed by a planet search than other types, as they are so small and orbit so far from their stars. That means that a planet catalogue represents only a small subset of the planets that are actually in orbit around the stars searched. Kunimoto used a technique known as 'forward modelling' to overcome these challenges.

"I started by simulating the full population of exoplanets around the stars Kepler searched," she explained. "I marked each planet as 'detected' or 'missed' depending on how likely it was my planet search algorithm would have found them. Then, I compared the detected planets to my actual catalogue of planets. If the simulation produced a close match, then the initial population was likely a good representation of the actual population of planets orbiting those stars."

Kunimoto's research also shed more light on one of the most outstanding questions in exoplanet science today: the 'radius gap' of planets. The radius gap demonstrates that it is uncommon for planets with orbital periods less than 100 days to have a size between 1.5 and two times that of Earth. She found that the radius gap exists over a much narrower range of orbital periods than previously thought. Her observational results can provide constraints on planet evolution models that explain the radius gap's characteristics.

Previously, Kunimoto searched archival data from 200,000 stars of NASA's Kepler mission. She discovered 17 new planets outside of the Solar System, or exoplanets, in addition to recovering thousands of already known planets.

Breakthrough discovery to transform prostate cancer treatment

Date: June 20, 2020
Source: University of South Australia
Summary: A novel formulation of the prostate cancer drug abiraterone acetate— currently marketed as Zytiga— will dramatically improve the quality of life for people suffering from prostate cancer, as pre-clinical trials show the new formulation improves the drug's effectiveness by 40 per cent.

A novel formulation of the prostate cancer drug abiraterone acetate— currently marketed as Zytiga— will dramatically improve the quality of life for people suffering from prostate cancer, as pre-clinical trials by the University of South Australia show the new formulation improves the drug's effectiveness by 40 per cent.

Developed by Professor Clive Prestidge's Nanostructure and Drug Delivery research group at UniSA's Cancer Research Institute, the breakthrough discovery uses an oil-based oral formulation that not only enables a smaller dose of the drug to be effective, but also has the potential to dramatically reduce possible side effects such as joint swelling and diarrhea.

Despite Zytiga being the leading formulation to treat prostate cancer, lead researcher, Dr Hayley Schultz says the new formulation will ultimately provide a better treatment for patients with prostate cancer.

Prostate cancer is the most commonly diagnosed cancer in men, with one in six at risk of diagnosis before the age of 85. In 2019, more than 19,500 cases of prostate cancer were diagnosed in Australia. Globally, prostate cancer cases reached 1.28 million in 2018.

"Many drugs are poorly water soluble, so when they're ingested, they enter the gut but don't dissolve, which means that their therapeutic effect is limited," Dr Schultz says.

"This is the case for Zytiga. Here, only 10 per cent of the dose is absorbed, leaving the other 90 per cent undissolved, where it simply passes through the body as waste.

"On top of this, patients taking Zytiga must fast for two hours prior to taking the drug, and another hour after taking the drug to achieve predictable absorption. And as you can imagine, this can be painstakingly inconvenient.

"Our new formulation changes this. By using oils to mimic pharmaceutical food effects, we're able to significantly increase the drug's solubilisation and absorption, making it more effective and a far less invasive treatment for patients."

The new formulation uses very high levels of abiraterone acetate dissolved within a specific oil and encapsulated within porous silica microparticles to form a powder that can be made into tablets or filled into capsules. Applied to human treatment, it could reduce the dose from 1000mg to 700mg per day, without the need for fasting.

Professor Prestidge says if the team can secure funding, clinical trials in humans could be just two years away.

"Based on our knowledge of this drug's pharmaceutical food effect, we hypothesise its absorption in humans will be extensively improved using this technology," Professor Prestidge says.

"Anything we can do to contribute to the development of a commercialised product to improve the lives of patients, is invaluable.

"This novel formulation is flexible enough to be adopted by thousands of different medicines; its potential to help patients of all kinds is exponential."

No single solution helps all students complete MOOCs

Date: June 15, 2020
Source: Cornell University
Summary: In one of the largest educational field experiments ever conducted, researchers found that promising interventions to help students complete online courses were not effective on a massive scale suggesting that targeted solutions are needed to help students in different circumstances or locations.

In one of the largest educational field experiments ever conducted, a team co-led by a Cornell researcher found that promising interventions to help students complete online courses were not effective on a massive scale— suggesting that targeted solutions are needed to help students in different circumstances or locations.

Researchers tracked 250,000 students from nearly every country in 250 massive open online courses (MOOCs) over 2 ½ years in the study, "Scaling Up Behavioural Science Interventions in Online Education," published June 15 in the Proceedings of the National Academy of Sciences.

"Behavioural interventions are not a silver bullet," said Rene Kizilcec, Assistant Professor of information science and co-lead author.

"Earlier studies showed that short, light-touch interventions at the beginning of a few select courses can increase persistence and completion rates," he said. "But when scaled up to over 250 different courses and a quarter of a million students, the intervention effects were an order of magnitude smaller."

The study was co-led by Justin Reich of the Massachusetts Institute of Technology and Michael Yeomans of Imperial College London. The research was conducted on the edX and Open edX platforms, and edX has engaged in work to make the data available to institutional researchers to advance educational science at scale.

The 250 courses the researchers studied came from Harvard University, MIT and Stanford University.

Failure to complete online courses is a well-known and long-standing obstacle to virtual learning, particularly among disadvantaged communities and in developing nations - where online education can be a key path to social advancement. The findings have added relevance with so much education around the world taking place online during the COVID-19 pandemic.

"My advice to instructors is to understand and address the specific challenges in their learning environment," Kizilcec said. "If students have issues with their internet connection, you can't help them overcome them with a self-regulation intervention. But if students need to go to bed on time in order to be awake for a morning lecture, or they need to plan ahead for when to start working on homework in order to have it ready to hand in, then a brief self-regulation intervention can in fact helps students overcome these obstacles."

Previous, smaller-scale research, performed by Kizilcec and his co-authors as well as other scholars, found that goal-setting interventions such as writing out a list of intentions at the start of the class improved students' course completion rates.

In this study, the researchers explored the effects of four interventions:

- plan-making, where students are prompted to develop detailed plans for when, where, and how they complete coursework;
- a related activity in which students reflect on the benefits and barriers of achieving their goal, and plan ahead about how to respond to challenges;
- social accountability, where they pick someone to hold them accountable for their progress in the course, and plan when and what to tell them; and
- value-relevance, where they write about how completing the course reflects and reinforces their most important values.

For the first three interventions, involving planning ahead, the researchers found that the approach was effective in boosting engagement for the first few weeks of the course, but the impact dwindled as the course progressed. The value-relevance intervention was effective in developing countries where student outcomes were significantly worse than others, but only in courses with a global achievement gap; in other courses, it actually had a negative impact in developing countries.

The researchers tested whether they could predict in which courses an achievement gap would occur, in order to decide where the extremely difficult to predict.

intervention should be added, but found it "Not knowing if it will help or hurt students in a given course is a big issue," he said.

The researchers attempted to use machine learning to predict which interventions might help which students, but found the algorithm was no better than assigning the same intervention to all students.

"It calls into question the potential of AI to provide personalised interventions to struggling students," Kizilcec said. "Approaches that focus on understanding what works best in individual environments and then tailoring interventions to those environments might be more effective."

The researchers said their findings suggest that future studies should be designed to consider and reveal the differences among students, in addition to studies assessing overall effects.

The paper was co-authored by Christopher Dann of Carnegie Mellon University, Emma Brunskill of Stanford University, Glenn Lopez and Dustin Tingley of Harvard, Selen Turkay of the Queensland University of Technology and Joseph J. Williams of the University of Toronto. The research was partly funded by the National Science Foundation, a Stanford Interdisciplinary Graduate Fellowship and a Microsoft Faculty Fellowship.

Survey finds large increase in psychological distress reported among US adults during the COVID-19 pandemic

Date: June 3, 2020
Source: Johns Hopkins University Bloomberg School of Public Health

Summary: A new survey conducted during the COVID-19 pandemic found a more-than-threefold increase in the percentage of US adults who reported symptoms of psychological distress— from 3.9 per cent in 2018 to 13.6 per cent in April 2020.

A new survey conducted by researchers at the Johns Hopkins Bloomberg School of Public Health during the COVID-19 pandemic found a more-than-threefold increase in the percentage of US adults who reported symptoms of psychological distress— from 3.9 per cent in 2018 to 13.6 per cent in April 2020. The percentage of adults ages 18–29 in the U.S. who reported psychological distress increased from 3.7 percent in 2018 to 24 per cent in 2020.

The survey, fielded online April 7 to 13, found that 19.3 per cent of adults with annual household incomes less than $35,000 reported psychological distress in 2020 compared to 7.9 per cent in 2018, an increase of 11.4 percentage points. Nearly one-fifth, or 18.3 per cent, of Hispanic adults reported psychological distress in 2020 compared to 4.4 per cent in 2018, a more than four-fold increase of 13.9 percentage points. The researchers also found that psychological distress in adults age 55 and older almost doubled from 3.8 per cent in 2018 to 7.3 pe rcent in 2020.

The survey found only a slight increase in feelings of loneliness, from 11 per cent in 2018 to 13.8 per cent in 2020, suggesting that loneliness is not driving increased psychological distress.

The findings were published online June 3 in a research letter in JAMA.

The disruptions of the COVID-19 pandemic- social distancing, fear of contracting the disease, economic uncertainty, including high unemployment— have negatively affected mental health. The pandemic has also disrupted access to mental health services.

"We need to prepare for higher rates of mental illness among US adults post-COVID," says McGinty. "It is especially important to identify mental illness treatment needs, and connect people to services, with a focus on groups with high psychological distress, including young adults, adults in low-income households, and Hispanics."

The survey used a scale to assess feelings of emotional suffering and symptoms of anxiety and depression in the past 30 days. The survey questions included in this analysis did not ask specifically about COVID-19. The scale, a validated measure of psychological distress, has been shown to accurately predict clinical diagnoses of serious mental illness.

Using NORC AmeriSpeak, a nationally representative online survey panel, the researchers analysed survey responses of 1,468 adults age 18 and older. They compared the measure of psychological distress in this survey sample from April 2020 to an identical measure from the 2018 National Health Interview Survey.

"The study suggests that the distress experienced during COVID-19 may transfer to longer-term psychiatric disorders requiring clinical care," says McGinty. "Healthcare providers, educators, social workers, and other front-line providers can help promote mental wellness and support."

"Psychological distress and loneliness reported by US adults in 2018 and April, 2020" was written by Emma E. McGinty, Rachel Presskreischer, Hahrie Han, and Colleen L. Barry.

The study was supported by the Johns Hopkins University, the Johns Hopkins Bloomberg School of Public Health, and the Robert Wood Johnson Foundation.

Bat 'super immunity' may explain how bats carry coronaviruses, study finds

Bat-virus adaptation may explain species spillover, researchers say

Date: May 6, 2020
Source: University of Saskatchewan
Summary: Researchers have uncovered how bats can carry the Middle East Respiratory Syndrome (MERS) coronavirus without getting sick— research that could shed light on how coronaviruses make the jump to humans and other animals.

A University of Saskatchewan (USask) research team has uncovered how bats can carry the Middle East Respiratory Syndrome (MERS) coronavirus without getting sick- research that could shed light on how coronaviruses make the jump to humans and other animals.

Coronaviruses such as MERS, Severe Acute Respiratory Syndrome (SARS), and more recently the COVID19-causing SARS-CoV-2 virus, are thought to have originated in bats. While these viruses can cause serious and often fatal disease in people, for reasons not previously well understood, bats seem unharmed.

"The bats don't get rid of the virus and yet don't get sick. We wanted to understand why the MERS virus doesn't shut down the bat immune responses as it does in humans," said USask microbiologist Vikram Misra.

In research just published in Scientific Reports, the team has demonstrated, for the first time, that cells from an insect-eating brown bat can be persistently infected with MERS coronavirus for months, due to important adaptations from both the bat and the virus working together.

"Instead of killing bat cells as the virus does with human cells, the MERS coronavirus enters a long-term relationship with the host, maintained by the bat's unique 'super' immune system," said Misra, corresponding author on the paper. "SARS-CoV-2 is thought to operate in the same way."

Misra says the team's work suggests that stresses on bats - such as wet markets, other diseases, and possibly habitat loss— may have a role in coronavirus spilling over to other species.

"When a bat experiences stress to their immune system, it disrupts this immune system-virus balance and allows the virus to multiply," he said.

The research was carried out at USask's Vaccine and Infectious Disease Organization-International Vaccine Centre (VIDO-InterVac), one of the world's largest containment level 3 research facilities, by a team of researchers from USask's Western College of Veterinary Medicine and VIDO-InterVac.

"We see that the MERS coronavirus can very quickly adapt itself to a particular niche, and although we do not completely understand what is going on, this demonstrates how coronaviruses are able to jump from species to species so effortlessly," said VIDO-InterVac scientist Darryl Falzarano, who co-led the bat study, developed the first potential treatment for MERS-CoV, and is leading VIDO-InterVac's efforts to develop a vaccine against COVID-19.

So far, the SARS-CoV-2 virus has infected more than 3.5 million people worldwide and killed 7 per cent of those infected. In contrast, the MERS virus infected nearly 2,500 people in 2012 but killed one in every three people infected. There is no vaccine for either SARS-CoV-2 or MERS. While camels are the known intermediate hosts of MERS-CoV, bats are suspected to be the ancestral host.

Coronaviruses rapidly adapt to the species they infect, Misra said, but little is known on the molecular interactions of these viruses with their natural bat hosts. A 2017 USask-led study showed that bat coronaviruses can persist in their natural bat host for at least four months of hibernation.

When exposed to the MERS virus, bat cells adapt— not by producing inflammation-causing proteins that are hallmarks of getting sick, but rather by maintaining a natural antiviral response, a function which shuts down in other species, including humans. Simultaneously, the MERS virus also adapts to the bat host cells by very rapidly mutating one specific gene, he said.

Operating together, these adaptations result in the virus remaining long-term in the bat but being rendered harmless until something—such as disease or other stressors–upsets this delicate equilibrium.

Next, the team will turn its focus to understanding how the bat-borne MERS virus adapts to infection and replication in camelid (a group of even-toed ungulates that includes camels) and human cells.

"This information may be critical for predicting the next bat virus that will cause a pandemic," said Misra.

Lead researchers on the paper were Misra's former PhD students Arinjay Banerjee and Sonu Subudhi who are now at McMaster University and Massachusetts General Hospital respectively. Other team members included researchers Noreen Rapin and Jocelyne Lew, as well as summer student Richa Jain.

Why COVID-19 may be less common in children than adults

Findings could lead to potential biomarker of susceptibility

Date: May 22, 2020
Source: The Mount Sinai Hospital / Mount Sinai School of Medicine
Summary: Researchers have found that children have lower levels of ACE2 gene expression than adults, which may explain children's lower risk of COVID-19 infection and mortality.

The virus that causes COVID-19 uses a receptor known as ACE2, found on the surface of certain cells in the human body, to enter its victims. Now, Mount Sinai researchers have found that children have lower levels of ACE2 gene expression than adults, which may explain children's lower risk of COVID-19 infection and mortality. Gene expression is a measure of how much a gene is transcribed.

These results, published in JAMA on Wednesday, May 20, may point to a potential biomarker of susceptibility to the virus, known as SARS-CoV-2.

"ACE2 expression may be linked to our susceptibility to COVID-19," says lead author Supinda Bunyavanich, MD, MPH, Professor of Genetics and Genomic Sciences and

Pediatrics, Icahn School of Medicine at Mount Sinai. "ACE2, which stands for angiotensin converting enzyme 2, is a receptor that some might be familiar with because of its role in blood pressure regulation. The coronavirus uses ACE2 to enter the human body, where it spreads. ACE2 is known to be present in our airway, kidneys, heart, and gut. In our study, we took this knowledge a step further, finding that there are low levels of ACE2 expression in the nasal passages of younger children, and this ACE2 level increases with age into adulthood. This might explain why children have been largely spared in the pandemic."

The research focused on ACE2 due to its significance in COVID-19 infection. The nasal passages are usually the first point of contact for SARS-CoV-2 and the human body. Dr. Bunyavanich's study is one of only a few examining the relationship between ACE2 in the airway and age.

The retrospective analysis, led by Dr. Bunyavanich, examined nasal passages epithelium from Mount Sinai Health System patients aged 4 to 60. The researchers found ACE2 gene expression in nasal epithelium was age-dependent, lowest in younger children and increasing with age into adulthood.

Wearing surgical masks in public could help slow COVID-19 pandemic's advance Masks may limit the spread diseases, including influenza, rhinoviruses and coronaviruses

Date: April 3, 2020
Source: University of Maryland
Summary: Surgical masks may help prevent infected people from making others sick with seasonal viruses, including coronaviruses, according to new research. In laboratory experiments, the masks significantly reduced the amounts of various airborne viruses coming from infected patients, measured using the breath-capturing 'Gesundheit II machine.'

Surgical masks may help prevent infected people from making others sick with seasonal viruses, including coronaviruses, according to new research that could help settle a fierce debate spanning clinical and cultural norms.

In laboratory experiments, the masks significantly reduced the amounts of various airborne viruses coming from infected patients, measured using the breath-capturing "Gesundheit II machine" developed by Dr. Don Milton, a professor of applied environmental health and a senior author of the study published April 3 in the journal Nature Medicine.

Milton has already conferred with federal and White House health officials on the findings, which closely follow statements this week from the head of the Centers for Disease Control and Prevention saying the agency was reconsidering oft-stated advice that surgical masks aren't a useful precaution outside of medical settings. (The debate takes place at a time when clinicians themselves face dangerously inadequate supplies of masks- a shortfall other UMD researchers are scrambling to help solve).

The question of masks has roiled society as well, with some retailers refusing to let employees wear them for fear of sending negative signals to customers, and cases of slurs and even physical attacks in the United States and elsewhere against Asians or Asian Americans who were wearing masks, a measure some consider a necessity during a disease outbreak.

The study, conducted prior to the current pandemic with a student of Milton's colleagues on the Faculty of Medicine at the University of Hong Kong, does not address the question of whether surgical masks protect wearers from infection. It does suggest that masks may limit how much the infected- who in the case of the novel coronavirus often don't have symptoms–spread diseases including influenza, rhinoviruses and coronaviruses.

Milton, who runs the Public Health Aerobiology, Virology, and Exhaled Biomarker Laboratory in the School of Public Health, demonstrated in a 2013 study that surgical masks could help limit flu transmission. However, he cautions that the effect may not be as great outside of controlled settings.

Nevertheless, he said, the chance they could help justifies taking a new look at whether all people should be encouraged to wear them when they venture out of their houses to stores or other populated locations during the current COVID-19 lockdown.

"In normal times, we'd say that if it wasn't shown statistically significant or the effective in real-world studies, we don't recommend it," he said. "But in the middle of a pandemic, we're desperate. The thinking is that even if it cuts down transmission a little bit, it's worth trying."

Previous studies have shown that coronavirus and other respiratory infections are mostly spread during close contact, which has been interpreted by some infectious disease specialists to mean that the disease could spread only through contact and large droplets, such as from a cough or sneeze— a message that has often been shared with the public.

"What they don't understand is that is merely a hypothesis," Milton said. The current study (along with earlier ones) shows, by contrast, that tiny, aerosolised droplets can indeed diffuse through the air. That means it may be possible to contract COVID-19 not only by being coughed on, but by simply inhaling the breath of someone nearby who has it, whether they have symptoms or not. Surgical masks, however, catch a lot of the aerosolized virus as it's exhaled, he said.

The study was conducted at the University of Hong Kong as part of the dissertation research of the lead author, Dr. Nancy Leung, who, under the supervision of the co-senior authors Drs. Cowling and Milton, recruited 246 people with suspected respiratory viral infections. Milton's Gesundheit machine compared how much virus they exhaled with and without a surgical mask.

"In 111 people infected by either coronavirus, influenza virus or rhinovirus, masks reduced detectable virus in respiratory droplets and aerosols for seasonal coronaviruses, and in respiratory droplets for influenza virus," Leung said. "In contrast, masks did not reduce the emission of rhinoviruses."

Although the experiment took place before the current pandemic, COVID-19 and seasonal coronaviruses are closely related and may be of similar particle size. The report's other senior author, Professor Benjamin Cowling, division head of epidemiology and biostatistics, School of Public Health, HKUMed, and co-director of the World Health Organization Collaborating Centre for Infectious Disease Epidemiology and Control, said, "The ability of surgical masks to reduce seasonal coronavirus in respiratory droplets and aerosols implies that such masks can contribute to slowing the spread of (COVID-19) when worn by infected people."

Milton pointed to other measures his research has found is even more effective than masks, such as improving ventilation in public places like grocery stores, or installing UV-C lights near the ceiling that works in conjunction with ceiling fans to pull air upwards and destroy viruses and bacteria.

"Personal protective equipment like N95 masks are not our first line of defense," Milton said. "They are our last desperate thing that we do."

Crises are no excuses for lowering scientific standards, say ethicists

Date: April 23, 2020
Source: Carnegie Mellon University
Summary: Ethicists are calling on the global research community to resist treating the urgency of the current COVID-19 outbreak as grounds for making exceptions to rigorous research standards in pursuit of treatments and vaccines.

Ethicists from Carnegie Mellon and McGill Universities are calling on the global research community to resist treating the urgency of the current COVID-19 outbreak as grounds for making exceptions to rigorous research standards in pursuit of treatments and vaccines.

With hundreds of clinical studies registered on ClinicalTrials.gov, Alex John London, the Clara L. West Professor of Ethics and Philosophy and director of the Center for Ethics and Policy at Carnegie Mellon, and Jonathan Kimmelman, James McGill Professor and director of the Biomedical Ethics Unit at McGill University, caution that urgency should not be used as an excuse for lowering scientific standards. They argue that many of the deficiencies in the way medical research is conducted under normal circumstances seem to be amplified in this pandemic. Their paper, published online April 23 by the journal Science, provides recommendations for conducting clinical research during times of crises.

"Although crises present major logistical and practical challenges, the moral mission of research remains the same: to reduce uncertainty and enable care givers, health systems and policy makers to better address individual and public health," London and Kimmelman said.

Many of the first studies out of the gate in this pandemic have been poorly designed, not well justified, or reported in a biased manner. The deluge of studies registered in their wake threaten to duplicate efforts, concentrate resources on strategies that have received outsized media attention and increase the potential of generating false positive results purely by chance.

"All crises present exceptional situations in terms of the challenges they pose to health and welfare. But the idea that crises present an exception to the challenges of evaluating the effects drugs and vaccines is a mistake," London and Kimmelman said. "Rather than generating permission to carry out low-quality investigations, the urgency and scarcity of pandemics heighten the responsibility of key actors in the research enterprise to coordinate their activities to uphold the standards necessary to advance this mission."

The ethicists provide recommendations for multiple stakeholder groups involved in clinical trials:

- Sponsors, research consortia and health agencies should prioritise research approaches that test multiple treatments side by side. The authors argue that "master protocols" enable multiple treatments to be tested under a common statistical framework.
- Individual clinicians should avoid off-label use of unvalidated interventions that might interfere with trial recruitment and resist the urge to carry out small studies with no control groups. Instead, they should seek out opportunities to join larger, carefully orchestrated studies.
- Regulatory agencies and public health authorities should play a leading role in identifying studies that meet rigorous standards and in fostering collaboration among a sufficient number of centers to ensure adequate recruitment and timely results. Rather than making public recommendations about interventions whose clinical merits remain to be established, health authorities can point stakeholders to recruitment milestones to elevate the profile and progress of high-quality studies.

"Rigorous research practices can't eliminate all uncertainty from medicine," London and Kimmelman said, "but they can represent the most efficient way to clarify the causal relationships clinicians hope to exploit in decisions with momentous consequences for patients and health systems."

Scientists unveil how general anesthesia works

Date: April 27, 2020
Source: Okinawa Institute of Science and Technology (OIST) Graduate University
Summary: The discovery of general anesthetics— compounds which induce unconsciousness, prevent control of movement and block pain— helped transform dangerous operations into safe surgery. But scientists still don't understand exactly how general anesthetics work. Now, researchers have revealed how a general anesthetic called isoflurane weakens the transmission of electrical signals between neurons, at junctions called synapses.

Hailed as one of the most important medical advances, the discovery of general anesthetics— compounds which induce unconsciousness, prevent control of movement and block pain— helped transform dangerous and traumatic operations into safe and routine surgery. But despite their importance, scientists still don't understand exactly how general anesthetics work.

Now, in a study published this week in the Journal of Neuroscience, researchers from the Okinawa Institute of Science and Technology (OIST) Graduate University and Nagoya University have revealed how a commonly used general anesthetic called isoflurane weakens the transmission of electrical signals between neurons, at junctions called synapses.

"Importantly, we found that isoflurane did not block the transmission of all electrical signals equally; the anesthetic had the strongest effect on higher frequency impulses that are required for functions such as cognition or movement, whilst it had minimal effect on low frequency impulses that control life-supporting functions, such as breathing," said Professor Tomoyuki Takahashi, who leads the Cellular and Molecular Synaptic Function (CMSF) Unit at OIST. "This explains how isoflurane is able to cause anesthesia, by preferentially blocking the high frequency signals."

At synapses, signals are sent by presynaptic neurons and received by postsynaptic neurons. At most synapses, communication occurs via chemical messengers— or neurotransmitters.

When an electrical nerve impulse, or action potential, arrives at the end of the presynaptic neuron, this causes synaptic vesicles- tiny membrane 'packets' that contain neurotransmitters— to fuse with the terminal membrane, releasing the neurotransmitters into the gap between neurons. When enough neurotransmitters are sensed by the postsynaptic neuron, this triggers a new action potential in the post-synaptic neuron.

The CMSF unit used rat brain slices to study a giant synapse called the calyx of Held. The scientists induced electrical signals at different frequencies and then detected the action potentials generated in the postsynaptic neuron. They found that as they increased the frequency of electrical signals, isoflurane had a stronger effect on blocking transmission.

To corroborate his unit's findings, Takahashi reached out to Dr. Takayuki Yamashita, a researcher from Nagoya University who conducted experiments on synapses, called cortico-cortical synapses, in the brains of living mice.

Yamashita found that the anesthetic affected cortico-cortical synapses in a similar way to the calyx of Held. When the mice were anesthetised using isoflurane, high frequency transmission was strongly reduced whilst there was less effect on low frequency transmission.

"These experiments both confirmed how isoflurane acts as a general anesthetic," said Takahashi. "But we wanted to understand what underlying mechanisms isoflurane targets to weaken synapses in this frequency-dependent manner."

Tracking down the targets

With further research, the researchers found that isoflurane reduced the amount of neurotransmitter released, by both lowering the probability of the vesicles being released and by reducing the maximum number of vesicles able to be released at a time.

The scientists therefore examined whether isoflurane affected calcium ion channels, which are key in the process of vesicle release. When action potentials arrive at the presynaptic terminal, calcium ion channels in the membrane open, allowing calcium ions to flood in. Synaptic vesicles then detect this rise in calcium, and they fuse with the membrane.
The researchers found that isoflurane lowered calcium influx by blocking calcium ion channels, which, in turn, reduced the probability of vesicle release.

"However, this mechanism alone could not explain how isoflurane reduces the number of releasable vesicles, or the frequency-dependent nature of isoflurane's effect," said Takahashi.

The scientists hypothesized that isoflurane could reduce the number of releasable vesicles by either directly blocking the process of vesicle release by exocytosis, or by indirectly blocking vesicle recycling, where vesicles are reformed by endocytosis and then refilled with neurotransmitter, ready to be released again.

By electrically measuring the changes in the surface area of the presynaptic terminal membrane, which is increased by exocytosis and decreased by endocytosis, the scientists concluded that isoflurane only affected vesicle release by exocytosis, likely by blocking exocytic machinery.

"Crucially, we found that this block only had a major effect on high frequency signals, suggesting that this block on exocytic machinery is the key to isoflurane's anesthetizing effect," said Takahashi.

The scientists proposed that high frequency action potentials trigger such a massive influx of calcium into the presynaptic terminal that isoflurane cannot effectively reduce the calcium concentration. Synaptic strength is therefore weakened predominantly by the direct block of exocytic machinery rather than a reduced probability of vesicle release.

Meanwhile, low frequency impulses trigger less exocytosis, so isoflurane's block on exocytic machinery has little effect. Although isoflurane effectively reduces entry of calcium into the presynaptic terminal, lowering the probability of vesicle release, by itself, is not powerful enough to block postsynaptic action potentials at the calyx of Held and has only a minor effect in cortico-cortical synapses. Low frequency transmission is therefore maintained.

Overall, the series of experiments provide compelling evidence to how isoflurane weakens synapses to induce anesthesia.

"Now that we have established techniques of manipulating and deciphering presynaptic mechanisms, we are ready to apply these techniques to tougher questions, such as presynaptic mechanisms underlying symptoms of neurodegenerative diseases," said Takahashi. "That will be our next challenge."

Replacing time spent sitting with sleep or light activity may improve your mood

Date: May 20, 2020
Source: Iowa State University
Summary: New research found that substituting prolonged sedentary time with sleep was associated with lower stress, better mood and lower body mass index (BMI), and substituting light physical activity was associated with improved mood and lower BMI across the next year.

Moving more and sitting less was a challenge for many of us, even before states started issuing stay-at-home orders. Despite disruptions to our daily work and exercise routines, there are some subtle changes we can make at home to help improve our mental health.

New research, published by the American Journal of Preventive Medicine, found that substituting prolonged sedentary time with sleep was associated with lower stress, better mood and lower body mass index (BMI), and substituting light physical activity was associated with improved mood and lower BMI across the next year. Jacob Meyer, lead author and Assistant Professor of kinesiology at Iowa State University, says, "light activity can include walking around your home office while talking on the phone or standing while preparing dinner."

"People may not even think about some of these activities as physical activity," Meyer said. "Light activity is much lower intensity than going to the gym or walking to work, but taking these steps to break up long periods of sitting may have an impact."

Meyer and colleagues used data collected as part of the Energy Balance Study at the University of South Carolina. For 10 days, study participants, ranging in age from 21 to 35, wore an armband that tracked their energy expenditure. Meyer, director of the Wellbeing and Exercise Lab at Iowa State, says the data allowed researchers to objectively measure sleep, physical activity and sedentary time, rather than relying on self-reports.

In addition to the benefits of sleep and light physical activity, the researchers found moderate to vigorous activity was associated with lower body fat and BMI. Given the negative health effects of prolonged sedentary time, Meyer says the findings may encourage people to make small changes that are sustainable.

"It may be easier for people to change their behaviour if they feel it's doable and doesn't require a major change," Meyer said. "Replacing sedentary time with housework or other light activities is something they may be able to do more consistently than going for an hour-long run."

Getting more sleep is another relatively simple change to make. Instead of staying up late watching TV, going to bed earlier and getting up at a consistent time provides multiple benefits and allows your body to recover, Meyer said. Sleeping is also unique in that it is time you're not engaging in other potentially problematic behaviors, such as eating junk food while sitting in front of a screen.

Something we can control

Making these subtle changes was associated with better current mood, but light physical activity also provided benefits for up to a year, the study found. While the research was conducted prior to the COVID-19 pandemic, Meyer says the results are timely given the growing mental health concerns during this time of physical distancing.

"With everything happening right now, this is one thing we can control or manage, and it has the potential to help our mental health," Meyer said.

As the states start to ease stay-at-home restrictions, Meyer is looking at changes in physical activity and sitting time with potentially interesting results for those who regularly worked out prior to the pandemic. Preliminary data from a separate study show a 32 per cent reduction in physical activity. The question he and colleagues hope to answer is how current changes in activity interact with mental health and how our behaviours will continue to change over time.

Control over work-life boundaries creates crucial buffer to manage after-hours work stress

Date: June 25, 2020
Source: University of Illinois at Urbana-Champaign, News Bureau
Summary: Workers with greater boundary control over their work and personal lives were better at creating a stress buffer to prevent them from falling into a negative rumination trap, says a new study by experts who study occupational stress and employee well-being.

When work intrudes after hours in the form of pings and buzzes from smartphone alerts, it can cause spikes of stress that lead to a host of adverse effects for workers, including negative work rumination, poor affect and insomnia.

But according to research co-written by a team of researchers at the University of Illinois at Urbana-Champaign who study occupational stress and employee well-being, those who have greater "boundary control" over their work and personal lives were better at creating a stress buffer that helped protect them from falling into a negative-rumination trap.

Information communication technologies such as smartphones and tablets enable employees to work anywhere and anytime, thereby blurring work and non work boundaries. But that convenience comes at the expense of increased stress and mental health woes for workers unless they have control over the boundaries between work and non work life, said YoungAh Park, a professor of labor and employment relations at Illinois.

"Most people simply can't work without a smartphone, tablet or laptop computer," she said. "These technologies are so ubiquitous and convenient that it can lead some people to think that employees have to be always on or always available. Clearly, this kind of after-hours intrusion into the home or personal life domain is unhealthy, and our research shows that an always-on mentality has a big downside in the form of increased job stress."

In the study, Park and co-authors surveyed more than 500 full-time public school teachers in grades K-6 to measure their off-the-clock work intrusion via technologies on a weekly basis for five consecutive weeks.

"We asked about their weekly work intrusion involving technology, specifically their after-hours work— whether they were expected to respond to work-related messages and emails immediately, and whether they were contacted about work-related issues after hours," she said.

The researchers found that teachers' adoption of technological boundary tactics such as keeping work email alerts turned off on smartphones was related to lower perceptions of the weekly work intrusion.

The study builds on recent scholarship on how coping with off-hours occupational demands is becoming an increasingly important issue for workers, said Yihao Liu, a professor of labor and employment relations at Illinois and a co-author of the study.

"Managing your work-life balance through boundary control is not only helpful for you and your family, it also could be a benefit for your co-workers, because they also have to potentially read and respond to the back-and-forth messages that people are sending after the workday is done," he said. "Setting a good boundary between work and regular life is going to help more people and more stakeholders. Overall, it's critical that individuals manage their work-life boundaries for their own health and well-being, but also for their own productivity and their colleagues' productivity."

Moreover, the researchers found that teachers' boundary control softened the work intrusion-negative rumination link and that this boundary control was an important mechanism by which two "border keepers"—principals, who effectively functioned as supervisors in the study; and parents, who could be thought of as clientele— can affect teachers' weekly stress experiences.

In other words, the weekly strain symptoms involving work intrusion can be alleviated by a supervisor who supports employees' work-life balance, Park said. Or conversely, it can be aggravated by clientele who expect employees to be always accessible and available.

"A really important point around the sense of boundary control is that stakeholders can influence employees' control," she said. "Our study suggests that school principals can play a positive role in that their support for work-life balance was associated with the teachers' greater sense of boundary control. When you have supportive leaders who model behaviors for work-life balance and work effectively with employees to creatively solve work-life conflicts, that translates into less stress for teachers through boundary control."

Although the study only included elementary school teachers in its sample, the findings about drawing clear boundaries after work ought to apply to most workers, especially now that more are working remotely due to the COVID-19 pandemic, the researchers said.

"Our initial motivation was to study teachers because we tend to assume that their work and nonwork lives are separate and distinct," Park said. "Teachers have set schedules in a physical building, along with discrete blocks of free time over the weekends. But even with this working population, we found that after-hours work intrusion via technology can be really stressful for them. So although this finding is particular to teachers, a class of employees who we tend to assume have clear work-life boundaries, it's now an issue for everyone who is electronically tethered to their work after regular hours."

Drinking sugary drinks daily may be linked to higher risk of CVD in women

Date: May 13, 2020
Source: American Heart Association
Summary: In a study of female California teachers, drinking one or more sugary beverages daily was associated with nearly a 20 per cent higher risk of having cardiovascular disease (CVD) when compared to those who rarely or never drank sugary beverages. Daily consumption of fruit drinks with added sugars was associated with a 42 per cent greater likelihood of having cardiovascular disease when compared to those who rarely or never drank sugary beverages.

Drinking one or more sugary beverages a day was associated with a nearly 20 per cent greater likelihood of women having a cardiovascular disease compared to women who rarely or never drank sugary beverages, according to new research published today in the Journal of the American Heart Association, an open access journal of the American Heart Association.

In the large, ongoing California Teacher's Study, which began in 1995, drinking one or more of any type of sugary beverage daily was associated with a 26 per cent higher likelihood of needing a revascularization procedure, such as angioplasty to open clogged arteries and a 21 per cent higher likelihood of having a stroke compared to women who rarely or never drank sugary beverages. Sugary beverages in this study were defined as caloric soft drinks, sweetened bottled waters or teas and sugar-added fruit drinks, not 100 per cent fruit juices.

There were also differences based on the type of beverage women consumed. Drinking one or more sugar-added fruit drinks daily was associated with a 42 per cent greater likelihood of having cardiovascular disease. Drinking soft drinks such as sodas daily was associated with a 23 per cent higher risk of cardiovascular disease overall, compared to those who rarely or never drank sugary beverages.

The study included more than 106,000 women, with an average age of 52, who had not been diagnosed with heart disease, stroke or diabetes when they were enrolled in the study.

The women reported how much and what they drank via a food questionnaire. Statewide inpatient hospitalisation records were used to determine whether a woman had experienced a heart attack, stroke or surgery to open clogged arteries. Women with the highest sugar-sweetened beverage intake were younger, more likely to be current smokers, obese and less likely to eat healthy foods, among other things.

"Although the study is observational and does not prove cause and effect, we hypothesize that sugar may increase the risk of cardiovascular diseases in several ways. It raises glucose levels and insulin concentrations in the blood, which may increase appetite and lead to obesity, a major risk factor for cardiovascular disease," said lead study author Cheryl Anderson, Ph.D., M.P.H., M.S., professor and interim chair of Family and Public Health, University of California San Diego, and chair of the American Heart Association's Nutrition Committee.

"In addition, too much sugar in the blood is associated with oxidative stress and inflammation, insulin resistance, unhealthy cholesterol profiles and type 2 diabetes, conditions that are strongly linked to the development of atherosclerosis, the slow narrowing of the arteries that underlies most cardiovascular disease," said Anderson.

Strengths of the study included its large sample size, extensive follow-up time and prospective data collection on sugar-sweetened beverages and lifestyle characteristics. In addition, the ability to annually link to statewide hospitalisation and procedure records resulted in accurate endpoints.

Limitations of the study included having only one measurement of sugar-sweetened beverage intake. The study was also unable to evaluate consumption of artificially sweetened beverages and/or sweetened hot beverages.

The American Heart Association recommends limiting added sugar to no more than 100 calories a day (6 teaspoons of sugar or 25 grams) for most women, and no more than 150 calories a day (9 teaspoons of sugar or 38 grams) for most men. Sugar-sweetened beverages are the biggest source of added sugars in the American diet; a typical 12-ounce can of regular soda has 130 calories and 8 teaspoons (34 grams) of sugar.

Although diet soda may provide an alternative for some people who are trying to reduce the amount of sugary drinks in their diet, they do include artificial sweeteners such as saccharin, aspartame, sucralose and others. Water remains the most accessible and healthy beverage to drink regularly -- water has no sugar, no artificial sweeteners and no calories.

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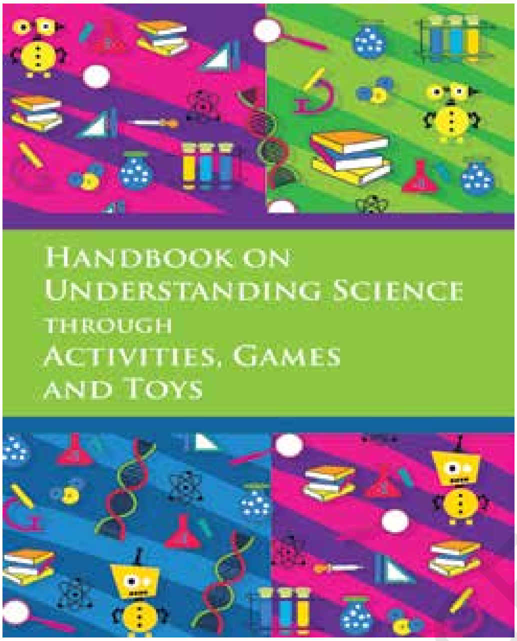

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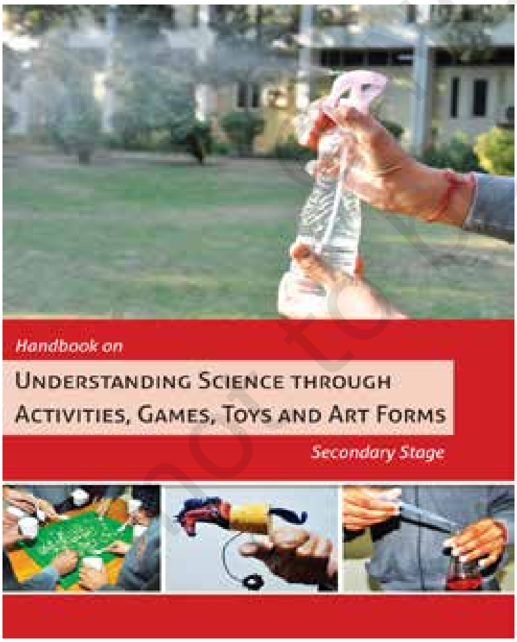

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