TEACHING GRADUATE BIOLOGY

VOLUME II

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Preface

The purpose of higher education is evolving in India and all over the world. It is no longer just a means of gaining subject knowledge and employment thereafter. Equally important goals are developing foresight, critical thinking, people skills, and communication skills, and empowering students to find solutions to problems of today and tomorrow. Educators carry the onus of fulfilling these goals and IndiaBioscience strives to facilitate their success.

How? We believe that networking and sharing of ideas among educators can help them bring their best versions to their classrooms. Yet, the opportunities for them to connect with one another are highly limited. IndiaBioscience, through its online articles, discussion forums, and in-person events, offers **educators at the undergraduate level** and above a platform to share their experiences, challenges, triumphs, ideas and concerns with their peers across the country, and take their pedagogical skills to the next level.

This book is a compendium of select online articles, webinars and podcasts published on the website of IndiaBioscience (https://indiabioscience.org/educators) between 2019 and 2022. Segregated into **7 themes**, this compendium throws light on the **lives and ideologies of educators** (pp. 4-36), their **innovative pedagogical techniques** (pp. 37-62), approaches to address their students' **misconceptions** (pp. 63-83), and their experiences with **undergraduate research** (pp. 84-111).

Education took a significant hit during the COVID-19 pandemic. Educators navigated the waves of the pandemic by shifting their classrooms online – an unfamiliar mode of education for students and teachers alike, saddled with challenges of infrastructure and personal interaction. The fifth section of this compendium is dedicated to **virtual learning** (pp. 112-134) – its good, bad and ugly facets (pp. 113-116), and ways to tap its potential during and beyond the pandemic.

In the penultimate section of the compendium, we discuss matters around current **policies and practices** (pp. 135-156) in higher education, including the National Education Policy (NEP) 2020. And last but far from least, we cover stories and podcast episodes on a topic of immense importance, yet shrouded in myths and taboos – **mental health** (pp. 157-166).

We hope that this compendium is useful to educators as they reflect on the current teaching practices in the country. We also hope that they feel inspired to share their own ideas and experiences with their peers across India by publishing articles on our website, using our online discussion forum (https://discuss.indiabioscience.org/c/education/9), and joining hands with us in organising events, webinars, workshops or podcasts for educators. **We can be reached at education[at]indiabioscience[dot]org**.

We thank all the authors and speakers mentioned in the compendium for choosing IndiaBioscience as a platform to give voice to their thoughts. We also thank our readers, viewers and listeners who have been an invaluable and a constant source of encouragement for us. Furthermore, we thank the Pandit Madan Mohan Malviya National Mission for Teachers and Teaching (PMMMNMTT) Scheme of the Ministry of Education, Govt. of India (2016 to 2021), Department of Biotechnology, Govt. of India (2022- present), and other funding bodies without whose financial support we could not have carried out these activities.

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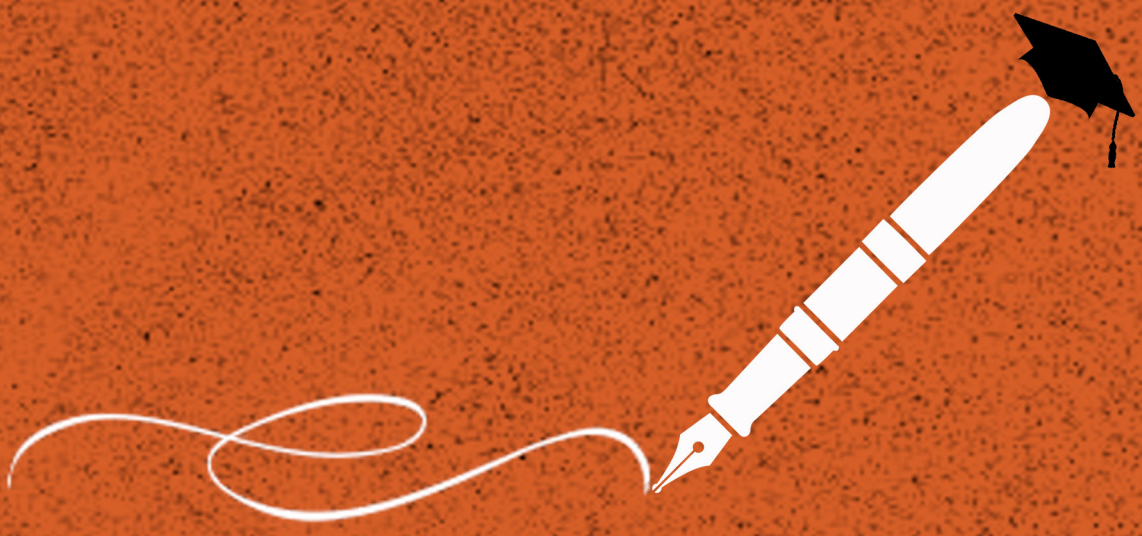
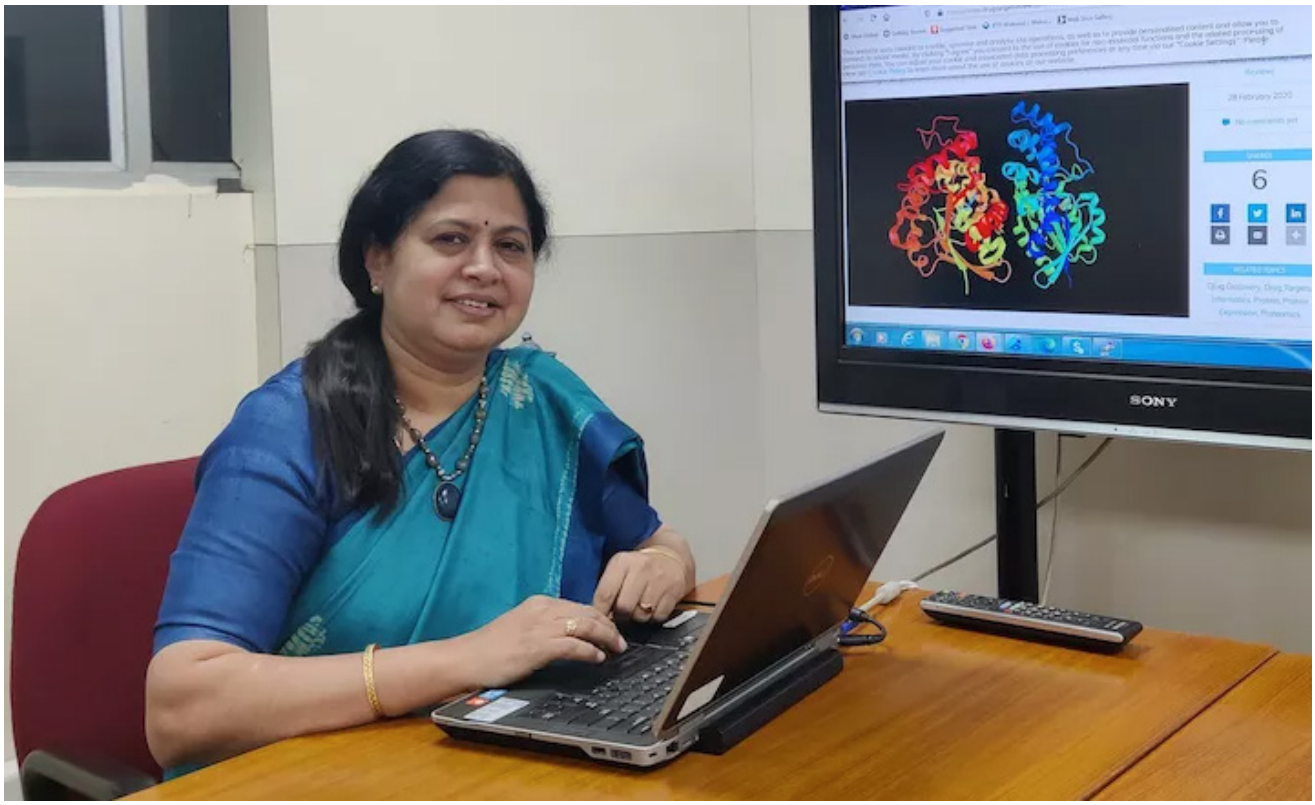


01

Talk with teachers:
Developing academic depth beyond the curriculum

Author: **Vijeta Raghuram**
Date of publication: **15 Mar 2021**

Excerpt: **N. Latha is a scientist and an award-winning educator in the area of bioinformatics & computational biology at Sri Venkateswara College, University of Delhi. The bioinformatics training facility that she has set up and been coordinating in her college has benefitted not only students but also several school and college teachers. Her work has won her many laurels, including the Excellence Award for Teacher in Service by the University of Delhi in 2019 and, more recently, the INSA Teachers Award 2020. In this interview, she shares with IndiaBioscience her reflections on education in the 21st century and the importance of conducting undergraduate research.**



N Latha

Congratulations on winning the INSA Teachers Award 2020! What does this award mean to you and your college?

Thank you! I am honoured to receive the prestigious INSA Teachers Award for the year 2020. There is nothing more gratifying than recognition for a job well done. I feel very proud to be able to set an example that hard work and being passionate about what you do leads to success. I express my sincere gratitude to Sri Venkateswara College, Delhi for continuous support in my journey of teaching and research.

Tell us about your professional journey. What were the challenges you faced during this journey?

I had the opportunity to study in India's finest institutions – Miranda House, University of Delhi for an undergraduate degree in Chemistry, University of Delhi South Campus for a post-graduate program in Biochemistry, and IIT Delhi for a doctoral degree in Bioinformatics & Computational Biology. My teachers have been great pillars for all the foundation and training that helped me reach this far.

I have faced several challenges on my way, but each one of them has only strengthened me and made me a better person. A lot of hard work, motivation, self-learning and patience have helped me along the way.

My teaching career at Sri Venkateswara College, Delhi started immediately after my post-graduation in 1990. I realized from day one that teaching is not a 'one-size-fits-all' experience. In my journey of teaching, the challenges have included improving teaching methodologies to cater to a diverse set of students, adapting to new changes in the curricular framework and facilitating students to the learning process, while also managing all the paperwork, meetings, semester planning, evaluation and assessments. Every batch of students and every academic year present a new challenge. The process of engaging young minds has been a continuous learning experience for me.

Next, after completion of my PhD at IIT Delhi in 2005, the biggest challenge was to set up a Bioinformatics Facility for training and research in an undergraduate college. Generating interest among the undergraduate students in bioinformatics through short-term research projects and certificate courses was the next focus. Research started gaining momentum through collaborative projects at both the national & international levels. All along, to be able to carry out quality research in an undergraduate college has been quite a challenge.

How to be a better teacher? How to balance teaching and research in the college? How to achieve a healthy equilibrium between my professional and personal life? These are some of the everyday challenges I face.

"The 21st-century classroom has its own set of demands, and educators need to be open to providing a learner-centric environment focussing on life and employability skills."

In your 30 years of teaching experience, how have the role and the challenges of educators evolved over time?

Higher education in India has witnessed many changes in the last 30 years. In the initial years of my service as a teacher, curriculum planning and execution, teaching-learning, and evaluation were the major focus areas.

Though there has been an almost unanimous agreement among the educators on the curricular aspects, different pedagogical styles have arisen that have been used extensively.

In light of technological advances, the educational environment has witnessed a change in the entire teaching-learning process. Learning is not just confined to the traditional classroom experience and instruction does not primarily consist of lecturing through textbooks; it's available in bits and bytes.

At the same time, students are more matured and technically well-advanced than in previous times. With increasing batch strength, we come across students from diverse learning abilities and from different socio-economic backgrounds. It is challenging to work on the average student to instil in them the confidence to do better. Today's youth are a bundle of energy. It is important that we channelize their energy in the right direction and make them aware of who they are and what they are capable of.

The 21st -century classroom has its own set of demands, and educators need to be open to providing a learner-centric environment focussing on life and employability skills.

"Supervision of undergraduate research is not seen as integral to academic practice but as an extra, which adds to the academic workload."

There is a lot of emphasis on incorporating research at the undergraduate level. Tell us a bit about the research projects in your lab and how your undergraduate students have benefitted from them.

Biologists have been concerned about the quality of education imparted at the foundational level. Conventionally, teaching-learning practices in biology at the undergraduate level have involved delivering content from textbooks, aided with experimental skills. Over the years, developing academic depth in the chosen discipline beyond the curriculum has become essential. Research has thus become an integral part of undergraduate programs in several universities/colleges across the country. The research component allows a broader educational experience that helps students clarify their interests, and plan their next steps after graduation.

I have mentored several undergraduate projects in the area of bioinformatics & computational biology that have helped my students pursue their higher education. Most of the projects have involved the application of bioinformatics to understand disease biology and in silico approaches for drug designing. The emphasis has always been on emerging diseases that ranged from tuberculosis, HIV, malaria to dengue infection. Recently, students have also investigated computational screening of phytochemicals derived from Indian medicinal plants to identify potential antivirals for SARS-CoV-2 infection.

Another interdisciplinary project with undergraduate students was a 'Delhi University Innovation Project' that involved studying how the brain processes music. We examined the effects of music (Indian ragas) on brain anatomy and structure using neuroimaging techniques. Through this project, the students (both from science & non-science backgrounds) appreciated the therapeutic effects of music on neurological and psychological mechanisms underlying stress management.

Understanding basic concepts, reading scientific articles, learning technical language and terminology, and understanding a hypothesis-driven scientific process have helped students build on a research foundation and

develop independent critical thinking and improved communication skills.

What are the challenges of doing research at the undergraduate level? How can these challenges be overcome?

Time, funding and resources have been the biggest challenges in conducting undergraduate research programmes. Supervision of undergraduate research is not seen as integral to academic practice but as an extra, which adds to the academic workload. However, schemes like the Star College Scheme by DBT have immensely benefitted many colleges (including ours) across the country with funding to promote innovation and research at the undergraduate level. Our College has also initiated an undergraduate programme – "SRI Venkateswara Internship Program for promotion of Research and Academics" (SRIVIPRA) – that offers research internship activities during summer under the mentorship of faculty from all disciplines. In this programme, multidisciplinary projects have proved to extend the classic skill set associated with different disciplines to build cooperation and collaboration between academic units.

"Networking of educators will definitely help in providing a learning workspace for collective professional growth."

Besides teaching regular courses, you also conduct many workshops on bioinformatics for school and college teachers. What is the primary goal behind these workshops?

I have found that organizing workshops has not only helped many faculty members but also contributed to my own personal growth. Despite the central place held by bioinformatics in modern biology, it has been integrated very recently at the undergraduate level. The purpose of organizing these workshops is to promote the teaching of biology through bioinformatics. Most of them are focussed on imparting basic foundations in bioinformatics with hands-on training sessions on databases and online software/tools. These programs have empowered teachers to successfully adopt innovations in bioinformatics into the curriculum and have helped them design short-term undergraduate research projects. The workshops have provided a platform for faculty to interact with experts from both academia and industry.

Speaking of interactions and collaborations, can building a network of educators in the country help the educators?

Yes! Networking of educators will definitely help in providing a learning workspace for collective professional growth. Traditional faculty development includes workshops and seminars often driven by short-term goals. Learning doesn't take place just in training programs but should be part of everyday activity. Networking with peers offers new spaces in which one may learn to grow with a diverse set of educators. Educators can help each other for knowledge exchange and share useful pedagogical methods to promote innovative solutions to teaching-learning practices. Further, recent technological advancements have allowed them a means to expand their web of connections beyond the conventional meetings or forums and to aggregate vast quantities of professional knowledge at any time and from anywhere.

Before we conclude, any advice for new educators?

Great teachers are not born; they are made over time. Nonetheless, I can certainly give new educators a few more words of practical advice based on my own experiences in UG teaching. Work hard and be passionate about teaching or research. Classroom planning, discipline and effective time management are important challenges in teaching. Adapt positively to the rapidly changing times of higher education!!

Postscript:
Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/talk-with-teachers-developing-academic-depth-beyond-the-curriculum

02

The tigress and her cubs

Author: **Yashada Kulkarni**
Date of publication: **05 Sep 2022**

Excerpt: **In this article, a student remembers a phenomenal educator, researcher and mentor from her undergraduate days, who inspired generations of students. The author portrays the strong personality of this leader and her lesser-known softer side.**

Madhavi Indap, Prof. Emeritus at the Central Research Laboratory, D. G. Ruparel College, Mumbai and the former Head of the Zoology Department of the college. Source: Yashada Kulkarni

It was the Diwali vacation of 2005. With great difficulty, I convinced the lordly security guards at the gate that I was indeed a student of the very college they were guarding – D. G. Ruparel College, Mumbai – and that all I wanted to do by entering the premises during vacation time was to check out the Zoology Department notice board.

It was almost evening when I finally entered the eerily silent Science Wing of the college. The shuttered classrooms made the corridors look longer. As I approached the Zoology Department, I saw that the entrance door to the laboratory was ajar and the lights were on. I peered inside and saw the Department Head sitting on one of the long ancient wooden tables with one of her PhD students. The chief lab techie, *Yashwant kaka*, was jostling around the lab carrying jars of preserved zoological specimens. The place reeked of formaldehyde. The specimen jars were out on the lab desks instead of the cabinets lining the walls. Wooden boxes of microscopy slides were stacked on the tables too, and the once dusty, stuffed taxidermic specimens of an anteater, *barasingha* and a juvenile Indian mugger glistened on the floor.

All three (live) occupants of the room were busy with their work and, I presumed, had not noticed me walk to the notice board hung outside the lab. I was only there to check which practical we would be doing on the first day of college reopening so I could come prepared. But I forgot all about the notice board as I peered inside. The sight of our Department Head made my palms sweat and increased my heart rate. She did that to people. I was just about to slip out of sight when she called out to me. She *had* noticed me, after all.

Dr. Indap with her student attendees and staff at an Animal Tissue Culture workshop she organised at the Central Research Laboratory, D. G. Ruparel College, Mumbai, in 2019. Even after her retirement, she continues to work as Professor Emeritus at the college and has played a pivotal role in establishing and managing the laboratory. Source: Organisers of the workshop

Women are known to have a higher-pitched voice than men, but Dr. Madhavi Indap's voice is a notch above the average woman's. Nothing about her is average, for that matter; from her physique to her style of work. When broad-shouldered, 5-foot-8-inch Dr. Indap, wrapped in a rare expensive saree that is never even a centimetre out of place, walked the corridor, we undergrads shivered and walked out of her way; so did most of the postgrads and many of the staff too.

I walked in.

Her eyes bore into mine and said, "Diwali is a time we clean our house. Then why shouldn't we clean our workplace too?" That explained the sight of the lab. Indap ma'am had sat there all day changing the age-old formalin that preserved the zoological specimens, meticulously re-labelling each jar with a fresh label, while the lab techie cleaned and dusted, and her student helped in arranging the jars back in place. In that one day spent away from her family during a time of festivity, she breathed new life in those lifeless specimens. Visit the lab today and pick up a random jar and read its label. Chances are, you read Indap madam's handwriting, as perfect and structured as if it's in print.

She pointed at the stacked boxes of slides and said, "Some of these slides are about 80 years old. They have been imported from the US when the college was established. You will not get such good quality slides even if you pay a fortune today". I heard the sheer passion in her voice as she spoke about the artefacts of the lab. Later, I was to see that passion reflected in all that she did.

From left to right: Dr. Madhavi Indap; Dr. P. M. Sule, Principal, D. G. Ruparel College; Dr. S. Ayyappan, Director, Central Institute of Fisheries Education (CIFE); and Dr. Joe Baker, Commissioner for the Environment ACT Canberra, Australia at the First Symposium on Marine Biotechnology, held in Mumbai, 2001. Dr. Indap was a life-long admirer of the now late Dr. Joe Baker, an eminent Australian marine scientist and this symposium was held in his honour. Source: File photo.

The year I witnessed the Diwali lab cleaning was the year Dr. Indap became the Head of the Zoology Department. Within six months we saw the lab transform from an average uninspiring place to a space of innovation and inspiration. Nothing escaped her eye. She did not fail to notice *Rohini Tai*, one of the lab techies, drawing intricately on blackboards in her free time one day. Instead of berating her and assigning her more work, she encouraged Rohini to draw more. This while preparing for a massive marine biotech conference with delegates arriving from the world over.

She expected all her students, faculty, and non-teaching staff to do more with their time in the department than their basic duties. If you gave her the moon, she wanted the sun, stars and the rest of the planets too. And she led by example.

Not content with teaching alone, Dr. Indap almost single-handedly erected an animal cell culture facility in the college to conduct research. Research not being a focus area for a Mumbai undergraduate college in the 1990s, all that the institution could spare for her endeavour was the tiniest room on campus located adjacent to a ladies' toilet – not an ideal location for a facility that requires sterilised conditions to function, where a single germ could impede months, even years of hard work. Undaunted, she endeavoured, and maintained several cell cultures on which she and her research students studied the effects of bioactive compounds from marine extracts. Today she heads the Central Research Laboratory of the college, where she is Prof. Emeritus, and continues to work in the realm of marine biotech, anti-cancer drug discovery, immunomodulation, and chemical communication in insects.

Dr. Indap in her very first lab established in a small room. She mentored her PhD students in this lab and produced several research papers despite the challenges of the cramped environment. Source: Sangeeta Gogawale

She made us develop our own research projects in our final year of BSc, which was over and beyond what was expected of us to clear our exams. What's more, she made us submit the project reports before the exams. All

our efforts to convince her to let us write the project reports after the exams were turned down. We wrote the reports somehow, keeping our exam syllabus aside, and then resumed studying for the exams. One of us entered the university's toppers list that year. Dr. Indap had showed us that if we pushed ourselves hard enough, we could achieve anything. Also, though I didn't know it then, I had just learnt the importance of completing a job on time. Many of us conduct our research but don't write about it on time, and crucial publications never see the light of day.

Her *modus operandi* was simple. Find an unfathomable part of the sea, throw us in the deep end and show no mercy. Eventually, we found a way to swim back. But once we did swim back to shore, her affection knew no bounds. From paying the fees of a deserving student who could not afford them to purchasing the best quality lab equipment from her pocket, she did everything within her capacity for her students.

One day, in my second year of BSc, I mustered the courage to tell her about my interest in studying evolutionary biology and behavioural ecology. Many students chose a subject like Zoology at that time simply to get the stamp of graduation on their resumes. Many jumped to an MBA course or joined banking soon after. Evolutionary biology was a bit more elitist, not a piece to be chewed on by an undergrad student. Indap ma'am dispelled this myth and encouraged me to study the subjects that I loved. After my post-graduation, I toyed with the idea of working on the behavioural ecology of rock lizards through a project at the National Centre for Biological Sciences, Bengaluru. Dr. Indap was the first to tell me to pack my bags and head to Bengaluru. If it hadn't been for her, I probably would not have chased those rock lizards, or studied tigers in India's north, surveyed birds in the west, flirted with butterflies for my doctorate, or even tackled corporate sharks as I worked with businesses as a biodiversity professional for my day job.

Dr. Indap teaching at the Animal Tissue Culture workshop she organised at the Central Research Laboratory, D. G. Ruparel College, Mumbai, in 2019. She continues to teach and host workshops, seminars, and other events even after retirement. Source: organisers of the workshop.

When it was time to decide the topic for my PhD, while I played safe with subjects I could juggle with my day job, she gave me the courage to work on what I truly loved. PhDs can't be done on something you don't enjoy doing, she said. If it wasn't for that advice, I would not have worked on sexual communication in butterflies for my doctorate and discovered presumptive pheromones in a butterfly species, the first for the Indian subcontinent. During my PhD, tired of having to juggle research and a job, one day I decided to quit my job. "You will do your PhD along with your job", she declared when I told her of my decision. She mobilised the entire lab to come to my aid and made sure every instrument, every lab member, and every lab chore was bent to fit my schedule so I could manage my job and research. She even made sure the college security guards knew of me and let me inside the campus on weekends, public holidays, after-hours and vacations. She would lay down the red carpet for you, all you had to do, was perform.

Once during my undergrad years, we did not see Indap ma'am for about a week. Later we learnt that she was on a short break as her family from abroad was visiting, including her two granddaughters. Then one day, our ears finally caught that all too familiar voice from the corridor and the whole department milled into the largest lab for a meeting. Instead of the office chair, ma'am was casually plopped on the desk. Two little girls played around her. One snatched her saree's pallu playfully while the other climbed on top of the desk to hug her grandma from behind. This sight of Indap madam, my Indap madam, resolving the lab's problems while her grandchildren tugged at her clothes in the background, has been her defining image in my head. Like a tigress with her cubs, her stern and fierce side were in complete harmony with her gentle, kind and loving self. Under her guidance, we produced quality research projects, developed a butterfly garden in the college, organised a marine biotech conference, countless symposia and workshops, earned our doctorate degrees, and most importantly, began our journey towards the best version of ourselves. We were all, indeed, cubs of that tigress.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/the-tigress-and-her-cubs

03

Talk with teachers:
I am glad that I was mentored, not 'supervised'

Author: **Aditi Jain**
Date of publication: **19 Jun 2019**

Excerpt: **PK Burma is a Professor at the Department of Genetics, Delhi University. He is a plant geneticist with a passion for teaching. He reminisces about his academic mentors and shares his views on professional networking for teachers.**

Burma interacting with school science teachers (Photo: Kamal Soni)

Please tell us a bit about your journey so far in academia. Were you always interested in teaching?

I was unwillingly exposed to science in my childhood, as both my parents were researchers. I drifted into academia; as an undergraduate, I wanted to be a politician and an administrator!

I studied Zoology at the Banaras Hindu University and had excellent teachers with tremendous patience to mentor students like me. My first foray into research was a small project with SC Lakhotia (with whom I did my PhD) studying a locus encoding non-coding RNA in *Drosophila melanogaster*.

My postdoctoral experience with Samir Brahmachari was also exciting. He mentored me for an interview for a lectureship position at the Department of Genetics, University of Delhi (DU). At DU, Deepak Pental convinced me to work on plant biology; we developed transgenics that we hope to see being farmed in the near future.

I owe it to my teachers for kindling in me a love for science. Mentorship has played a significant role in helping me reach this stage of my academic journey. I am glad that I was mentored and not 'supervised'. I feel that academic mentorship is fading away.

To me, teaching is a 'work of heart'. I discovered this love around examination time, I understood the topic better once I taught it to my friends. This is true today – I achieved clarity in genetic concepts once I started teaching students. The joy of teaching is best achieved when an alumnus remembers my classes.

Do you introduce elements of your research in teaching?

To me, education is an amalgamation of learning, teaching, and research. What I teach in the classroom finds its way into research. My first-hand experience with research supplements my teaching.

I share my mistakes that arise due to the vagaries of the system under study – it is important for students to know that mistakes are acceptable. I teach a course on 'Regulation of Gene Expression' and my work on plant transgene expression gets plugged into teaching.

During my PhD, in addition to conducting experiments, I learnt to fabricate apparatus, repair appliances, handle finances, and run projects on a shoestring budget. Today I realise that we received holistic training that has enabled me to impart this philosophy.

Which pedagogical tools have worked best for you in classrooms? Have you tried non-conventional approaches to teaching?

I mostly use the blackboard, supported by a few video slides (if needed). We have a small class and I vary my approach depending on the educational background of the students.

I love discussing classic papers of Mendel or Jacob and Monod to inspire students. My intent is to inspire students to read and forage on their own. An unconventional mode of teaching is compiled in the book 'Great Scientists Speak Again' by Richard M Eakin. To attract students, Eakin used to dress up like scientists and enact his experiments in class. A flair for drama always helps!

For practical sessions, I try to design experiments that ask students to reason out explanations based on their observations. A few times they have suggested explanations that forced me to think in a new direction.

Over the years I have stopped students from writing the typical 'practical record book/copy'. I feel the norm

of writing practical notebooks is the biggest example of plagiarism as most students copy exercises from the seniors.

What are your views on undergraduate research? What are the pros and cons of such an approach?

Are we really equipped to carry out research in most of our colleges (except in a few elite institutes)? Routine lab practicals are not conducted optimally because of student overload and decimating infrastructure. Proper library facilities, access to journals, and residential campuses are a must for implementing research in undergraduate courses.

The first step should be to improve the current design of experiments for fostering student engagement and inculcating the spirit of questioning.

Our knowledge in the field of biology has increased rapidly. Which relevant courses do you think can be added to the curriculum?

With the development of knowledge, the curriculum needs to be updated on a regular basis. However, it is equally important to focus on building basic concepts.

Courses should continue teaching organismal biology. Through the teaching of phylogenetics, evolutionary biology should be introduced. Biostatistics too needs to be comprehensively taught. In today's age of data, it is important to make students understand its importance.

A course on writing skills is a must. 'History of science' that discusses the evolution of a scientific field can also be experimented with.

Do you think professional networking is important in teaching as it is in research? How can one benefit from such networking?

It is very important to share one's teaching experience with others. The first step could be that teachers attend each other's classes and have constructive discussions on the teaching methodology. Just like research, 'teaching skills' need to be nurtured.

We do have a few networking platforms – an orientation program and two refresher courses. This is an opportunity for teachers across the country to network, these opportunities should be strengthened in a meaningful way.

How would you feel about sharing your teaching experiences as a mentor during teacher conferences? Do you know of any conferences for teachers of STEM in India? Do you think having these conferences is a good idea?

I would love to do it, though I am not aware of any conferences for STEM teachers.

It is important that these forums be used to discuss new topics that could be taught, approaching the same in

an interesting way and nurturing experimental skills. These forums can help teachers in pedagogy innovation.

All these have to be conducted keeping in mind the ground reality of our colleges and post-graduate departments. All such conferences or discussion meetings should be meaningful, not another box to be ticked in an academic year.

Postscript:

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04

Talk with teachers: Collaborating with a senior teacher can facilitate faculty mentoring

Author: **Aditi Jain**
Date of publication: **21 Jun 2019**

Excerpt: **Manjari Jain in an Assistant Professor at IISER Mohali. She is a behavioural ecologist with a passion for teaching. Here she shares her views on teacher mentoring and networking. She suggests co-teaching as a method to help young faculty get comfortable with teaching.**

Manjari teaching animal behaviour to undergraduates at Maulana Azad College, Kolkata. (Photo: Subir Dasgupta)

Please tell us a bit about your journey into academics. Do you enjoy teaching? What course do you enjoy teaching the most?

For my Masters in Zoology, I wanted to specialise in genetics and toxicology. However, a final year project took

me to the Western Ghats, I was thrilled to see animals in their natural habitat and decided upon ecology for my career. After completing my Masters in ecology I moved to the Indian Institute of Science for a PhD on acoustics and animal behaviour. I joined IISER Mohali as a faculty six years ago.

I enjoy teaching. In addition to advanced courses for Masters and PhD students I teach an undergraduate course on ecology and animal behaviour. I also take lab for a course on evolution and genetics. It is particularly challenging to teach undergraduates as many of them have not taken biology in high school. Yet, towards the end of the course, I found that they enjoyed ecology — this I considered a personal victory. Teaching advanced courses is much easier as it involves a specialised audience trained in biology.

How did you balance teaching and establishing a lab?

Oh it was very challenging! It was an overwhelming time as I started teaching immediately after joining, at the same time when I was setting up my lab, applying for grants and getting lab equipment. I also got married and had a child during the time.

I was teaching theory, was involved in lab practicals and was assisting other teachers. Having said that, I was fortunate to have peers who guided me in handling large classes. Additionally, Professor Sathyamurthy, the founding director, was very inclusive and generously helped with the smooth setting up of the lab.

I faced many difficulties due to the nature of my field work which majorly involved observing wild animals. The institutional rules did not allow scholars to be away for more than 120 days a year – making it difficult to stay in the field for more than 4 months. Such difficulties in maintaining a long-term project drove me towards working on backyard animals – made possible because of India's biodiversity! I also fought hard against the 120-day rule by engaging the institution with ecology experts, and now it is revoked.

An ecology lab usually does not require the infrastructure and funding that a molecular study lab does. We have special requirements though — a soundproof room for acoustic studies. The sound proof room has been principally sanctioned. However, we still do not have it due to procedural delays and space issues.

Did you ever wish for a faculty training module? How can scientists be trained to teach?

I did not undergo a formal faculty training program at IISER Mohali. The enormous load did not stress me as I enjoy teaching.

PhD and postdoctoral students should be formally involved in teaching duties, this might help in swift transition to teaching (informally, students usually contribute as teaching assistants). A candidate having a good research and teaching experience is better suited for a faculty position.

A buffer time could be provided to a new faculty: perhaps a year to settle in with no immediate teaching load. This can help get the lab running.

Institutions can have multiple instructors for a course which can facilitate guidance. For example, a new faculty teaching a course along with a senior professor. For this, faculty recruitment should incorporate all major fields

of specialisation adequately so that the teaching load can be well-distributed.

Do you think that a network of peers and mentors could help teachers of higher education?

It would be fantastic if one has a network for sharing teaching experiences.

The network could help us with teaching skills, handling student diversity and pedagogical tools. Such mentors can belong to any scientific field. Subject experts also can help us with the teaching of specific concepts.

A mentor can guide you on making assignments and creating an engaging and informative course structure. Education conferences and virtual platforms can help us achieve this.

IISER programs lay emphasis on undergraduate research, how has this impacted students' scientific aptitude?

I feel the university system lacks a discussion on science, other than that it is not less glorious than others. IISER students are taught by scientists, research being their major job role. This I feel is the critical difference. IISER students hang around in labs, witness research hands-on and conduct experiments.

An undergraduate joined my lab as a summer intern and continued his Masters. His work (along with a PhD student) has been recently accepted for publication in Biology Letters — one of many success stories of IISERs research-driven education policy.

Such an environment inspires undergraduates towards research, probably why many of our students take up academia as a career path. I think if universities can invite scientists to teach certain modules of their courses, an excitement for research can be developed.

Credits: Anindya. Modified to current form: Navodita

Do you introduce elements of research in teaching? Any interesting courses you want to introduce in the curriculum?

I feel that we are moving away from core biology, probably because expensive science seems glamorous. We now graduate with specialised degrees. However, we often find that students are not broadly trained to understand basic biology.

Though it is necessary to teach the latest techniques, it is more important to teach their use to solve research problems leading to the development of a scientific attitude.

I teach field methods in ecology that includes methods like camera-trapping, mist-netting and collecting behaviour data from free-ranging animals. This is an advanced elective. However, even in the second-year lab course, we have sessions in which we ask students to formulate their questions, come up with a hypothesis, collect semester-long data and also use biostatistics to analyse data. This is an early exposure to a scientific way of working.

I believe that for holistic understanding, students should be taught biology at different levels – ranging from organismal to molecular. I would like new courses to be fundamental, having a core structure, post which a student can specialise.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/talk-with-teachers-collaborating-with-a-senior-teacher-can-facilitate-faculty-mentoring

05

Fail faster, fail better

Author: **Mayuri Rege**
Date of publication: **04 Feb 2020**

Excerpt: **Mayuri Rege is a DST-INSPIRE Faculty in the Department of Microbiology at Ramnarain Ruia Autonomous College, Mumbai. She is one of the Young Investigators selected to attend YIM 2020 in Mahabalipuram. In this invited article, she writes about the importance of facing and learning from failure as a scientist, and how she tries to instil this value in the undergraduate students she teaches.**

Mayuri Rege

Failure is an integral part of doing research. Whether it's the story of Edison's 1000 bulbs or Rosalind Franklin's trials leading up to the famous Photo 51 of the DNA double helix, failure is a lesson we should have learnt the moment we embarked on the research track.

However, ask yourself, how often do experiments fail in a typical undergraduate practical lab? For example, before the session on PCR, the teachers will often ensure that the band is always present and at the right size even though PCRs regularly fail in real-life research. To add to this, reference books and publications that

students refer to typically discuss only the successful finding and breakthroughs without any mention of the multiple failed attempts it took to get there.

Thus, we do not adequately prepare young researchers to face the most frequent situation in a lab — a failed experiment! I reflect on my attempts to deal with this issue as I set up my lab primarily with undergraduate and postgraduate students in one of the top colleges in the country.

My first encounter with failure was when I was a master's student at the Tata Institute of Fundamental Research (TIFR), Mumbai. I wanted to understand what made males more susceptible to malaria compared to females using a mouse model. We wanted to check for differential compounds in samples obtained in the least invasive method, namely urine.

Although it is pretty straightforward for humans, how does one collect mouse urine for analysis in a non-invasive manner? Since mice are not housetrained, we had to use expensive metabolic cages that had a special funnel design to collect the urine without disturbing the animals. However, I soon found out that our mice just would not pee in these cages! Bizarrely, they would just sit in one place, not drink any water and eventually die — even the control mice that weren't infected.

I changed multiple parameters — gave them different food, and widened the pore of the water feeder so they could 'drink' more water but none of these made the mice 'happy', leading to several failed experiments and this becoming a running joke amongst fellow students. Eventually, I figured out that the bar spacing on the bottom of these cages was too wide for our mice to move freely- explaining why they were perched in one place. Placing a smaller spaced '*jaali*' on the bottom immediately solved my problem and to my relief, I could finally collect mouse urine to perform my experiment.

Perhaps the first step of getting students accustomed to failure is to shift the focus from 'getting good results' to learning the research methodology. Teaching them to design experiments demonstrates the importance of controls that help to cross-check experimental conditions and give expected results.

But the first time our experiment fails to give an 'expected' result, my students are just dumbfounded – they haven't ever encountered this possibility before! Their knee-jerk reaction is to simply repeat the experiment as is because they presume that they have done something wrong along the way. On probing them about what might have gone wrong, they only have vague hand-wavy answers and no concrete reasoning that justifies repeating the experiment. This observation was a turning point for me as I realised that students need to be taught to step back and interpret failures.

Troubleshooting a failed experiment is what gets students to think critically because this time the answer is not already available on the internet. Importantly, I have to resist the urge to *give* them the answer and *wait* for them to arrive at the solution on their own. A natural consequence of this is that the students then proactively suggest what the next experiment should be – finally setting the scientific process in motion.

Another aspect of young researchers dealing with failure in the lab is at an emotional level. These are students who have excelled at academics and I have to remind them to not take failure in the lab personally. A failed experiment isn't a reflection of who you are as a person. Students who cultivate resilience in the face of failure and show the tenacity to work through it are the ones that actually succeed as future graduate students. Coping mechanisms might differ — my students will often burst out into hysterical bouts of laughter when their best-laid

(experimental) plans fail and then work together to figure out the next steps.

Designing experiments that can actively disprove your hypothesis is the only way to rigorously test your science. An experiment that discriminates between your favourite hypothesis and others and can disprove your hypothesis is more important than several peripheral experiments that support it. There are two facets to this – avoiding confirmation bias and saving time.

An important skill to acquire as a young researcher is to identify that smoking gun for a given hypothesis – something that can happen if and only if the hypothesis is true. In practice, this is hard to achieve and such a smoking gun often involves a combination of observations. However, these are the experiments that must be done first in order to test the hypothesis effectively and fail quickly if we have to. This saves time that would have otherwise been wasted on inessential experiments.

How can we remove the fear of failure at the undergraduate level? One possibility is by changing the metric of performance for research done in colleges. We can reward original thought and proper research methodology, whether or not it leads to publishable results. While this is harder to assess, we can recognize undergraduate teachers who emphasise 'how to do research' rather than getting their students to produce results that lead to publications in predatory journals.

In our Department, we have implemented this through rigorous discussions of projects proposed by teachers by their peers. We also grade our students for clarity in formulating a hypothesis and engagement in discussions on experiments rather than just showing a result. Although it's too early to tell if this works for a majority of institutions, we see a remarkable improvement in students' ability to tackle problems after being subjected to frequent failures.

By letting them fail early, undergraduate research can teach students the correct process of doing research, prepare them for graduate school in the future and meaningfully contribute to the research enterprise in India.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/journey-of-a-yi/fail-faster-fail-better

06

Crafting Your Career: Informational interview with Pragya Verma – science education, part 2 (a podcast)

Date of Publication: **04 Sep 2020**

Excerpt: **This is part 2 of the eleventh "informational interview" in the season on Crafting your Career in science. Here IndiaBioscience chats with Pragya Verma, a researcher-turned educator, who still manages to do her science and take along with her school students as well as carry out social projects to promote application-based learning among students of all levels.**

Transcript with Timestamps

[00:02] — Lakshmi Ganesan

You're listening to IndiaBiospeaks, your one stop resource for science news and careers.

Listeners, welcome back to part two of our informational interview with Pragya Verma. We've been talking about making a paradigm shift from a theory based curriculum to one that is more application based. Pragya has been an enabler of this change, a much needed one, I must say.

Pragya, this seems to be already aligned with the new education policy that has been tabled recently. It is a really progressive and forward-looking change compared to say, when I was in school. Although, I must say that I was lucky to have good teachers. One particular teacher that I wish to mention is my high school biology teacher

Irene Stella to whom I owe much of my scientific temper. What she did to me as a teenager is pretty remarkable where she set up reward mechanisms especially when did they did not exist to think out of the box and to take initiatives to do something that's not particularly required of you, or even simply recognising that you are doing this as a student can help nurture and allow that quality in you grow. Pragya, being in the school ecosystem, I am sure will have its own rhythm. Can you share what a typical work day would look like for you?

[01:34] – Pragya Verma

My typical day starts at 7:30 a.m. until 2:30 p.m. I am exclusively with kids teaching them science and working on various projects with them. After 2:30 p.m. with some of the students who are motivated, we do the same activities of teaching science through our social service projects. In the present scenario, regular classes and after our classes are still going through various online meetings and WhatsApp calls, whichever works for the kids. After 4:30 p.m., the children are welcome to call me anytime if they come up with a great idea or question… The children nevertheless are very adjusting and they are both mindful and considerate not to disturb me and they are very patient. They also bond very well and if I do not reply soon enough for any reason, they get worried and enquire about me and my three year old son…

[04:30] – Lakshmi Ganesan

Pragya, to someone who is interested in seeking a teaching career, especially teaching in a school curriculum and as someone who has found your footing there, what would be your words of encouragement or words of advice?

[04:50] – Pragya Verma

I want to share that it is OK for a PhD to come into teaching. You may consider it a risk since it is not the norm, it is unconventional or may be less well accepted, but I find it very rewarding and to have an extraordinary return of investment To have teachers who love the subject, means to instill the same love in the students. This helps create well-founded and well-rounded science professionals of any kind for the future. One will also be surprised to find that it is also lucrative and pays well to be a teacher at the schools. It is personally gratifying to see so much positive change and to be able to mould impressionable young minds. It also helps me read and keep up to date with nuances in the sciences to be able to convey and work with students to design well-thought out projects with them. If you have done research and are looking for a way to give back then this is probably the best way. You are not only working with students at the right intellectual age, you are also working with innocent and impressionable minds that can be moulded and steered in a positive direction with relative ease. Their level of enthusiasm and eagerness is hard to find.

[07:45] – Lakshmi Ganesan

Pragya, now a young graduate may think teaching is a great way to give back, it could even be lucrative and there are examples of people who have done this well. Now, what does it take to be a good teacher? What skills does one need? Does one need to cultivate or does one need to be a natural to be able to teach? What are your thoughts?

[08:24] – Pragya Verma

Lakshmi, I find myself naturally gel well with the kids. When I started, I was an introvert and a bookworm. When I entered the school I found myself transforming, where the kids turned me from an introvert and extrovert. While I used to be shy to give lab presentations I found myself interacting with relative ease with the children. Regarding the skills required, someone with a PhD or any science graduate is already equipped with the requisite knowledge and also the ability to apply the knowledge to solve a problem. One thing I do is to prepare for every class by doing my pre-reads so that I am best able to answer the questions the kids might have. Overall it is a very relaxing job where you already have the essential skills and need not acquire any special skills. Perhaps, one can put themselves in teaching situations, during their training period, especially with the age-group that they would eventually like to work with, as a preparation and to test the waters so to speak.

[11:44] – Lakshmi Ganesan

Pragya, I must say if I put myself in a teaching situation in front of a bunch of teenagers, I would probably be terrified...haha, so how do you deal with, say, troublemakers in class?

[12:21] – Pragya Verma

Lakshmi I have had the worst troublemakers in class. But I found that if you give them something to think about, some alternate thing to chew on, some food for thought and healthy food for thought, one can get them hooked that way. This is a skill of a good teacher, to engage and teach, to entertain and teach, and teach not just to know but to apply the knowledge. This skill grows with time and one learns to deal with and work with students of all kinds. There is tremendous personal growth as well, alongside gratification of course. Children at this age, even if they create trouble or get into arguments of any kind they tend to forget and let go. They move on very easily and you learn to do the same. You accept and embrace them and even influence the situation in a positive way.

[14:11] – Lakshmi Ganesan

Yes Pragya and I think that's the beauty of being a teacher. a teacher always gives without expecting anything in return and very unselfishly so. He or she is the proudest when someone does well. Pragya are there any words of career wisdom that you would like to leave our listeners with from your journey so far?

[14:46] – Pragya Verma

Yes, Lakshmi. As a science graduate, never hesitate to take risks. Even if everything around you seems unfavourable and you may face resistance, if there is some instinct in you that tells you that is the right path for you, do not think twice about going for it and be unmindful of the opinions of others. As a science graduate you already have achieved the highest, you are equipped with many skills and the knowledge. If ultimately you are happy doing what you are doing, people around you will also change, the environment will become conducive and your path will pave itself to support your pursuit.

[16:27] – Lakshmi Ganesan

Pragya this is really well said. If you are happy doing what you do, that itself gives you the strength to overcome little challenges here and there. There is really no such thing as a challenge-free career path. As long as you have made a conscious choice, and the pros outweigh the cons, things will work to your advantage. Well, I must say that it was very inspiring to chat with you today Pragya, and what you are doing is genuinely laudable.. I also

would like to make this episode a tribute to all the teachers, particularly the ones in my life who helped mould me into what I am today. Without you, where will I be? Thank you all for listening, and do subscribe to our season on Crafting your Career in Science for more such inspiring stories from various science professionals.

[17:24] – Pragya Verma

Thanks a lot Lakshmi. It was a pleasure being here and stay safe everyone. Thank you.

[17:31] – Outro

If you're passionate about scientific research, communication, outreach and science education as we are, please connect and engage with us. And here are some ways that you can do so. Visit our website at www.indiabioscience.org. Subscribe to our newsletters. Write for us and join our online discussion forum discuss.indiabioscience.org. Advertise jobs and events in the life sciences on our website, and feel free to contact us anytime at hello[at]indiabioscience[dot]org. Until next time, enjoy your science and stay engaged to enable change.

Note to listeners: *This recording was done during the COVID-19 lockdown over a zoom meeting call. This has resulted in a slightly diminished audio quality with some mild disturbances in the recording, compared to a studio quality recording.*

Please find the link to this podcast here: <https://indiabioscience.org/indiabiospeaks/crafting-your-career/cyc16-02>
You can listen to the first part of this interview here:
https://indiabioscience.org/indiabiospeaks/crafting-your-career/cyc16-01

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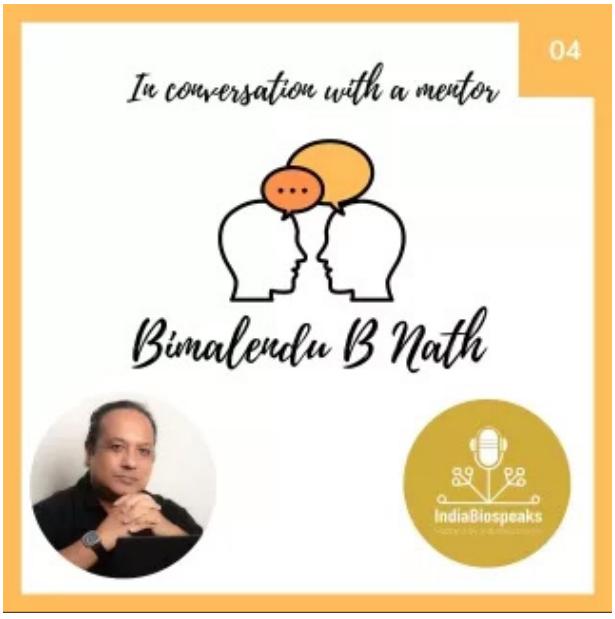
07

In Conversation with a Mentor: Bimalendu B Nath (a podcast)

Author: **Mayuri Rege**
Date of publication: **03 Nov 2021**

Excerpt: **The guest of this episode of 'In Conversation with a Mentor' is Bimalendu B. Nath, an Emeritus Professor of Savitribai Phule Pune University, and the Vice President of the Association of Teachers in Biological Sciences, Mumbai. Bimal has been teaching Genetics, Evolution, and Biodiversity for nearly three decades and is actively involved in science outreach programmes. In this episode, he talks about his journey as an educator and throws light on some of the current challenges of higher education in biology in India.**



Podcast Duration: 17 min 46 sec

Note to listeners: This recording was done over a zoom meeting call due to the COVID-19 pandemic. This has resulted in a slightly diminished audio quality with some mild disturbances in the recording, compared to a studio-quality recording.

[00:01] — Intro

You're listening to IndiaBiospeaks, your one-stop resource for science, news, and careers.

[00:11] — Vijeta Raghuram

Hello and welcome back to'In Conversation with a Mentor', a series of conversations with some pathbreaking mentors across the life science community. I am Vijeta Raghuram, the Program Manager — Education at IndiaBioscience, and the guest of this episode is Bimalendu B Nath, an emeritus professor of Savitribai Phule Pune University. Bimal has been teaching genetics, evolution, and biodiversity for nearly three decades, and is actively involved in science outreach programmes. He is currently the Vice President of the Association of Teachers in biological sciences and is working along with his colleagues to create a platform to motivate biology educators. His passion and active involvement in science pedagogy for the school and undergraduate students is well reflected in his writings in scientific periodicals, journals, and e-magazines. Hello, Bimal, and welcome to '*In Conversation with a Mentor*'.

[01:09] — Bimalendu B Nath

Hello. At the outset, thanks IndiaBioscience for inviting me to this podcast. It's a privilege.
[segue music]

[1:23] — Vijeta Raghuram

Bimal, you are a researcher, educator, author, and administrator, which role is closest to your heart and why?

[01:33] — Bimalendu B Nath

I enjoy each of these facets of my profession. But I'm very passionate about teaching. And research does not interfere with my teachings. Of course, there is a lot of administrative work to do. But finally, at the end of the day, it's the teaching and interaction with the students that make me feel happy and I get job satisfaction. My students often say that I was born to be a teacher and a mentor. Perhaps that's the reason why I enjoy my role as a teacher and a mentor more than anything else.
[segue music]

[02:12] — Vijeta Raghuram

Tell us the story behind your career journey. What made you choose this path? And were there moments in your life that you would call turning points?

[02:23] — Bimalendu B Nath

Quite often, one can get motivation from bad things that happen in life. I was born in Meghalaya and I grew up in Assam. My father had a transferable government job and so I studied at many schools in different places in Assam and Meghalaya. And in my school days, bad and unpleasant experiences motivated me to make a difference as a teacher, which I am now. And I wanted to change the culture of the learning environment. And when I got my job at Pune university, in 1992, I made sure that my students would never feel the way I suffered in my school and college days. Now, to answer your query or the turning point in my life, I'd rather say that there was not a single turning point and no two directions in my life were ever the same. I always faced an uncertain future. There were too many hurdles. So instead of a single turning point, I experienced many twists and turns.

In this context, I would love to mention six mentors who influenced me to shape my future professional life. My association with my BSc. teacher, Mr. Mohan Lal Zaigatar in the college Silchar, Assam affiliated with Guwahati university was phenomenal. You know, he helped me to discover LIFE in life sciences. It was really phenomenal for me because I used to find those school board textbooks lifeless, although they were textbooks for life science or biology. So he brought life to my life science, you know, the personal curriculum. Later on, I moved to the Visva-Bharati Central University, Santiniketan, West Bengal, to complete my master's in life sciences. And I met professor Samir Bhattacharya. He triggered my interest in biochemical pathways and he was instrumental for me to choose my specializations in environmental physiology and biochemistry. And then I worked as an MSc dissertation student under Professor Shelley Bhattacharya and then professor Achith Bharamdas. So Professor Das introduced a book to me, which I would like to mention. The title of the book is strategies of biochemical adaptation by Peter W. Hochachka and George N. Somero. Until today, I can tell you what is written on any of the pages, you can ask. The influence of this book went far beyond my doctoral and postdoctoral tenure and made me what I am today, a researcher in stress biology. When I met Professor Subhash Chandra Lakhotia and decided to work under him for my Ph.D. at Banaras Hindu University, the influence of Hochachka's book helped me to rationalize the philosophy of my doctoral work, we call it Ph.D., a doctorate in philosophy in some subjects, and my postdoctoral mentor or professor Devi Prasad Varma played a key role to enjoy science in real sense. So, Professor Samir Bhattacharya, Professor Lakhotia, and Professor Varma turned me onto a different level of intellectual path. So the book by Hochachka and Somero and my mentors had a profound influence on my career.
[segue music]

[05:58] — Vijeta Raghuram

Bimal, you have had a long and ongoing stint in the education sector. What is your philosophy of education?

[06:06] — Bimalendu B Nath

As a teacher, I must provide my students with a positive learning environment where they feel loved, and wanted. And teachers should know that each student has different learning strengths with different learning needs. As for me, I have never discriminated one student against the other. That was the bad experience I mentioned in one of the questions you asked. And so I have never discriminated any student with other students sitting in the classroom because all students can learn and succeed, which I believe, but not at the same level, on the same day. And also not in the same way. This is one thing you know, it's my personal philosophy of teaching. Slow learning, I must tell my teacher called it slow learning, is not a learning disability. One should understand. We always look for bright students, oh, this student is very bright, we glorify, and then we create a kind of social discrimination in the classroom. And then many students suffer from inferiority complexes. I never do that. I don't believe in applying the Darwinian principle in the teaching-learning process. I don't want to create a classroom environment where you know, there is a struggle for existence in the Darwinian sense. Yes, I must as a teacher prepare the students to compete in their future careers, but I must understand the heterogeneity of the student population and deal with them very sensitively. Okay. So I must deal with different cohorts of students differently. I must understand, that as a teacher, I have a job of harnessing the potential of bright talented students, true. But I have a challenging job also for slow learners. And I love to teach the so-called backbenchers. Teaching slow learners is challenging, but I can tell you, it is incredibly rewarding if one succeeds.

[08:05] — Vijeta Raghuram

Bimal, what is the biggest challenge that you have faced so far as an educator?

[08:11] — Bimalendu B Nath

Let me share my experience as an educator in biology, you know, I restrict myself to biology. Yeah, I've encountered students who are at the tertiary level of the education system, which includes undergraduate and postgraduate students. And many students opt for biology by default. And not by choice, mostly because they fail to go to other branches due to a relatively higher cutoff, which is demanded for the qualifying marks. So many students you know, they end up in biology, and they find this biology a boring subject and end up mugging up. So I teach undergraduate students who are enrolled in five-year integrated courses, and also master's students in geology, biotechnology... So, every year I struggle to give some of these students who had chosen biology by default, not by choice, so that you know, they gain a greater appreciation, because I alone cannot change the textbooks. And this and also the curricula, if you look at some of these textbooks for biology, at the secondary level of education, I feel helpless, because it is only loaded with information, there is nothing to understand. The conceptualization is missing, there is no clue. If student starts self-study without a teacher, they end up finding these books very monotonous.

[segue music]

[09:48] — Vijeta Raghuram

And now the pandemic has brought in new challenges, you know, overnight, the education shifted to online mode. So how are educators and students coping with these sudden changes that have been brought by the pandemic?

[10:00] — Bimalendu B Nath

This has been an unprecedented situation. Routine classroom-based teaching-learning has been suspended due to prolonged lockdown and other restrictions in order to check the spread of the Coronavirus, COVID-19. So, it has been a real challenge for all of us to shift from offline classroom to online mode and even conduct exams. So, in this context, biology as a discipline poses a number of challenges, which I feel are not generally encountered to that extent by the teachers of non-biology disciplines. For example, we're yet to find out how to execute online laboratory-based exercises in biology especially for real-time observation of living entities, like we have model organisms and microscopic observation, real-time microscopic observation of changes in the cells, microbes, and other physiological things, which we conduct in the laboratory-based exercises which we call practicals. And another challenge is the biology teaching, life sciences in general, there are many field-based studies. So field-based studies, and ecological surveys, are very difficult to do online. I have no clue, but maybe there are many suggestions coming up. But we are yet to find out about online learning for the laboratory and field-based exercises. So this is one of the challenges yet to be met and answered.

[11:38] — Vijeta Raghuram

So how do you mentor students and help them maintain a positive mindset in the face of all of these challenges and goals of education?

[11:48] — Bimalendu B Nath

My primary objective is to create an ambiance and positive learning environment. Teachers are influential in students' lives. So it becomes a rewarding profession when we take them along the way in the educational journey.

[segue music]

[12:11] — Vijeta Raghuram

Could you suggest a few actions that educators and administrators could take to address these challenges?

[12:21] — Bimalendu B Nath

Let me answer your question in two parts. And I'll restrict myself for biology students in particular, and for biology educators. First of all, we need to revamp our classroom teaching methodology. The dumping of information and memory-based data can be minimised. It's important because, without information, you cannot synthesise knowledge. So this is important, but we should minimise it and there should be a proper balance. And at the undergraduate level, I'm mostly referring to the undergraduate level. So we need to devote more time to helping the students to build up their mental bank, you know, to appreciate the complexity of the biological phenomenon. Visualisation is another way of making the dynamic nature of the living world and living processes interesting. We generally say, seeing is believing. And so, visual learning and visual aids are very, very important for the teachers to include in their teaching.

Now, the second part of the solution is related to the student community in the COVID-19 pandemic. In this scenario, the students across the states, over India, the situation is the same in other countries, too; they're suffering from something called COVID fatigue and there is serious concern about their mental health. So their attention span has reduced, which I have realised during my online lectures and when I meet them. So we as teachers need to be creative and incorporate breaks and some type of recreation. I'm saying that, like what I have done in one of the teachings, the long teaching I said — "Okay, next let us watch a video, which will explain what I explained so far. You will see the things in an educational video." So then they just relax and see and then I come back to these types of breaks in online teaching, maybe, you know, the warranted now. Otherwise, there will be serious, you know, the fallout of the COVID fatigue.
[segue music]

[14:43] — Vijeta Raghuram

Bimal, you are the Vice President of the Association of Teachers in Biological Sciences. Can you please tell us about the purpose and the work done by this association?

[14:54] — Bimalendu B Nath

Yeah, I'm a founder member of the Association of Teachers in Biological Sciences. Our aim is to create a platform for teachers in biological sciences to contribute to biological education. So ATBS, that's the Association of Teachers in Biological Sciences, along with Homi Bhabha Centre for Science Education, Mumbai, we organise exposure camps for biology teachers, conferences, and many other resource camps. ATBS publishes an email newsletter, Biome, which is the biology education messenger Biome, and I'm one of the editors. At Biome we try to motivate biology educators in India, the newsletter is available online, and anybody can get access to it. So I hope this small effort by ATBS will create awareness about the challenging needs of biology education right now.
[segue music]

[16:02] — Vijeta Raghuram

Bimal, thank you so much for joining us today and sharing your journey, your work, and your thoughts with us.

You raise some very pertinent and yet somewhat less addressed and less appreciated issues with the current higher education system. And we hope that your thoughts and experiences will inspire educators as well as administrators to view the process of teaching, learning, and mentoring in a fresh light. Thank you.

[16:31] — Bimalendu B Nath

Thank you IndiaBioscience once again for giving me this platform and forum to express my thoughts.

[16:41] — Vijeta Raghuram

Thank you all for listening to IndiaBiospeaks '*In Conversation with a Mentor*'. We look forward to receiving your comments and feedback.

[16:52] — Outro

If you are passionate about scientific research, communication, outreach, and science education as we are, please connect and engage with us. And here are some ways that you can do so. Visit our website at www.indiabioscience.org. Subscribe to our newsletters. Write for us and join our online discussion forum at discuss.indiabioscience.org. Advertise jobs, grants, and events in the life sciences on our website. And feel free to contact us anytime at hello@indiabioscience.org. Until next time, enjoy your science and stay engaged to enable change.

Credits:
Guest: Bimalendu B Nath
Host: Vijeta Raghuram
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Pedagogical tricks up your sleeve

Stories of innovative pedagogical approaches taken by educators in their classrooms, including memes, games, popular literature, and more.

08

How I tested my students through memes

Author: **Aniruddha Datta Roy**
Date of publication: **19 Jul 2022**

Excerpt: **What happens when an assignment for undergraduates combines learning with creativity and humour? Aniruddha Datta Roy, a faculty from the School of Biological Sciences at the National Institute of Science Education & Research (NISER), Bhubaneswar, designed such an assignment for his students. He shares his experience in this article.**

Meme by Mrithika S, student, taken from the tweet: https://twitter.com/skinkomani...

Govinda-style dance and the social media rants

It was the beginning of November 2019, almost towards the end of the semester, when I had to take an online quiz for the undergrads taking my Ecology course. I hate taking assignments such as quizzes, but I have to say,

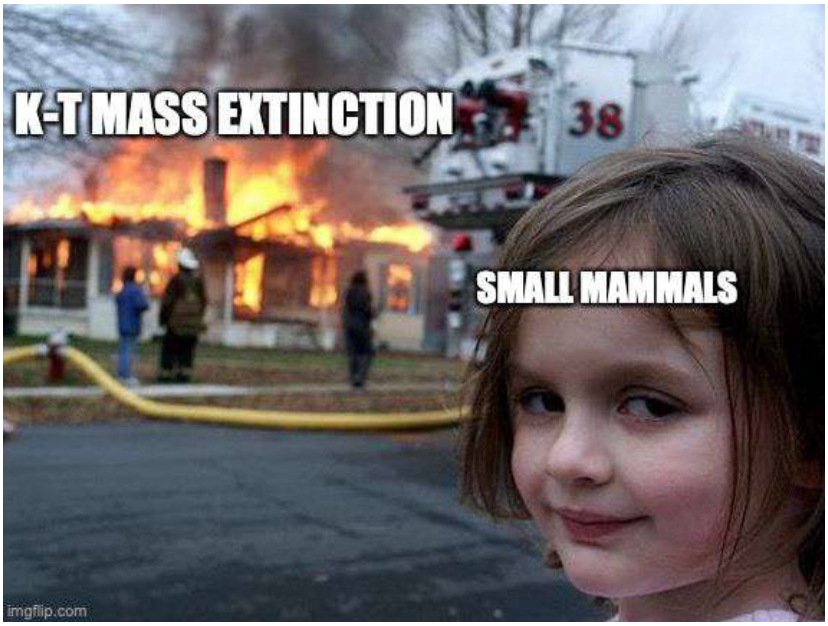
given the size of the class (usually upwards of 105 students), it is an easy way out. Online platforms such as Google forms make life easier for the instructor since the assignment results are obtained immediately. There was one issue, though. The students, at that time, were in their homes, unsurveilanced, and as a result, some of them would choose to find answers using unfair means. Here's a sample question from the quiz:

The honeybee Apis mellifera communicates with other members of its hive to provide the location of food source. Based on experimental studies, which of the following best describes a food source found in close proximity?

1. *Round dance*
2. *Waggle dance*
3. *Disco dance*
4. *Govinda-style dance*
5. *Kathakali*

For questions (and options) like these, it is easy for the student to discard the last three options and remember from the class lectures whether it is the "round dance" or the "waggle dance". For someone who does not recall the correct answer from the class lectures, an easy way out is to 'search' on the internet using strings like "honeybee", "dance", "close", and "proximity". That would give them the answer they are looking for. I thought that the only way to ensure that the students do not use unfair means to get to the answers is by assigning a time-constrained quiz. I thought that by reducing time, the students would not have the leeway to search for answers on the internet. So I gave them 15 minutes to answer 30 questions that were short, direct, and easy to read, such as the question above.

To my surprise, I found some students choosing "Govinda-style dance" as the answer! Perhaps 15 minutes was too short to answer 30 questions for many students, which is why some chose options randomly. I enquired with the students on the Google Classroom platform, asking why they would choose options such as "Govinda-style dance" or "Kathakali" in response to the question. Some of the students mailed me directly, confirming that they panicked because of the time constraint.



Meme by B. Varun Govind, student, taken from the tweet: https://twitter.com/skinkomaniac/status/1524995463921156097

I later found out that some students posted screenshots of my Google Classroom message on Instagram with captions such as "30 questions, 15 minutes, cannot blame them" and "15 mins, 30 questions, you decide whom to pick..whom to throw". I was not very happy about students taking to social media with their rants, and therefore I asked them to refrain from putting them up. A few of the students mailed me to apologise for putting up the stories, but almost all of them said that they, as students, tend to have the habit of making memes out of situations to make them humorous.

Memes, huh?

I knew the evolutionary definition of the word **meme**, as was coined by the British evolutionary biologist Prof. Richard Dawkins. A meme refers to a pattern of behaviour or idea that spreads within a culture via imitation. I was woefully unaware of the use of the "other" meme (internet memes), which are images or videos that may be copied with slight variations and used in a humorous way to explain a trending situation. The humorous nature of internet memes strikes a chord with young students, and that is when I realized that memes have the potential to be used as a teaching tool!

Meme by Sanjay Kumar S., student, taken from the tweet: https://twitter.com/skinkomaniac/status/1524995470313271296

The assignment

I decided to assign meme-making as one of my undergrad-level evolutionary biology course assignments. Towards the end of the course, when I had almost finished teaching the syllabus contents, I announced this assignment so that people can use the concepts taught in class to make internet memes. I asked each student to submit one meme that is based on a concept that was taught in class. It could even be related to an example that I may have mentioned in the classroom. I saw their faces light up in excitement when I announced this in the classroom. I knew that the students would enjoy this assignment, but little did I expect that some would even submit 5 – 6 additional memes just because they were having so much fun making them!

In my experience of teaching undergraduates, students tend to procrastinate; they either submit minutes before the deadline or well past it. In the case of the meme assignment, I faced the unprecedented situation of the entire batch of registered students (107) submitting their assignments a day before the deadline! This shows that novel and more relatable approaches are required to keep up the interest level of the students; else, it becomes mundane for the students.

Meme by Shaswat Nayak, student, taken from the tweet: https://twitter.com/skinkomaniac/status/1524995478450237440

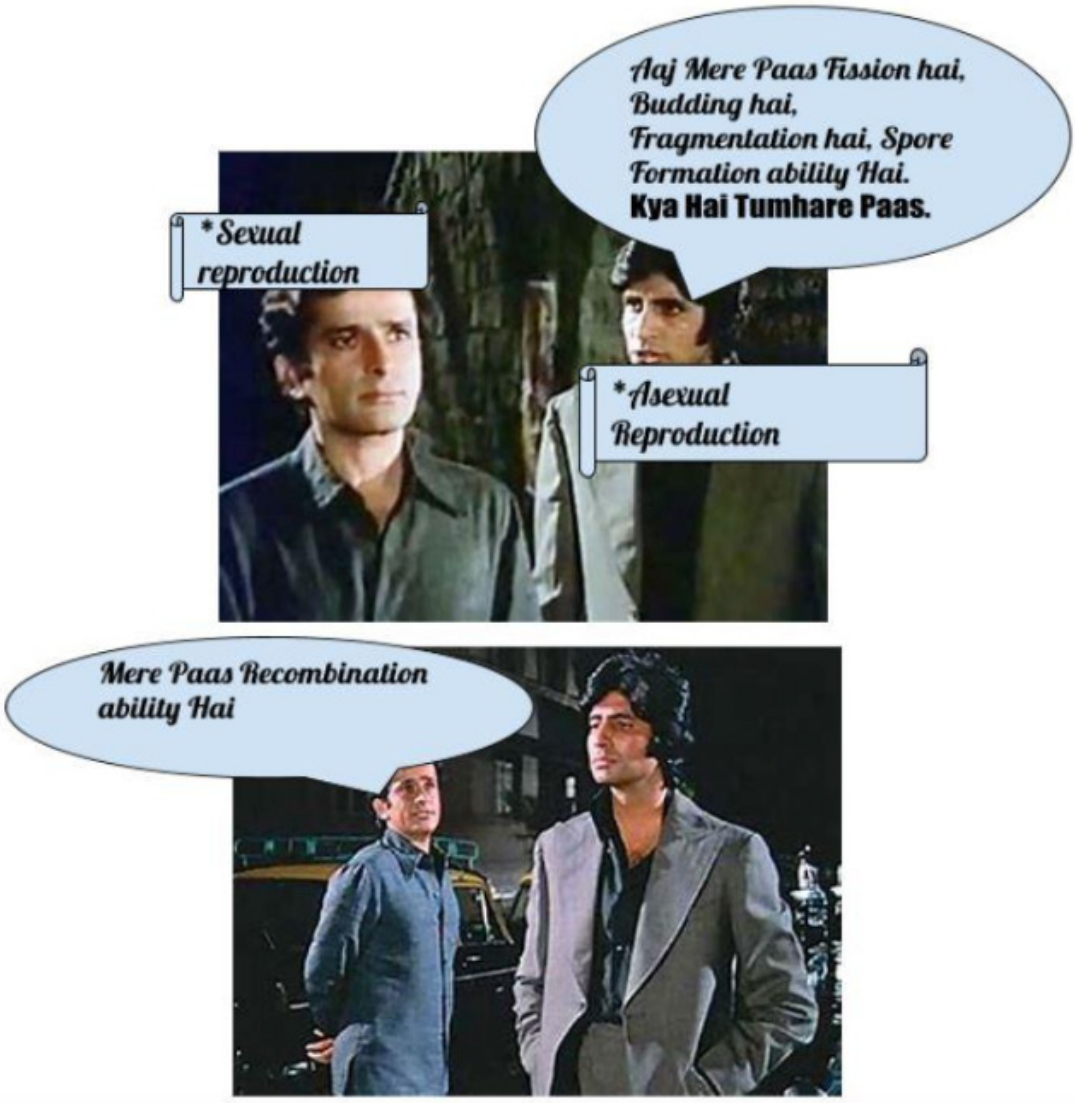
A 'serious' jury

Being unaware of the circulating internet memes, one of the issues I faced was grading the assignments. Thankfully, some of the members of my lab (about five members) understood memes very well and helped out in the grading. All these students had taken my course earlier and were well aware of the concepts and examples that were taught in class. I learned from them that every illustration in the 'meme-pool' should be

used in a specific manner. *(The meme makers take themselves very seriously!)* Keeping this in mind, the 'meme-judging committee' and I sat together and went through the main entries made by each student. The submission was displayed through a projector so that all the jury members could see it at once and discuss it. Thereafter, we assigned a score to each meme ranging from 1 – 10, with 10 being par excellence. It was GREAT fun going through each of the entries, and at times all of us would be cackling raucously.

The prize

Besides the grading, I provided further incentive to the students by announcing that the top five memes would be printed, framed, and presented to the maker in front of the class. After going through all the entries, we realised that many of the memes were brilliantly designed and deserved appreciation. Therefore, I went ahead and printed the top five memes as T-shirts and presented them to the meme makers. The top 6 – 10 meme makers were presented with framed prints that could sit at a desk. This could serve as a souvenir while giving them a sense of achievement.



Meme by Ashish Sahu, student, taken from the tweet: https://twitter.com/skinkomaniac/status/1524995486180319233

As course instructors moulding young impressionable minds, it is also up to us to keep up with the changing times and devise new ways to reach out to the students. Access to information is much easier now than a decade or two earlier. However, at times, students get bombarded with too much information and much of this is not retained or leaves an impression. Novel methods of teaching, such as meme-making or similarly engaging assignments that the students of that age can relate to, make a massive impression down the line.

Postscript:

For more memes from the assignment, see the original Twitter thread by the author.

Find related articles on the IndiaBioscience website using this link: https://indiabioscience.org/columns/education/how-i-tested-my-students-through-memes

09

How can science education research be used for improving college teaching?

Author: **Ashish Nerlekar**
Date of publication: **20 Jul 2020**

Excerpt: **Science education research delves into a multitude of ways through which the teaching practices in a science classroom can be better aligned with its learning goals. In this article, Ashish Nerlekar, a doctoral candidate and a Teaching Assistant studying grassland ecology at Texas A&M University, USA, describes some of the ideas provided by such research, to improve college teaching.**

An outdoor classroom at the Pench Tiger Reserve. (Photo: Ashish Nerlekar)

If you are teaching in higher education, I have a question for you — how much of your teaching is guided by research on how to teach? While most of the approaches used in research in any field are based on previous research, teaching decisions that most college teachers make are not quite based on science education

research and are considered greatly subjective. This has given rise to a multitude of misconceptions about how to teach effectively. In this article, I will share some research-based teaching decisions that will help achieve the goals we have for our students.

A large proportion of college science teaching remains ineffective-often leading to cascading impacts on the national research output. The problem with most of our teaching today actually is our approach and not goals. Most professors are clearly not inclined to ruin the learning experience for their students. They, in fact, want students to think critically, understand the subject content, develop analytical skills, communicate well, and be better citizens. Teachers are met with several barriers and concerns when they try to meet these goals. Here are three common concerns, which can be overcome using research-based approaches.

How do I get my students to respond and interact?

By behaving with them differently! Here are two among many ways in which you can do that.

1) *Watch your questions:* Let's say you are teaching the concept of ecological succession. The first thing you may instinctively ask (assuming you ask questions at all) is either 'Have you heard about succession?' or 'What do you know about succession?' In the first case, you would get some indistinct nods. In the second, usually, you would be met with silence, which is bound to make you wonder why this happens. The first question requires binary thinking (a yes/no answer), whereas, by asking the second, you are mistakenly assuming that students already know about the succession concept. Now, if you are planning to pose questions requiring an extended answer later, don't use these binary questions as ladders- they simply provide no material to build on. Instead, go for the 'why'/'how' questions right at the start. For example, you can frame the same question as 'How do you think might an abandoned agricultural field look like after 10, 50 and 100 years?' Education research shows that a great way to explain concepts is by using a series of well-crafted extended answer questions and building on student ideas. For example, in this case, asking students 'why' questions for the responses to the first question, and then discussing these mechanisms is an effective way to explain the concept.

2) *Silence matters:* If you are asking questions, all the right ones, and your students are still not speaking up, it probably means you need to stop talking! Pausing enough after you ask questions leads to miracles. Not only will you get more students to talk, you will also usually get the shy ones to interact. Waiting shows that you actually care for an answer. How much should you wait? Research shows most teachers pause for less than a second after asking a question, and pausing for at least 3 – 5 seconds is recommended. So try pausing after you ask a question, and also after a student completes their reply to your question (this is way harder).

A wonderful tool to understand how effective our verbal behaviour is, is to record any 15-minute section of your teaching and SATIC-code it (Figure 1). You would be surprised to know how much you overestimate your wait time! Comparing our verbal patterns with research-based ideal patterns helps to evaluate if we are getting better at promoting our goals.

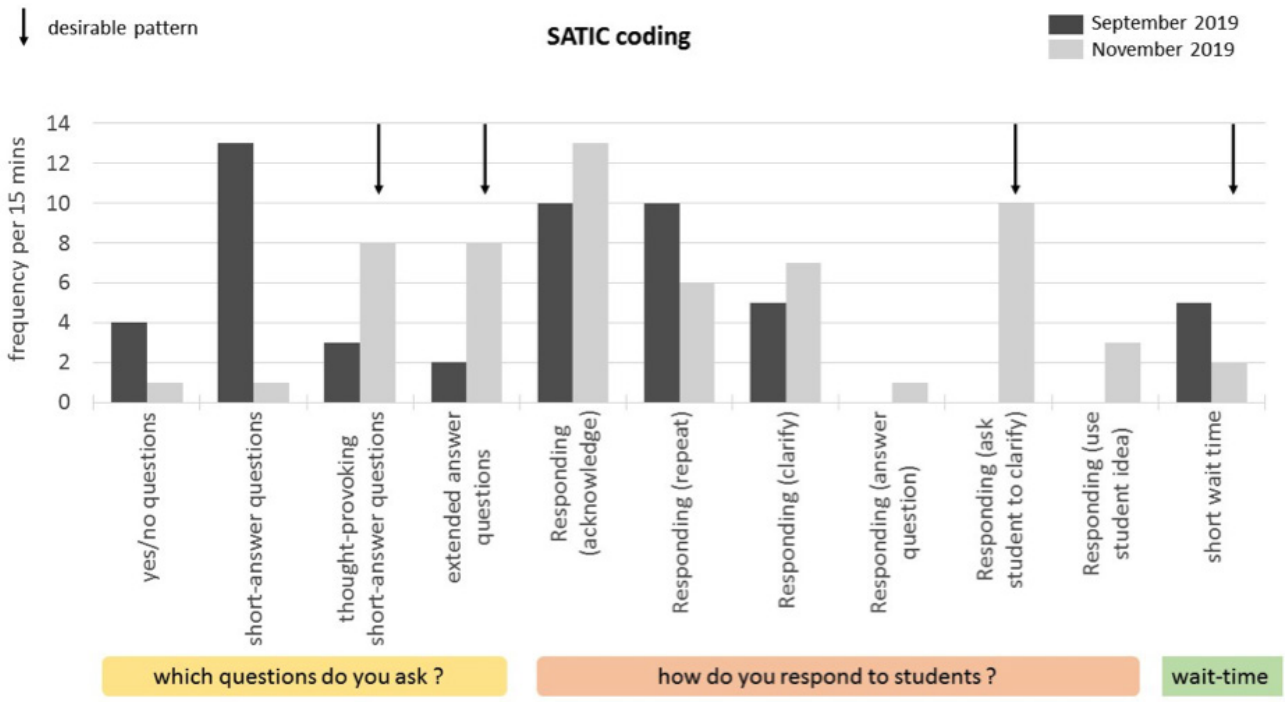


Figure 1: SATIC coding for two of my recordings of an Ecology-lab course. The bars represent frequencies of that particular behaviour in the 15-minute recording. Arrows point out some of the desirable behaviour patterns. Notice that the November pattern is relatively better than the September pattern, although the frequencies of some behaviours in the November recording like 'responding using student ideas' need to be even higher. Some types of behaviours have been omitted here for the sake of representation.

How well do students learn through 'self-learning'?

Turns out, not quite well. If that were the case, we simply wouldn't have taken centuries to figure out that the earth wasn't flat! Over the years we have understood quite a lot about how people learn. One of the most effective ways is by addressing students' prior misconceptions about the subject and constructing meaningful activities that help them change their prior ideas. As an aside, simply engaging in 'hands-on' teaching does not guarantee that students learn well.

In my lectures, I have explained the idea that grasslands are ancient and slow to recover once destroyed, in the following way. First, working in groups, I ask my students to give me a value in years they think it would take for a tropical forest to recover completely once destroyed (showing an image of a forest). I calculate the class average, put it up on the board, jotting down their reasons. Then, I repeat the same steps, but with an image of a grassland instead of a forest. Typically, students think forests take centuries and grasslands hardly a few decades to recover. I then present evidence that directly contradicts these misconceptions to show that grasslands too take centuries to assemble.

How can we identify an effective teacher?

Effective teaching can only be identified if you see your decisions (behaviour, strategies and activities) promoting the goals you have for your students (some listed in the second paragraph), and if these decisions are guided by

what we know about how people learn.

How do we currently identify effective teaching? First, we recruit professors on the basis of subject tests (NET) and/or a PhD. Neither of these indicates how well the candidate can teach something that a professor is primarily hired to do. Then, we assess professors based on years/courses taught: how long one teaches has no correlation with how effectively one teaches. Lastly, we also use student evaluations as a metric. To promote their goals, an effective teacher tries to change students' deep-seated prior misconceptions, which can be a stressful and uncomfortable experience for students. Contrast this with a teacher who simply lectures and doesn't do any of that. Students typically love the latter and hate the former. Now you can predict how the evaluations for these two teachers would look, and appreciate how faulty a metric this is. For assessing teaching efficiency, we must, therefore, use a research-based framework (which also includes metrics derived from the SATIC coding) that evaluates how closely our teaching decisions align with our goals.

Agreeably, the present system we have is not the best. But, it's important to understand the ideal way you would like to teach, and then try to follow that as much as you can. Instead of trying out different unscientific 'recipes' for teaching, science education research will provide you with an ideal direction. You would never try out random recipes for your research, so why do that for your teaching? Implementing this is surely not an easy task, but if one has a strong motivation to teach effectively, there are quite a few tricks of the trade available.

Postscript:

Acknowledgements:

I am grateful to Dr. Joanne Olson for exposing me to the Science Education literature, and changing several of my prior notions about teaching, and to Vignesh Kamath for reviewing an earlier draft of this article.

Key References:

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10

Games and higher education in biology

Author: **Saurabh Mahajan**
Date of publication: **24 May 2021**

Excerpt: **Games are not just invigorating and fun, they also keep the players focussed and motivated to learn and do better – qualities that all educators wish to inculcate in their students. In this article, Saurabh Mahajan, a biologist and educator from Atria University, describes ways in which games can be used to achieve better learning of biological concepts, with the same excitement, motivation and focus in students.**

This may be a familiar sight for a college educator- a bunch of students (mostly male, but occasionally female too) huddled together in the canteen, all intensely staring into the small screens in their hands, frantically moving fingers, and often, inanely shouting. The educator's response to this scene is often one of disappointment, admonishment, or sometimes neglect. You perhaps know what I am describing here. The problems with digital gaming are extensively discussed and researched. But let's try a different perspective and explore whether these scenes are telling us something else.

Through many years of my own education, and the past few years of teaching I have rarely seen so many students so sustainably excited, patiently engaged, and actively involved in anything! Moreover, it is something they have mastered on their own, and from their immediate and global peers. Excited, engaged, self-motivated, independent – sounds like a bunch of students from an educator's dream! Then why is this not the average situation in our classrooms? One of my former students, who is an avid gamer, put the blame squarely on my shoulders- "if our classrooms were as exciting as the games, we would automatically pay more attention and be more engaged". I am not sure I entirely agree with his analysis, but could we try to use games to make learning more engaging and effective?

Use of games in education and its potential

The idea of "play" (as in playfulness) is usually associated with activities performed for enjoyment out of intrinsic motivation without any material reward or explicit goal. "Play" has an important role in early childhood and later development and learning. A related idea is that of "gamification", meaning the use of game-like elements, such as point systems, badges, leaderboards, Avatars, etc., for learning, education, or training. This has been widely adopted by ed-tech ventures. Although both play and gamification are related to games and are useful ideas, this article focuses on the use of games in the context of higher education in biology.

Using games in formal education is also not a new idea. A variety of digital and non-digital games are used in school education. This is evident from websites dedicated to STEM games, centres for games and learning, online resources, and popular and research articles documenting the impact of using games for learning (more links can be found at the end of the article). While this appears more common in some countries such as the US, there appears to be great enthusiasm for this in India too (e.g. recently organized Toycathon by the GoI). Games can positively influence motivational, behavioural, and cognitive aspects of learning (see this review for examples). Specifically, playing games shares some common features with learning effectively – active engagement, focused goal-oriented action, and continuous feedback resulting in constant improvement. Moreover, pure fun and enjoyment are essential parts of games and can increase student motivation and engagement, especially in dealing with challenging or otherwise tedious concepts.

Unfortunately, compared to its potential, the use of games does not appear to have received enough attention for undergraduate education, especially in India. In a small survey of current/recent undergraduates, 85% of students (of the 81 Indian students who responded to an online survey) had never or rarely played educational games. Some of them who did, had done so outside their formal educational experience. On the other hand, 70% of students said that the idea of playing educational games sounds exciting, and almost all others were willing to play if these games were "interesting". While other studies (see here and here) and results from our survey suggest differences in male and female students with respect to their current gaming habits (33% of males, but only 5% of females who participated in the survey said they were regular gamers), both male and female students were equally enthusiastic about playing educational games. Reassuringly, all teachers who responded to the survey (a very small sample size) were willing to use games as part of their teaching.

Incorporating games in undergraduate biology courses

Games could be used for several purposes in formal education programs. They could be used as course-starters to excite students towards a topic, as tools for revision of core concepts or ideas, to enable learning of challenging

concepts, to enable application of learnt concepts to realistic situations, to enable independent discovery and in-depth investigations, and even to perform research!

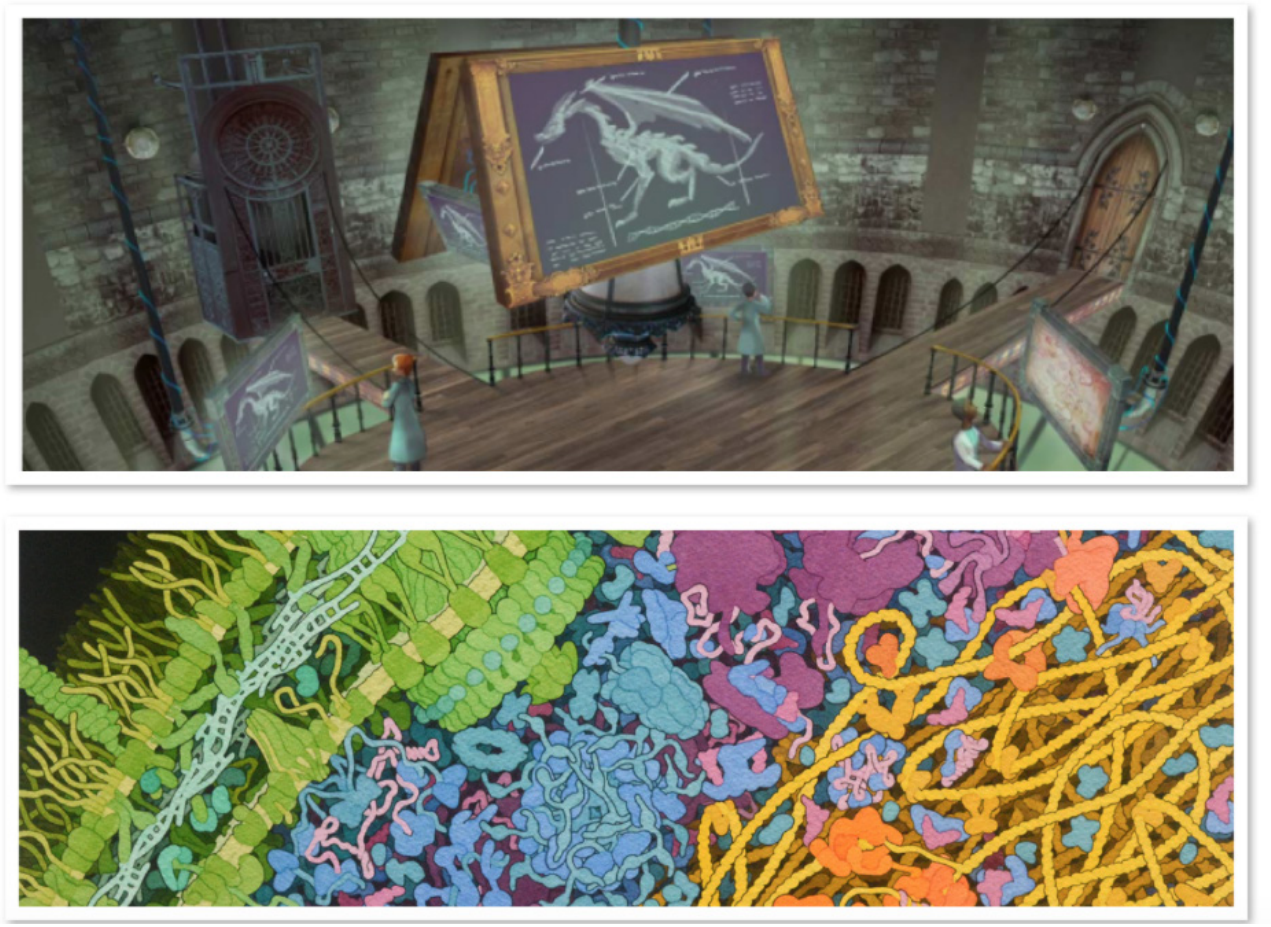

Figure 1: Top: Geniventure, a genetics game that features dragons and their model species. Bottom: Illustration by David S. Goodsell, RCSB Protein Data Bank. doi: 10.2210/rcsb_pdb/goodsell-gallery-028

Admittedly, developing new games can be a time-consuming and demanding task. Thus, a realistic starting point can be to look for existing games for a particular topic. This is easiest for certain basic and core topics in biology, such as cell biology, genetics, evolution etc. (although there are many games for other topics too). Many games developed for K-12 students in the US (and available online) can be appropriate for use in introductory undergraduate courses or as tools for revision or reinforcement of core concepts for advanced courses. For instance, this genetics game (Fig. 1 Top) based on breeding dragons covers core concepts of heredity, Mendelian genetics, sex determination etc.

A second approach could be to design games based on simple and standard templates such as jigsaws or crosswords. For instance, imagine a Jigsaw puzzle made out of David Goodsell's realistic images of a cell (Fig. 1 Bottom) or electron micrographs of cells. Such jigsaw puzzles could enable students to actively explore the structural features of cells or tissues and can be easily implemented using readymade online tools. This idea of developing games based on existing templates is also evident in many card-based games. These could involve the inventive use of usual playing cards, or the usage of custom-made cards (for example, this ecology card game based on bird species interactions).

Finally, some biology courses can include games that have successfully enabled deep engagement with complex

scientific topics. For instance, FoldIt is a digital game about protein folding, which allows students to manipulate the 3D structure of proteins to discover stable configurations. Previously, this game has also been used to involve citizens in protein-folding research. Following its use as an undergraduate educational tool, the scientist-developers of this game recently also introduced a module specifically for biochemistry education. More games in this category include Eterna (designing RNAs), Eyewire (tracing neural circuits), Phylo (improving multiple sequence alignments) and others.

Educators' and students' experience

Megha and Madhumita Krishnan, faculty at the Transdisciplinary University (TDU) in Bangalore, effectively use simple games for specific requirements in teaching-learning. For example, after realizing that participants in an Ayurveda biology course struggled with learning the correspondence between English and Sanskrit terms, they designed a crossword-based game. To enable the application of concepts of Ayurveda dietetics, they designed another game where students had to combine 3 dishes to make diets complete with the Shadrasaas, somewhat like the popular pizza-making game- Good Pizza Great Pizza. Megha thinks that playing these games together made learning more fun for the course participants.

Leveraging the experience of the global educators' community, I have incorporated the FoldIt game in a foundation biology course to enable students to discover and learn chemical interactions underlying protein structures. I am also encouraged by the experience of another former student. Manasa Sharma played FoldIt as a high-school and undergraduate student, and actually contributed to two research papers along with other players and researchers. She says, "the citizen science and research aspects of this game were actually more interesting than the curricular aspects".

Looking ahead

There is much more one can do, after experiencing the benefits of using educational games. Megha is now actually looking to take on the challenge of further developing her games by collaborating with professional game developers. The professional game development community in India can be a great help here. In multi-disciplinary institutes, this could actually be a great avenue for cross-disciplinary collaborations between science, design, and digital technology departments.

Despite all these interesting possibilities, the limitations of game-based education also need attention. Games by necessity abstract out reality and thus, even for specific topics, game-based learning might need to be supplemented with other learning strategies. Another legitimate concern is the addition to already extensive screen time. On the other hand, games could help with making online learning more engaging- a challenge of the current time.

Finally, one may worry that games will take away time from "serious" learning. If this thought crosses the mind, all one needs to do is remember the feeling of joy the last time one played a game. And decide to give joyful and playful education a chance.

Postscript:

Useful links:

- https://www.legendsoflearning.com/
- https://games.commons.gc.cuny.edu/
- https://bokcenter.harvard.edu/games
- https://guides.lib.umich.edu/c.php?g=282989&p=5955091
- https://mgiep.unesco.org/games-for-learning
- https://www.pbs.org/wgbh/nova/labs/lab/evolution/
- https://esgame.unige.ch/
- https://news.ncbs.res.in/archivednews/story/what-can-card-game-teach-us-about-evolutionary-biology
- https://www.edutopia.org/topic/game-based-learning
- https://www.tandfonline.com/doi/full/10.1080/10508406.2017.1333431

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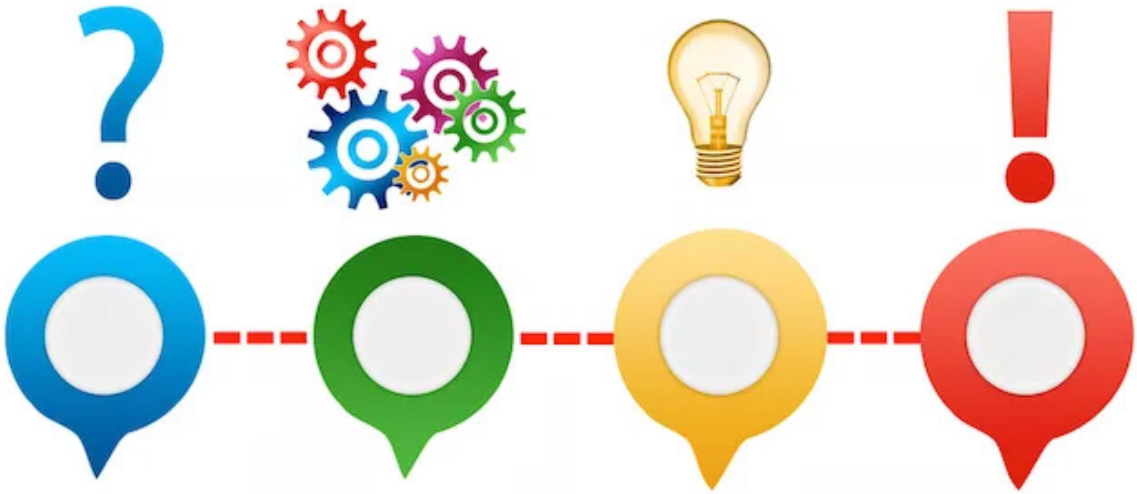
11

Problem-based learning can impart skills for life

Author: **Lakshmy Ramakrishnan**
Date of publication: **21 Feb 2022**

Excerpt: **Problem-based learning is a pedagogical approach that enables students to learn scientific concepts in real-life contexts. In this article, Lakshmy Ramakrishnan, a researcher and educator, elaborates on this approach with examples and explains why it is so useful.**



Problem-based learning (PBL) is a creative pedagogical approach that aims to promote self-learning by engaging students in contextual exercises. McMaster University, Canada, was the first to introduce PBL in their classrooms, way back in the 1960s, and shortly after, it was established in Europe and Australia. According to an eminent researcher in higher education from Deakin University, the main idea behind PBL is that 'the starting point for learning should be a problem, a query, or a puzzle that the learner wishes to solve.'

In this approach, students are given authentic problems that are in need of resolution. They are required to understand the situation, use prior knowledge to make connections, find resource material to better understand the concept, and formulate a solution. These exercises can be carried out individually or in small peer groups. Additionally, as it is carried out through discussion and analysis, a tutor facilitates these interactions and steers students along guided inquiry paths. This approach encourages students to think outside the box and realise that there might not be just one correct answer to a given problem.

Examples of PBL

(a) Students are given a DNA sequence; asked to identify the regions that are required for transcription and translation, identify signal and localisation sequences, and functional motifs in the peptide, and determine its function and under what conditions it is expressed.

Students could be further asked to design an experiment that involves cloning the cDNA into a suitable expression system.

This problem requires students to familiarise themselves with bioinformatics and apply molecular biology tools in a digital-lab format.

(b) Jenny is a teenager facing a critical decision. Should she have DNA testing for Huntington's Disease (HD), a genetic disease that took the life of her grandmother? Why does her mother insist that Jenny get tested? Why won't her father get tested when he's started to show symptoms of HD? What are the potential consequences of this decision for Jenny and for her family?

This problem requires students to understand the genetic cause of Huntington's Disease as well as the process of genetic testing, its risks, limitations, and bioethics.

Advantages of PBL

PBL has been popularly identified with medicine, nursing, and biological sciences, though it can be applied to any discipline. Studies have shown that PBL offers a significant advantage over traditional lecture-based learning environments in undergraduate biology courses. According to the Hun School of Princeton, PBL empowers students to think independently and become drivers of their own learning. It appears to be effective in imparting long-term retentivity and is efficient in developing critical thinking and collaborative skills. PBL encourages students to formulate new ideas based on scientific evidence. It coaches students to understand natural phenomena and find solutions to existing challenges, thereby applying scientific ideas and practices.

Problem-based learning does not dismiss the importance of traditional teaching styles, rather it reinforces material that has already been taught in the classroom by making students understand real-life concepts and apply knowledge. In PBL classrooms, instructors will need to divide the cohort into groups and constantly move around the room and engage with different groups. By roving, instructors will fulfil the role of 'cognitive coaches,' where they guide, probe, and support student initiatives, as opposed to lecturing and directing. In addition, the inclusion of novel assessment methods, including, self-reflection and peer assessment enables students to keep a track of their own learning.

Challenges

Implementing a problem-based learning method to a curriculum is challenging and poses certain questions, including, how can PBL be scheduled within the curriculum, will it meet course objectives, how will student learning outcomes be evaluated, and what methods will be included to organise and monitor groups. Higher-education providers could offer training programmes and workshops so that educators can have a defined understanding of the roles and responsibilities of instructors and students, thus equipping instructors with the necessary skills needed to lead PBL-based teaching.

Studies indicate that most of the challenges faced by educators stem from controlling course content, devising unique problems and questions, as well as ensuring that the problems meet academic standards. Despite its challenges, the PBL approach also serves as an avenue for educators to learn new teaching skills, and design and evaluate meaningful, high-quality projects.

In light of Covid-19

The importance of self-directed learning has only become more prominent with the advent of the Covid-19 pandemic. It has necessitated the adaptation and evolution of educational systems through distance and virtual learning. 'Unfinished learning', a term coined by McKinsey & Company, is used to demonstrate that students have missed out on opportunities that they normally would have had during a typical academic year, as a result of the Covid-19 pandemic. Be it schedule disruptions, unreliable internet connectivity, Zoom fatigue, Covid-19, or overall well-being, the pandemic set students back in some form or the other.

In India, there is a lack of robust data on the impact of the pandemic on the education system but according to the 'Covid-19 Learning Loss in Higher Education' by TeamLease, India has an estimated learning loss ranging between 40 – 60%. It is evident that the closure of educational institutions triggered a shift to technological and remote learning methods, which raised challenges, such as access to such technology, sustaining motivation to learning, and incorporating reliable assessment methods. In the case of disciplines that require hands-on practical classes, such as life sciences and engineering, there have been limitations imposed on access to classes and the nature of assessments.

It is with this novel scenario in mind that researchers called the need for innovative alternative education and assessment strategies. The pandemic has therefore acted as an opportunity for higher education providers to recalibrate the way they deliver their teaching styles. A study conducted at Aalborg University, Denmark, which has a long tradition of applying PBL in their educational activities, found that a digital PBL approach was able to mitigate some of the negative consequences of online learning. Digital PBL enabled students to work in a productive manner without the feeling of isolation and was effective in achieving positive learning outcomes when group collaborative online tools were used.

The way forward

Problem-based learning encourages students to give importance to evidence, formulate opinions, develop skills to justify their well-founded opinions, work as part of a team, improve written and oral communication skills, and actively engage in issues that are relevant in today's society. Bearing this in mind, the incorporation of a PBL

approach into the classroom can greatly motivate students to challenge themselves and develop transferable skills for higher education, such as doctoral programmes. Moreover, as education delivery methods are becoming dynamic, it is prudent for educators to incorporate innovative teaching styles, such as PBL, in their classrooms.

Postscript:

Find related articles on the IndiaBioscience website using this link:

https://indiabioscience.org/columns/education/problem-based-learning-can-impart-skills-for-life

12

Slaying hoaxes: harnessing fake 'scientific' information to teach science

Author: **Anusha Krishnan**
Date of publication: **28 Jun 2019**

Excerpt: **How do you perceive social media news of a common snack being made of plastic? Or that fast food never decays? The new currency notes carrying nano-GPS chips? Test such news before dismissing it (or accepting it) - the experiments are surprisingly simple, rational and logical, and an excellent opportunity to instil the practice of inquiry-based learning.**

As a teacher/researcher, how many times have you cringed on hearing a piece of well-meant, but terrible advice? Here's an example: "*Don't eat Kurkure, it's made of plastic!*"

For the record, this rumour was started because of a video clip that showed a piece of Kurkure 'burning and melting', which apparently meant that the popular snack contained plastic.

Fact: Most snacks that contain high levels of carbohydrates and oil will 'burn and melt' just like Kurkure.

A downright dangerous challenge: "*It's dengue season…for all those who want to avoid dengue, or cure dengue in a day, drink papaya leaf juice.*"

Fact: papaya leaf extracts do not prevent or even cure dengue (in a day?). Dengue fever causes a decrease in platelets in your body. Papaya leaf extracts boost your body's ability to make platelets, and help mitigate the effects of dengue – if you get bitten by a dengue-carrying mosquito, even though you have drunk papaya leaf juice, you can still get dengue.

When well-meaning friends or relatives, who are usually sharp enough to spot fake notes in a wad of money, believe in and pass on such messages, what do you do? Taking my responsibility as a former scientist and current science communicator very seriously, I decided to try and explain that this 'information' was not true.

The most common response to my carefully collated research material (and rational thinking) was, "Yes, yes, but all of this is done by someone else! How do you know they're telling the truth?". This is in truth, a fair question. The only way to counter it is to test these so-called facts by carrying out and interpreting the results of experiments by yourself.

This is exactly what an Associate Professor, Evan Lampert, and a graduate student, Holly Munro, at the University of North Georgia made undergraduate students do. The students designed their own hypotheses and set up experiments to test the veracity of a well-known and widespread modern myth in the USA – that fast food does not decay.

In a study that they published in The American Biology Teacher, Lampert and Munro made students inoculate hamburgers and other fast food items with the fungus Rhizopus stolonifer (black bread mould) as a part of an introductory biology class. R. stolonifer is usually harmless, easily obtainable, and easy to culture. Students used a 3 mm plug of R. stolonifer cultured on potato-dextrose agar to inoculate 60 mm disks of different foods such as burger patties, chicken nuggets, bread, burger buns, biscuits, and other baked products. Petri plates with the inoculated foods were sealed and incubated at 25 °C for four days, following which, the diameters of the fungal growths on the food were measured. During the incubation period, students were given worksheets where they had to list out the ingredients, including antimicrobials and preservatives, in the foods they were testing. Using this information, they were asked to formulate a hypothesis on whether a particular food item would support fungal growth or not, and explain their reasons for the hypothesis. Since most undergraduate students usually have difficulties in differentiating between a question, hypothesis, and prediction, the exercise was useful in helping them understand these concepts.

Through the experiments, the class observed that plain bread products, which contain the antifungal agent calcium propionate, seldom allowed fungal growth. Similarly, fungal growth was low in foods covered with condiments such as ketchup and mustard, which also contain high levels of preservatives. However, animal products like burger patties and chicken nuggets, and moist foods with sauces and glazes supported plentiful fungal growth. Overall, the experiments helped students understand that fungal growth depended on the moisture and preservative content of the food.

The entire exercise not only helped the class evaluate the reliability of online information, it also served as an introductory lesson on fungi. Using well-known foods boosted interest in the laboratory experiments, and

promoted discussions of nutritional practices. The authors report that after the experiment, many students expressed interest in changing their eating habits for a healthier future.

Lampert and Munro end their publication with thoughts on unlimited opportunities to examine online claims in lab courses. "We recommend that high school and college instructors seek out their own online stories and develop ways to test them or seek original information in peer-reviewed scientific literature. Such activities can be effective and engaging learning experiences," they add.

"Popular myths can be busted through simple hypotheses-driven experiments in colleges and schools. Students can be asked to identify and list prevailing online information — for example, certain rice brands made of wax or Maggi noodles being coated in wax," says Urmi Bajpai, an associate professor from the Acharya Narendra Dev college, New Delhi. "In testing such claims, students learn to prove/disprove a 'known fact' instead of doing cookbook-style experiments. They learn to question the credibility of unverified facts and understand the concepts of enquiry-based learning, along with learning experimental skills," she adds.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/cracking-modern-myths-harnessing-fake-scientific-information-to-teach-science

13

Reading popular literature helps build disciplinary literacy — an example from conservation science

Author: **Andrea Phillott**
Date of publication: **27 Jan 2020**

Excerpt: **Andrea D. Phillott, Professor in Environmental Studies, teaches Conservation Biology, Ecology, and Environmental Studies at FLAME University, Pune. In this article, she writes about an innovative approach she has followed to develop disciplinary literacy in her students viz., assigning them readings from popular literature, both fiction and non-fiction, pertaining to conservation science.**

Popular Literature

For university educators, one of the goals is to develop disciplinary literacy — the ability to read, write and communicate ideas in the discipline — in our students. Students develop disciplinary literacy during in-class activities (especially active learning activities as described here) complemented by out-of-class activities including assigned readings.

Traditionally, educators in the sciences have assigned readings from textbooks or research articles whose primary purpose is to communicate information or ideas. However, these sources have been described as challenging for readers unfamiliar with the technical language ('jargon') and writing structure (such as the IMRAD structure of research papers) and are often written in the passive voice.

In comparison, popular science writing presents less technical writing in an active voice, and places greater emphasis on the relevant actors and their thoughts and actions. Popular non-fiction literature with complementary learning activities have been used for assignments in undergraduate courses on general biology, microbiology (here and here), genetics, neurobiology, sensation and perception, the biology of cancer, biochemistry, biotechnology, organic chemistry, and the nature of science.

In addition, one published study investigated the use of popular literature in a course on conservation biology wherein students read the book 'Tigerland and other Unintended Destinations' by Eric Dinerstein (Island Press, 2005). The authors found that students made connections between the reading and conservation concepts and practices discussed in class and regarded the characters as role models.

Interested to see how reading popular literature could facilitate student learning in my own courses but hesitant to assign a single book because of students' varied interests, I planned a different approach.

I provided final year students studying the course 'Conservation Biology' during their Bachelor of Arts in Environmental Studies with a list of suitable books (ensuring close to equal proportions of male and female and national and international authors) available in the University library. However, they could also read a book from their personal collection.

My recommendations included the species-centric 'From Soup to Superstar: The Story of Sea Turtle Conservation Along the Indian Coast' by Kartik Shanker (HarperLitmus, 2015) and more species-diverse 'The Vanishing: India's Wildlife Crisis' by Prerna Singh Bindra (Viking, 2017). Other books were place-based; 'Nature in the City: Bengaluru in the Past, Present, and Future' by Harini Nagendra (Oxford University Press, 2016) and 'Islands in Flux: The Andaman and Nicobar Story' by Pankaj Sekhasaria (HarperCollins Publishers India, 2017) encouraged students to consider familiar locations through a conservation lens.

Exploration of conservation experiences was possible through memoirs, such as 'Running Away from Elephants: The Adventures of a Wildlife Biologist' by Rauf Ali (Speaking Tiger Books, 2018), or fictional works, including 'The Hungry Tide' by Amitav Ghosh (HarperCollins Publishers, 2004). Books examining conservation practice, such as 'The Big Conservation Lie: The Untold Story of Wildlife Conservation in Kenya' by John Mbaria and Mordecai Ogada (Lens & Pens Press, 2016) and 'Conservation from the Margins' by Umesh Srinivasan and Nandini Velho (The Orient Blackswan, 2018) had the potential to inspire lively, but thoughtful, conversation and debate.

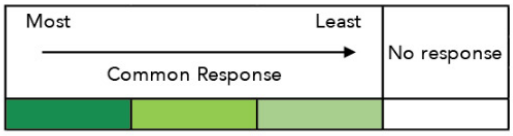
Students read at least one chapter a week and shared a 350 – 500 word reflection about how the content related to Conservation Biology course topics (including threats, population declines, and conservation actions) in an online class forum for everyone to read. Student reflections also contributed to their final grade for the course.

At mid-semester, students provided feedback on the activity using an anonymous survey and gave their consent for me to share the following responses. On a scale of 'Very limited' to 'Excellent', most students described their learning gains in building knowledge about concepts and applications in the discipline of conservation biology as 'Strong', and in relating course content to actual situations and making connections between conservation

biology and other disciplines as 'Excellent'. Students' self-assessed learning gains in these areas were greater than what they reported after other course assignments during which they read and summarised primary research literature.

Students' Feedback on Reading Activity

Learning Gain	Very Limited	Limited	Moderate	Strong	Excellent
Building knowledge about concepts and applications in the discipline of conservation biology					
Relating course content to actual situations in the discipline of conservation biology					
Understanding challenges in the discipline of conservation biology					
Understanding the experiences of people working in the discipline of conservation biology					
Making connections between conservation biology and other disciplines					
Identifying soft skills which help people working in the discipline of conservation biology					



However, the most valuable outcome of reading popular literature was beyond that of building knowledge about concepts and issues in conservation biology. Most students reported 'Excellent' learning gains in developing a personal understanding of challenges in the discipline, understanding the experiences of people working in conservation biology, and identifying skills such as photography which aid conservationists in their work. Of similar value to them was the development of a regular reading practice, albeit one that was hard to maintain at times when assessment was due for multiple courses.

In response to this feedback, I reduced the reading reflection requirement from weekly to fortnightly so as to maintain the sense of anticipation, interest, motivation, and engagement they described as the aspect of the activity they found the most rewarding. I did not want such positive emotions to be overwhelmed if the reading reflection became just another task to complete each week.

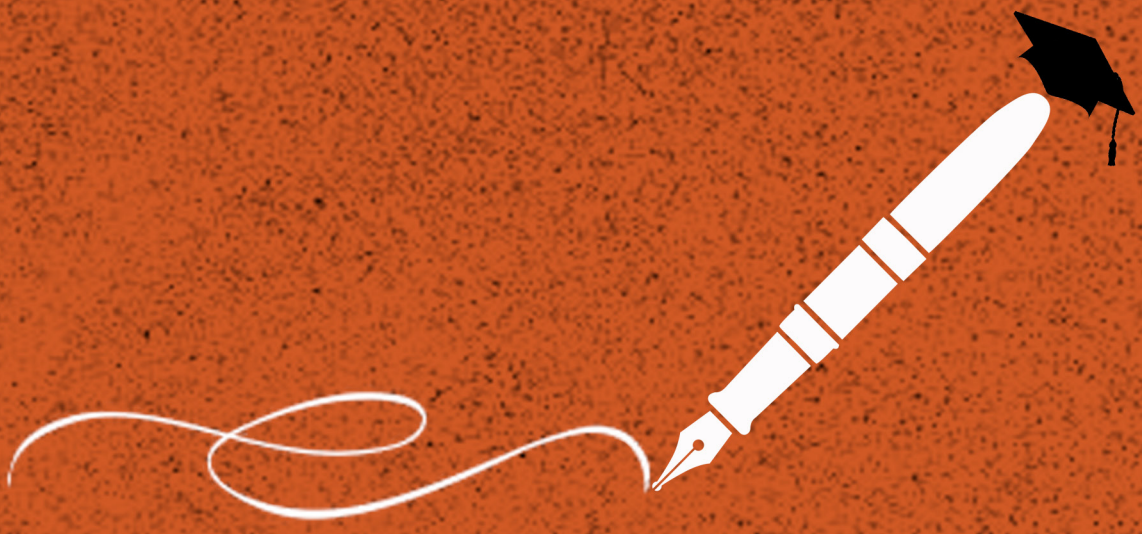
The students' feedback indicated reading popular literature contributed to the development of both disciplinary literacy in conservation biology (as discussed here, here and here) and a community of learners as students referred each other to chapters they believed would be of interest to their peers or linked to topics and assessment for other courses. I plan to continue the reading and reflections (which contribute to their final grade) in future years and strongly encourage educators in other science courses and disciplines to consider how it might benefit their students.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/reading-popular-literature-helps-build-disciplinary-literacy-an-example-from-conservation-science

Unravelling student misconceptions

Articles featuring some of the common misconceptions in biology that undergraduate students hold and approaches taken by educators to identify and address these misconceptions in their classrooms.

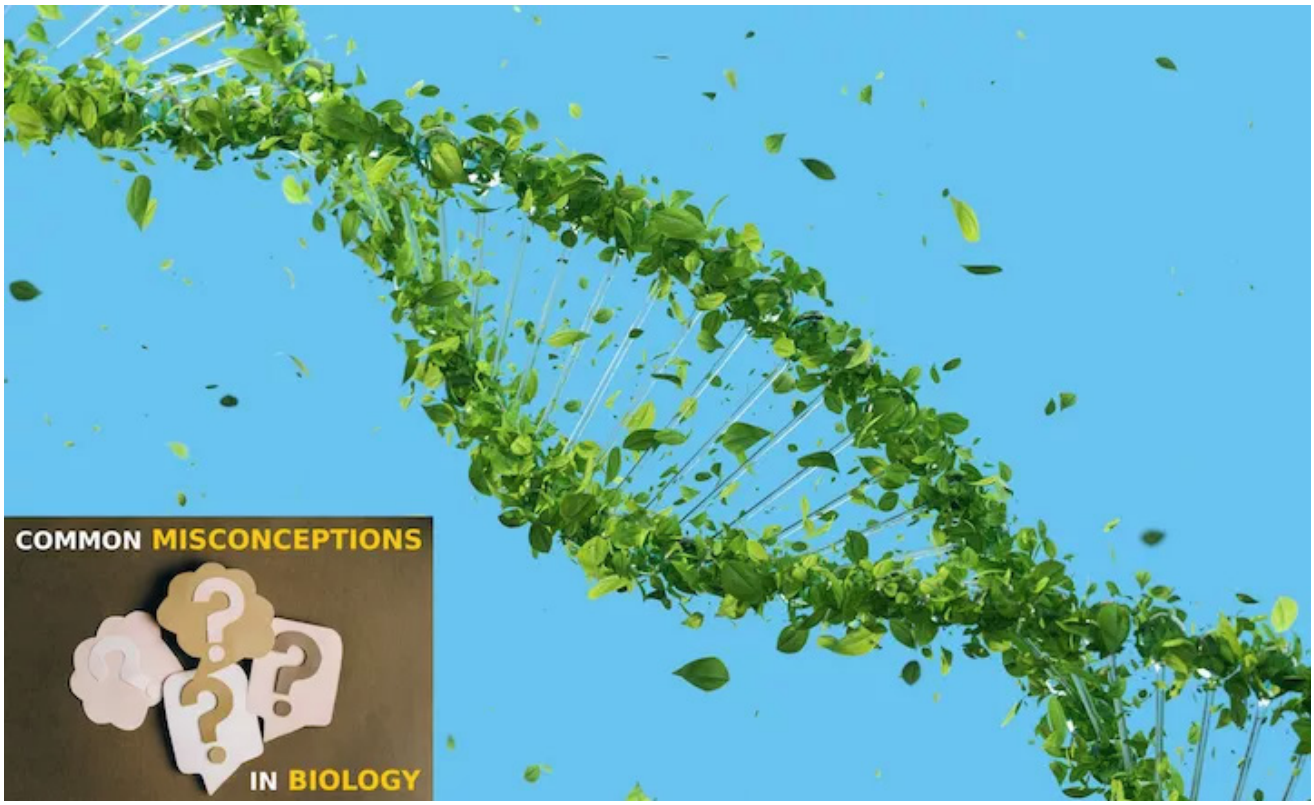


14

Common misconceptions in biology: Making sense of the sense and antisense DNA strands

Author: **Maya Murdeshwar**
Date of publication: **31 Jan 2022**

Excerpt: **Molecular biology textbooks teach us that during gene expression, only one strand of DNA is used to synthesize RNA. Does this mean that only one of the strands of an entire DNA duplex is functional? What does the other strand do? Which one is called the 'sense' strand? Is it the same as the 'template' strand? These are some questions that often baffle undergraduate students of biology. In this article, educator Maya Murdeshwar of St. Xavier's College, Mumbai describes how she approaches these concepts in her classroom.**



The discipline of molecular biology investigates information processing pathways in living cells, identifying the key players that synthesize our genetic blueprint – the deoxyribonucleic acid (DNA) molecule – and subsequently 'express' it into ribonucleic acid (RNA) and protein molecules – a process termed 'gene expression'. While it is fascinating to explore nature's information-processing pathways, reading through molecular biology textbooks

could be a daunting task for a rookie undergraduate not acquainted with the terminology used.

Different books use synonymous nomenclature interchangeably, making it difficult to differentiate between terms like 'sense/antisense', 'coding/non-coding', 'template/non-template'. The complementary base pairing of nucleotides and the anti-parallel nature of DNA strands add a further layer of complexity. This especially poses a challenge for students referring to multiple textbooks in their course of study. Those unable to make the right connections run the risk of incorrectly interpreting the fundamental processes of life. This article is the first in a two-part series that addresses some of the most common misconceptions in undergraduate molecular biology.

Misconception 1:

Only one strand of DNA is used to synthesize RNA.

This statement occurs in most textbooks leaving students with the notion that at all times, only one entire strand of DNA from the two strands in the duplex is transcribed into RNA, while the other strand is inert and has no role to play. This leads to an incorrect understanding of the process of 'transcription'. I first realized this when a student, having completed the assigned reading, asked me, "So, if only one strand of DNA is used for making RNA, what does the other strand do? Are there no genes present on this strand?" Since then, I make it a point to ask this very question in class to check whether students have thought about it at all and ensure to fill the gap in their understanding by means of a simple blackboard exercise.

Correct Concept:

Only one strand of the DNA duplex is used to synthesize RNA at a given time in a given region of the DNA.

Different regions of the DNA express at different stages in the life of a cell. Nucleic acid hybridization experiments have provided evidence for the same. When a particular region of the DNA is being transcribed, the strand of the DNA that is used to make a complementary RNA is termed the 'template' strand. At the same time, the other strand in the same region is NOT transcribed, and is therefore termed the 'non-template' strand. The latter strand may, however, act as the template strand in a different region of the DNA or at a different time in the same region.

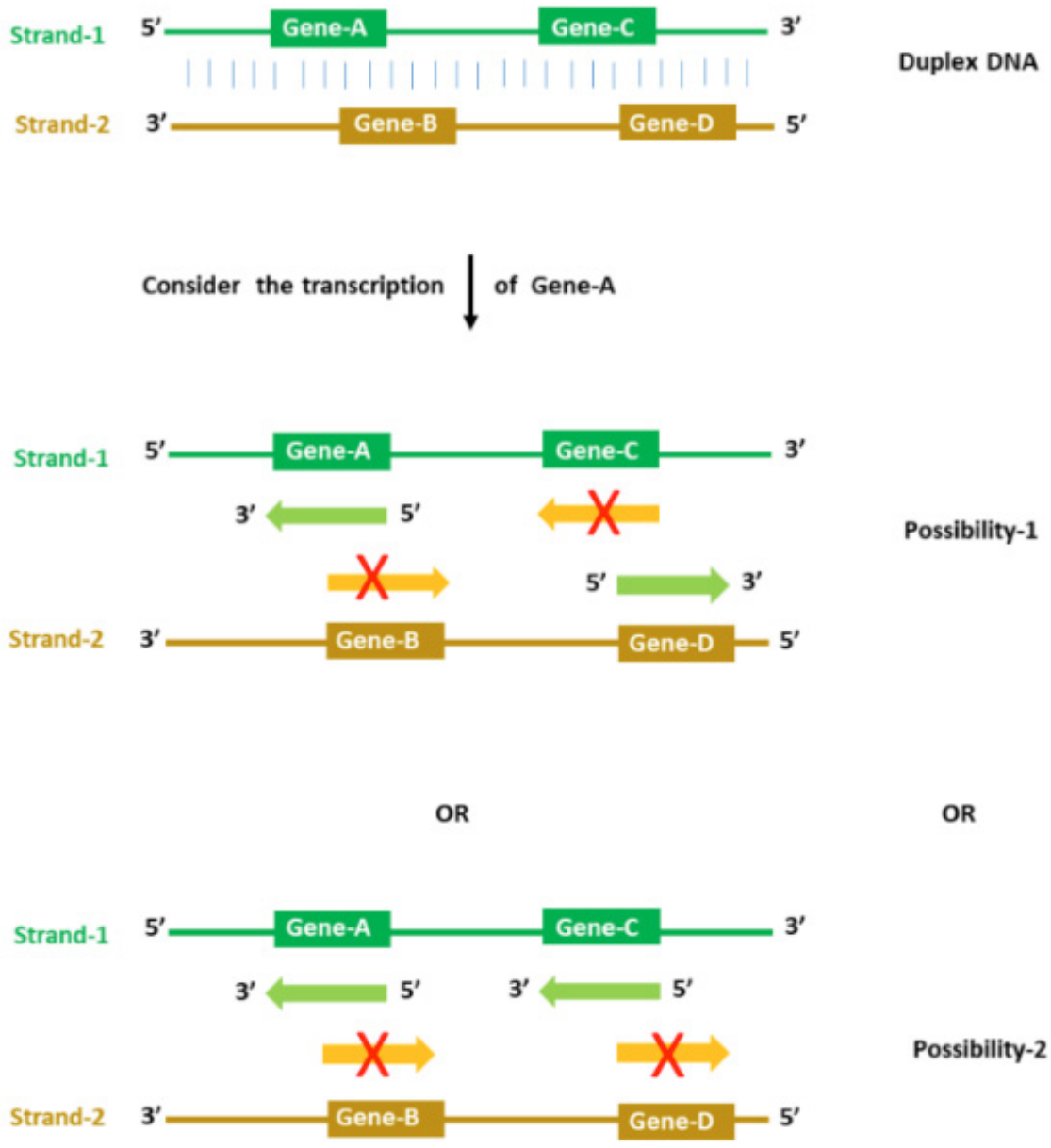


Figure 1. Both strands of DNA can be used as templates in the synthesis of RNA by the process of transcription. When one region on the DNA is being used as a template for RNA synthesis, the complementary region on the other DNA strand is not. Photo credit: author.

Figure 1 depicts a scenario where genes A and C partially overlap with genes B and D, respectively, on the opposite strand. Strand – 1 is the template strand for genes A and C, whereas strand – 2 is the template strand for genes B and D. When strand – 1 is being used for RNA synthesis from gene A, its complementary region on strand – 2 cannot be used to transcribe gene B. However, strand – 2 can be used at the same time to transcribe gene D (Fig.1, Possibility – 1). Alternatively, when gene A is being transcribed from strand – 1, at the same time, a different region on strand – 1 can be used to synthesise gene C (Fig. 1, Possibility – 2). Further, gene B can be transcribed at a different time when gene A is not being transcribed. The possible combinations of simultaneous gene transcriptions are listed in Table 1.

Transcription of	Simultaneous transcription possible on: either Same strand OR Opposite strand		Simultaneous transcription NOT possible for	Template strand	Non-template strand
Gene-A	Gene-C	Gene D	Gene-B	1	2
Gene-B	Gene-D	Gene-C	Gene-A	2	1
Gene-C	Gene-A	Gene-B	Gene-D	1	2
Gene-D	Gene-B	Gene-A	Gene-C	2	1

Table 1. Patterns of gene transcription possible with reference to Figure 1 above.

Why is this so?

If the complementary regions on both strands of DNA were to be transcribed simultaneously, the two RNA molecules thus formed would pair with each other due to their complementary nature. They would thus not be available for protein synthesis (translation) (Figure 2a).

Further, if such regions were to be transcribed and translated, the two proteins synthesized would have completely different amino acid sequences (Figure 2b). They would be two completely different proteins with distinct functions. If nature were to optimize the function of one protein by modifying the DNA sequence encoding it, this would result in a corresponding change in the nucleotide sequence on the complementary DNA strand, thus changing the sequence and modifying the function of the protein encoded by that strand. Hence, a change in the coding region of one DNA strand would be possible only at the expense of a corresponding change in the coding region of the other strand. It would therefore not be possible to optimize the function of both proteins simultaneously – an evolutionary disadvantage to the cell. These are probably the reasons why nature favours transcription from only one strand of a region of DNA at a time and the occurrence of overlapping genes (like genes A and B in Fig. 1) is rare.

To aid visualization of these concepts, I write actual nucleic acid sequences on the blackboard and walk students through DNA –> RNA –> polypeptide synthesis (Figures 2a and 2b). Given a duplex DNA sequence, students are expected to transcribe it to the corresponding mRNA and translate the mRNA to the corresponding peptide sequence using the standard genetic code. This in-class exercise has helped greatly in clarifying doubts.

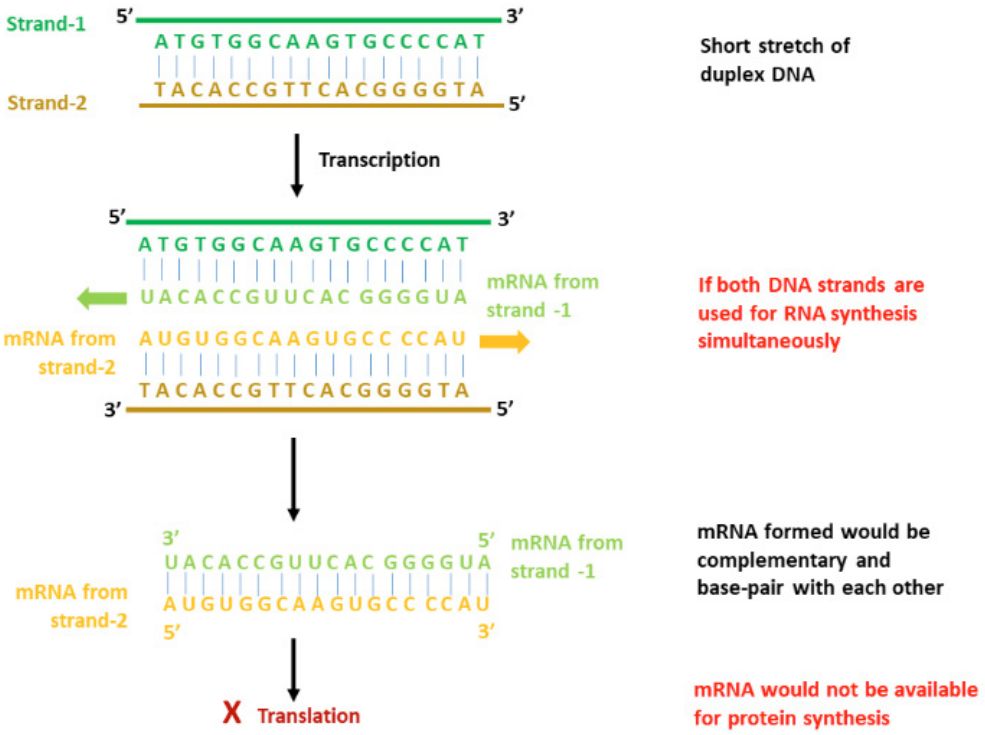


Figure 2a. Simultaneous synthesis of RNA from the corresponding region on the two strands of DNA does not occur. A possible reason could be the complementary nature of the mRNA formed that would cause them to base-pair with each other, making them unavailable for protein synthesis. The stalling of protein synthesis is detrimental to cell survival, and hence nature has selected against it. (Green and orange arrows indicate the direction of transcription).

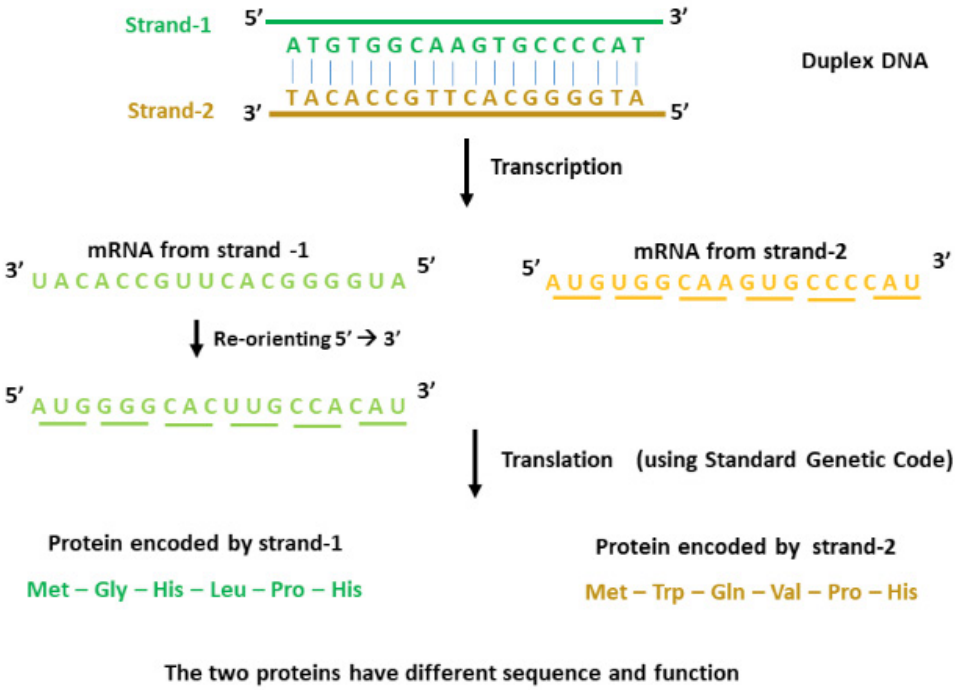


Figure 2b. Protein synthesis from the corresponding region on the two strands of DNA leads to the formation of two proteins having different sequences and functions. While simultaneous synthesis is not possible, the two proteins can be synthesized at different times, with only one strand of DNA in a specified region being involved in transcription at any given time.

Misconception 2:

The 'sense', 'coding' and 'template' strands of DNA are the same.

The 'antisense', 'noncoding' and 'non-template' strands of DNA are the same.

Students incorrectly interpret that the 'sense' strand of DNA is used to synthesize mRNA that finally encodes the protein, therefore it is called the 'template' or 'coding' strand. The other strand is the 'non-template' or 'antisense' or 'non-coding' strand and has no role to play in the transcription process.

This is apparent from a simple exercise of presenting the sequence of a DNA duplex and the mRNA sequence corresponding to any one strand, and asking students to appropriately name the strands (Figure 3). In my experience, most students confuse the nomenclature since their understanding of the concept behind the definitions is not clear.

Correct Concept:

This is a classic example of 'too many cooks spoil the broth' wherein the use of several alternative terms interferes with the correct understanding of the associated concept. Further, the terms are not all synonymous. Students mistakenly club them together – all positive-sounding terms in one group and their opposites in another.

As defined earlier, in the region being transcribed, the 'template' strand refers to that strand of DNA being used to synthesize RNA. The sequence of the newly synthesized RNA is, therefore, *complementary* to that of the template strand.

On the other hand, the non-template strand is also termed the 'sense' strand since its nucleotide sequence is *identical* to that of the synthesized RNA, with the exception of U replacing T in RNA. Nature makes 'sense' of the information coded in the DNA. In turn, the sequence of RNA (if it is mRNA), read as triplet codons, dictates the specific sequence of amino acids in the protein being translated from it. Extrapolating back to DNA, the 'sense' strand contains the genetic code for making the RNA and the corresponding protein, and hence, is also known as the 'coding' strand. It is important to note that the sense/coding strand of the DNA is not *transcribed*. It is the same as the 'non-template' strand discussed above. By corollary, the 'template' strand is known as the 'antisense' or 'non-coding' strand.

The equalities in terms of nomenclature, therefore become:

- Template = Transcribed = Antisense = Non-coding strand = complementary in sequence to the synthesized RNA
- Non-template = Non-transcribed = Sense = Coding strand = same sequence as synthesized RNA (T replaced with U in RNA)

This can be understood better using actual nucleotide sequences (Figure 3).

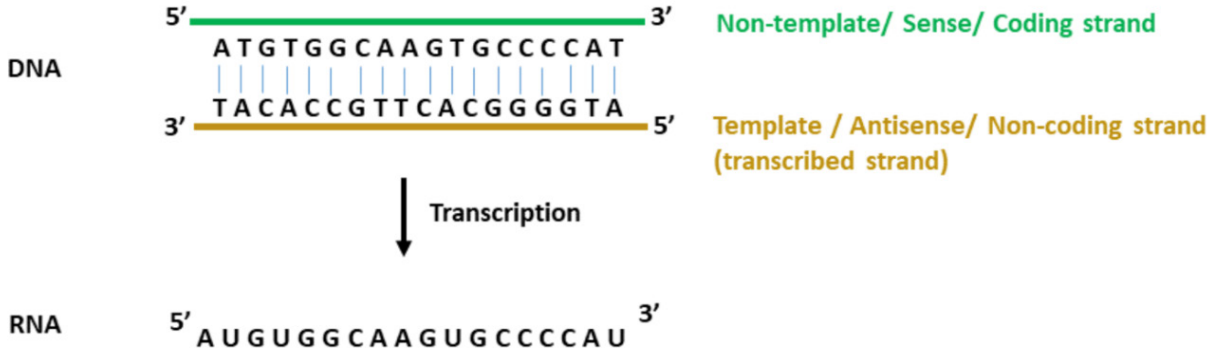


Figure 3. Equivalence in nomenclature of DNA strands understood using DNA and RNA sequences.

The above are only a couple of common misconceptions that students of molecular biology have with respect to the transcription process. In the next article in the series, we will discuss some of the misconceptions about protein translation.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/common-misconceptions-in-biology-making-sense-of-the-sense-and-antisense-dna-strands

15

Common misconceptions in biology: Misconceptions around diffusion and osmosis

Author: **Nagarjuna G**
Date of publication: **23 Jul 2021**

Excerpt: **Many biological phenomena, like respiration, osmoregulation or nerve conduction, have a basis in physical processes like diffusion and osmosis. Definitions and diagrams may contain nuances that students may miss, especially when these are not viewed through the lens of physics. In this article, Nagarjuna G, Former Professor, Homi Bhabha Centre for Science Education, TIFR gives examples of some of these misconceptions and offers simple simulations to provide a more accurate picture of these processes.**

Diffusion and osmosis are physical phenomena that happen everywhere in a living organism but they enter the discussion more explicitly while dealing with water transport in plants, gaseous exchange, osmoregulation, absorption of digested food in the intestine, and nerve transmission.

Most organs in the body and organelles in the cell are mapped to some function. If there is a structure, it has a function. So, it is roots that absorb water and minerals; lungs exchange oxygen and carbon dioxide, kidneys perform osmoregulation, the intestine absorbs digested food, axons conduct nerve impulses. This thought process is predominant in biology, which gives rise to several misconceptions.

Physical processes happen whether we like it or not, whether there is an organ or not. It is one of the features of a living cell to regulate this happenstance. Accumulating something in a location and partitioning that location from the constantly perturbing physical environment is a requirement for the origin and sustenance of life. In this process, regulating diffusion is most likely one of the first steps of living. A good grounding in thermal, chemical, and electrical phenomena is essential for understanding biological processes.

For instance, when we probe students about how we take oxygen and release carbon dioxide, they often answer that the lungs do that filtering. Lungs are incapable of making any selection of this kind since no such selection ability exists at the respiratory surface. It is pure diffusion. The students also pass the role of filtering onto RBC or haemoglobin, which are waiting in the lungs to capture oxygen and release carbon dioxide. They do not see that there is an aquatic medium in between and that the process happens entirely through diffusion. The respiratory surface is wet in all organisms, both aquatic and terrestrial. Gases must first dissolve in water before they can be used by the cells. The misconceptions related to diffusion and osmosis arise when we ignore physics while teaching biology.

Additionally, we often rely on defining terms independent of a theoretical model. Misconceptions also arise from the definitions and the terms we use. The misconceptions associated with diffusion and osmosis arise not only from the definitions of the terms "diffusion" and "osmosis" but also "solution," "solvent," "solute," and popularly drawn distinctions regarding the mixtures and compounds on the one hand and physical and chemical changes on the other. Students develop mental models by learning each of these concepts independently. It is essential to situate all these concepts in a model which provides meaning to them, by invoking model-based reasoning.

Resolving misconceptions about diffusion

The definition of diffusion mentions that the process takes place from high concentration to low concentration. When we give students an example of a drop of the dye placed in one corner of a beaker filled with a solution and ask them if the dye diffuses, their answer is yes. But when we ask whether the diffusion of the dye continues after an equilibrium state reaches, most of them respond that diffusion stops when concentration is uniform across the solution. Similarly, when we present them with a beaker with a salt solution of a given concentration and ask whether there would be any diffusion, most say, "no", since there is no concentration gradient. Students do not realize that the process is due to the **dynamic** and **particulate** nature of matter **but instead remain stuck to the idea of concentration gradient**, since the definition puts it so. Particles diffuse even without a concentration gradient, as long as there is kinetic energy in the substance. The dynamic character of the matter does not come to a halt after reaching equilibrium.

It is only the "net" flow in a specific direction that depends on a concentration gradient. For example, during the COVID-19 pandemic, the virus infection affected the available surface area for the diffusion of oxygen into the blood of the patients. The atmosphere has about 21% oxygen which is good enough under normal circumstances. By delivering a higher concentration of oxygen (60 – 95% depending on the severity of the patient's case) through the nose, the lungs with the decreased surface area can be made to contain the required levels of oxygen in

the blood. Thus the direction of the net flow can be regulated by a change in concentration, but the underlying process does not halt after reaching equilibrium.

One of the best ways to appreciate the dynamic character of any substance is to know that there is a phenomenon called **self-diffusion**. Will there be diffusion in a substance of the same kind, say only water? Since there is no other solute, the concept of concentration gradient cannot be invoked. Water molecules move among other water molecules even at very low temperatures. Self-diffusion is known even in solids, even though the movement is relatively restricted. Experimentally such a movement is measured by using radioactive tracers (József Kónya, Noémi M. Nagy, in Nuclear and Radiochemistry, 2012).

We often do not focus on the thermodynamic nature of the solution; instead, we focus on concentration alone. Mere concentration does not help in diffusion unless the particles are dynamic. Since the dynamic character of a substance can be reduced by lowering the temperature, it is even possible to counter diffusion due to concentration gradient by thermal gradient. (See thermal diffusion https://www.thermopedia.com/content/1189/)

Since the definition is defined in terms of high and low concentration, the mental model students develop is that of crowded areas and less crowded areas. So, they attribute the cause of movement to the crowded state and not to the thermodynamic nature of the phenomena. Hence when the solution becomes uniformly crowded, i.e. isotonic, students surmise that there is no movement anymore. We often also hear from students that the particles 'want to' or 'tend to' spread out to occupy vacant spaces.

Resolving misconceptions about osmosis

Definitions also force us to think in terms of either the solute or solvent. The other most common misconception is that solvent is fluid and continuous while the solute is particulate. Definitions imply that a process is a diffusion when the solute moves from higher concentration to lower, and it is osmosis when the solvent moves from higher to lower concentration (but only when a semi-permeable membrane is present)!

When a drop of dye is placed in one corner of the beaker filled with a solvent, students think of diffusion only in terms of the dye. But the solvent particles also diffuse. Since students consider the dye as the solute, since there is no membrane, students assume that the solute alone diffuses and not the solvent. But both solute and solvent are particulate and both of them diffuse.

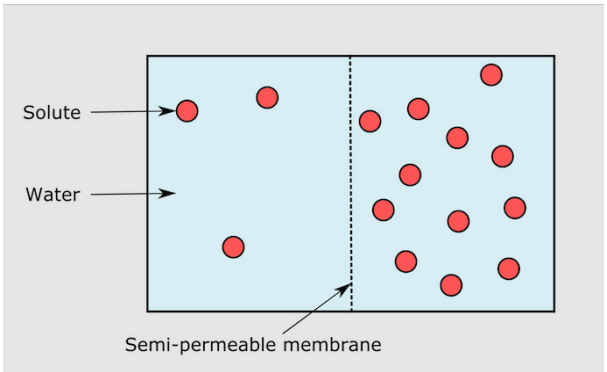


Figure 1. Picture recreated from school textbooks. Here water is shown as a continuous medium, while the solute is shown as particulate. This representation promotes the misconception that water molecules do not diffuse, and they are not discrete.

The mention of the membrane in the case of osmosis is another reason for misunderstanding. Moreover, what is the role of a semi-permeable membrane is often not discussed in detail. Neither is a correlation made between the size of the solute molecules and the size of the pores of the membrane or the polarity of the membrane surface and the polarity of the molecules. As a result, the students think of the membrane as an agent that 'decides' what to transmit and what not to transmit through it. They think that the membrane makes some 'selection' in osmosis, which allows the solvent and not the solutes. This is one reason why some students consider osmosis as an active process since an organelle is involved, and a process that stops when the cell is dead! Attributing vital characters to biological structures is a very common problem. Most biology texts avoid mathematical and physical imagination from entering into the discussion, making room for such misconceptions.

Science education research points out that misconceptions also arise because of the way diagrams are drawn. The picture shown in popular school textbooks indicates the solvent is a continuous sheet of blue colour (Fig 1), while the solute is shown as particles.

To develop a sound understanding of the dynamic particulate nature of the phenomena, one strategy that I often adopt in my workshops with science teachers is to provide a visual experience of the phenomena through computer simulations. I recommend the following simulations:

The video of the simulation shows both solute and solvent as 'particles'. They both diffuse, and the process never stops. You can play the simulation online from the link: https://phet.colorado.edu/sims/html/diffusion/latest/diffusion_en.html

The video of the simulation shows how the solvent molecules diffuse both ways, while the membrane prevents the diffusion of solute from one side to the other, building osmotic pressure on the left side. This is shown by the movement of the membrane to the right. Please note the numbers on the left side of the screen that changes dynamically as the process takes place. You can play with the simulation online by varying the parameters from this link: Netlogo simulation showing osmosis and osmotic pressure.

In general, developing a thermodynamic view of life processes is essential for a biologist. Ignoring this, because it is physics and not biology, will not provide a sound foundation to biology and lead to several misconceptions.

Postscript:

Further Reading:

- Treagust, D.F., Chandrasegaran, A.L., Crowley, J. et al. Evaluating Students' Understanding of Kinetic Particle Theory Concepts Relating to the States of Matter, Changes of State and Diffusion: A Cross-national Study. Int J of Sci and Math Educ8, 141 – 164 (2010).
- Arthur Louis Odom. "Secondary & College Biology Students' Misconceptions about Diffusion & Osmosis." The American Biology Teacher, vol. 57, no. 7, 1995, pp. 409 – 415.
- Ellen J. Yezierski and James P. Birk, "Misconceptions about the Particulate Nature of Matter. Using Animations To Close the Gender Gap" Journal of Chemical Education 200683 (6), 954
- Holbert, N. and Wilensky, U. (2012). NetLogo Osmotic Pressure model. http://ccl.northwestern.edu/netlogo/mod

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- Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

Notes:

The netlogo simulations are licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License. The PhET simulations are licensed underthe Creating Commons Attribution 4.0 License.

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/common-misconceptions-in-biology-misconceptions-around-diffusion-and-osmosis

16

Common misconceptions in biology: What fuels the body?

Author: **Maya Murdeshwar**
Date of publication: **26 Feb 2021**

Excerpt: **Undergraduate students of biochemistry may know the sequence of reactions in different pathways of energy metabolism. But how well do they understand the interconnections between these pathways? Maya Murdeshwar, an educator from St. Xavier's College, Mumbai, uses a quiz featuring cheetahs, triathlons and monozygotic twins to test her students and uncover their misconceptions about these pathways. She explains her approach in this article.**

Photo: Pexels, Pixabay

A question I often pose to my undergraduate Biochemistry and Nutrition class is about energy sources – what fuels the human body? The answer invariably is 'glucose' or 'carbohydrates'. Rarely ever does a student answer 'fats' or 'proteins'.

While carbohydrates serve as the chief fuel source for the body, they are definitely not the only source. The human body is capable of preferentially utilizing carbohydrates, fats, proteins, phosphocreatine and ketone bodies as energy sources under different conditions. This depends upon a variety of factors like the availability of oxygen (abundant/lacking), the presence or absence of sub-cellular structures (mitochondria) and associated enzymes, the physiological state of the body (fasting/fed), the intensity and duration of the physical activity being performed (resting/mild/moderate/heavy) and the tissue that is metabolizing the energy (muscle/liver/brain/heart/adipose). Students find it difficult to comprehend this distinction even after an in-depth study of individual energy metabolizing pathways. The integration of various energy metabolizing pathways proves to be a challenge for them.

One reason could be the greater emphasis laid on carbohydrate metabolism in classroom teaching at the high school and undergraduate levels. A substantial amount of time is spent on glycolysis and the Kreb's cycle, the central pathways for carbohydrate breakdown, as compared to that spent on lipolysis (fat breakdown) and amino acid oxidation (protein breakdown). Compartmentalization of these topics into separate chapters in standard textbooks facilitates their in-depth study, but creates invisible barriers in the minds of students, making it difficult to comprehend the intertwined nature of the metabolic web.

Both fat and protein metabolism feed into carbohydrate metabolism at various points, ensuring their efficient utilization as alternative energy sources. Textbooks usually deal with this integration in a separate chapter towards the end of the book. While this might seem logical, it is equally important to mention the interconnections at relevant places in individual chapters. This will help students to connect the dots and understand the bigger picture. Additionally, topics of integrative nature are usually taught towards the end of the course, after the individual pathways and cycles have been explained in detail. The lack of time at this stage makes the instructor hurry through these topics, leaving students with less time to assimilate them. The onus then lies on the instructor to devote adequate time to highlight these interconnections and cite appropriate examples to provide students with the necessary context to understand and appreciate them.

To help students understand the general and special cases in energy metabolism, I use the questioning approach and, if time permits, peer learning through POGIL sheets[1]. Gentle probing helps identify the flaws in their understanding:

- What is the chief source of energy for the human body?
- Can any other sources be used?
- If yes, under which conditions are these alternative sources utilized?
- Is energy metabolism during short and long-term fasting the same as in a well-fed state?
- Which fuel source does the body use when at rest as opposed to exercising? Do you think this would change if the intensity and duration of the exercise changes?
- When would the body burn the most fat – during light, moderate or heavy exercise?
- Which energy sources fuel Strength (Sprint/Swim/Weight Lifting) vs Endurance training? (Marathon/Triathlon/Tour de France)
- A crocodile expends large amounts of energy in a short period to catch its prey. A cheetah hunts down its prey after a short, intense chase. Is there any difference in the way they metabolize energy?
- Would the energy metabolism of monozygotic identical twins differ considering they have exactly identical genetic constitutions? Consider one to be a triathlete and another a truck driver. Does nature versus nurture play a role in energy metabolism?

Questions like these, while capturing the interest of students, also put their learning into context. It makes them think deeper and apply concepts 'across textbook chapters'. From textbooks that confound them with structures and reactions, they are transported back into a familiar world. It gives them a chance to explore the immense possibilities that the integration of metabolic pathways has to offer, better clarity on the bigger picture, and proper closure to the topic under study. More importantly, it leaves them with a deeply humbling appreciation for the intricately woven web of life.

A brief explanation of the key concepts in energy metabolism is as follows:

'Energy metabolism' is the process of generating energy from consumed food. Through a series of biochemical reactions and interconnected pathways, nutrients are systematically broken down to generate adenosine triphosphate (ATP), the usable form of energy. In the presence of oxygen, a complete breakdown of nutrients to carbon dioxide and water occurs in a process termed 'aerobic respiration' (aerobic = requiring oxygen) that occurs in membrane-bound structures within the cell called 'Mitochondria' (singular: Mitochondrion). This process generates large amounts of ATP. On the other hand, when the oxygen supply is deficient, the body switches to 'anaerobic' respiration (anaerobic = lacking oxygen) that occurs in the cell cytoplasm and generates comparatively lesser ATP. The human body thus prefers aerobic over anaerobic respiration.

Carbohydrates, fats and proteins, in that order, act as fuel sources for the body. While carbohydrates are the chief source of energy in a well-fed state, fats and the ketone bodies formed from fats act as fuels in the fasting state. Only under prolonged starvation or the continued absence of proteins in the diet, does the body resort to breaking down its own protein, a condition termed 'wasting' that ultimately results in death. This preferential usage is because the breakdown of carbohydrates requires much less oxygen than that of fats and proteins.

Energy metabolism is best explained in terms of exercise. In the resting state and during mild exercise, the body receives an adequate supply of oxygen. This promotes the utilization of fats as fuel [Figure 1]. During moderate exercise, oxygen availability decreases slightly, recruiting carbohydrates for energy production. Both carbohydrates and fats are aerobically broken down in equal measure. In contrast, under oxygen-limiting conditions like high-intensity exercise (sprint/swim/weight lifting) and strength training (activities that require large bursts of energy in a short period of time), the body switches to anaerobic respiration.

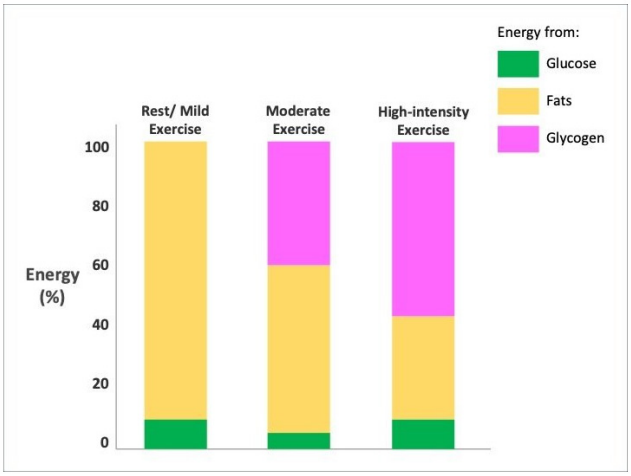


Figure 1: Fuel sources vary with exercise intensity. The human body switches from majorly breaking down fat during rest or mild exercise to utilizing fat and muscle glycogen in almost equal measure during moderate exercise, to relying heavily on muscle glycogen breakdown to glucose during high-intensity exercise. Source: The figure was created by the author based on Berg, J. M., Tymoczko, J. L., & Stryer, L. (2002). Biochemistry (Chapter 30), and Loon et al., 2001. J Physiol. doi: 10.1111/j.1469 – 7793.2001.00295.x.

The sudden burst of activity at the start necessitates ATP to be synthesized almost instantaneously. This is achieved by utilizing a high-energy compound called phosphocreatine, whose limited reserves can sustain 20 – 30 seconds of intense activity [Figure 2]. In order to continue, the body switches to anaerobic respiration. Oxygen being in short supply, fats are not metabolized at this stage. Thus, contrary to popular belief, high-intensity exercise burns carbohydrates, not fat. Additionally, anaerobic respiration causes the build-up of lactic acid in the tissue causing cramps and intense pain termed 'muscle fatigue'. The activity can no longer be sustained, thus stopping completely, or slowing down the pace. Deep, heavy breathing at this point compensates for the oxygen deficit, causing aerobic respiration to resume.

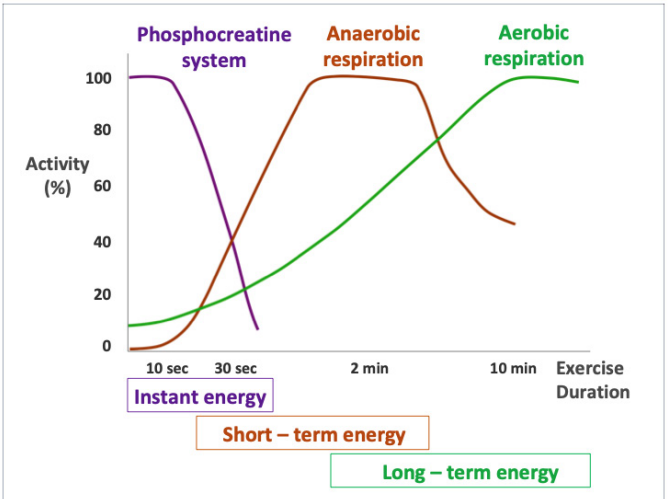


Figure 2: Fuel metabolism varies with exercise duration. Phosphocreatine and anaerobic metabolism function during high-intensity exercise and strength training, while aerobic metabolism is required for endurance exercise and training. Adapted from Colberg, S. Diabetic Athlete's Handbook, 2009.

The lactic acid build-up is the reason why crocodiles and cheetahs follow up the high-intensity ambush of their prey with long periods of rest and recovery. On the other hand, endurance sports enthusiasts like marathon runners, triathletes and Tour de France contestants (who require small amounts of energy over a long period of time) function mainly on aerobic respiration, mainly burning fat. They have well-developed lungs and a strong healthy heart that ensure a steady and adequate supply of oxygen for the entire duration of the activity. Burning of fat thus spares carbohydrates for the intense speed required towards the finish of the race. This active lifestyle of a triathlete over the sedentary one of his truck driver identical twin is the reason why nurture seems to play a bigger role than nature and genetics in this case.

Another misunderstanding of a related concept is with respect to slow and fast twitch muscle fibres. The slow twitch (red) muscle fibres present in our legs are densely populated with mitochondria. The fast twitch (white) muscle fibres present in the eyes have fewer mitochondria. When asked which of these fibres play a greater role in high-intensity activities, students usually answer 'red' fibres since they have more mitochondria, forgetting the fact that high-intensity activity creates an oxygen deficit that prevents mitochondria from aerobically respiring. A proper understanding of energy metabolism and associated concepts will help students overcome such misconceptions.

Postscript:

POGIL stands for 'Process Oriented Guided Inquiry Learning'. It is a popular learner-centric peer-learning pedagogical tool. Instructors design 'POGIL Sheets' with questions and illustrations that help students understand a particular concept. Students are divided into small groups, each of which works on the sheet to answer the questions and understand the key concept in their own way. The instructor acts as a facilitator, joining a group to help troubleshoot problems, and pointing students in the right direction to think. As an add-on, individual groups can be made to share their approach with the class, further strengthening effective peer learning and the gaining of different perspectives on the same topic. Read more about POGIL here: https://pogil.org/about-pogil/what-is-pogil

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/common-misconceptions-in-biology-what-fuels-the-body

17

Common misconceptions in biology: Species richness and diversity are the same?

Author: **Abhijeet Bayani**
Date of publication: **11 Jan 2021**

Excerpt: **What's the measure of species diversity of a habitat? Is it the number of inhabitants? Is it the number of species? Or is it the presence of a rare species? In this article, Abhijeet Bayani, a field biologist from the Indian Institute of Science, throws light on how he approaches this question of species 'diversity' in his classroom (a.k.a nature), while ensuring that his students do not confuse it with a very related concept of species 'richness'.**

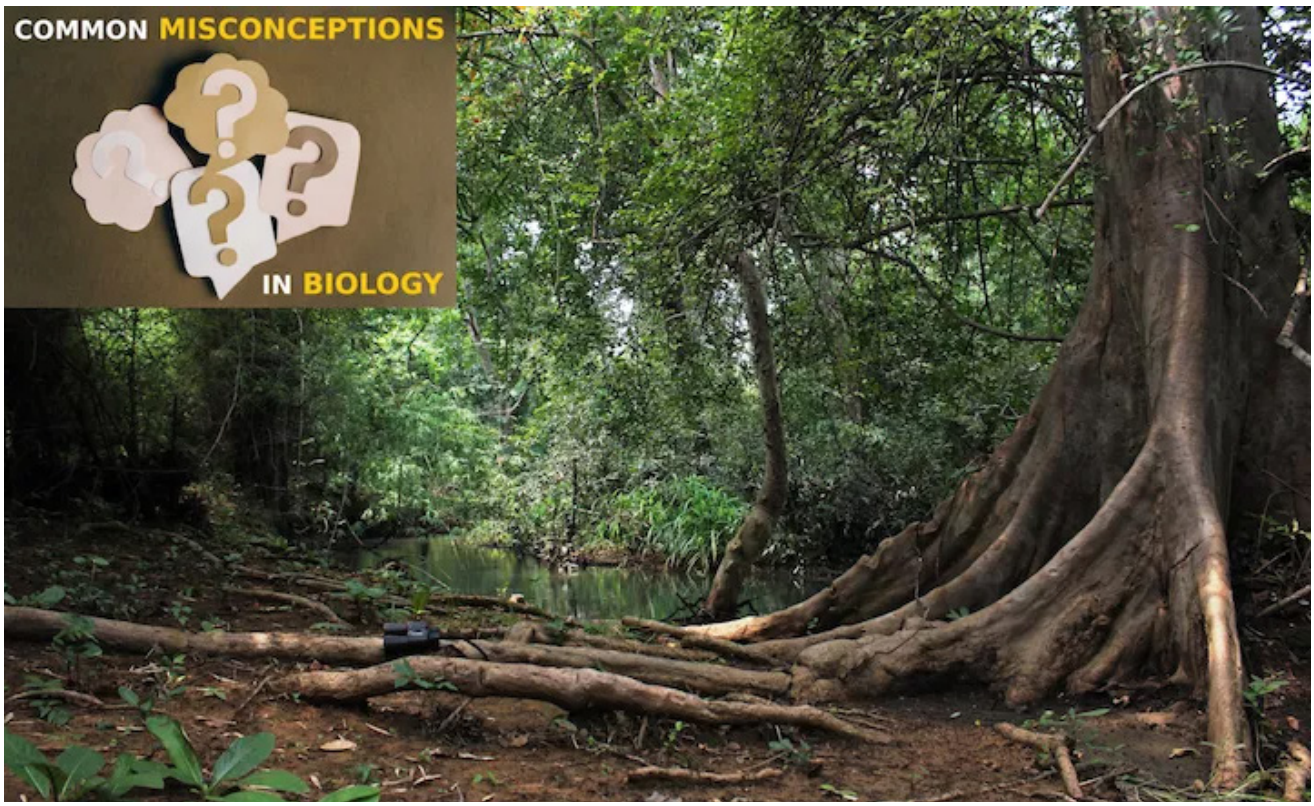


Photo: Abhijeet Bayani (from one of his field trips)

The beginning of ecological research in a new geographical area usually begins with understanding what flora and fauna are present in it. In the same way, I like to begin teaching ecology or organismal biology to my undergraduate students by introducing the term species diversity to them. Since many sub-fields of ecological research revolve

around why we have so many species around us, students also show a great interest in discussing the topic at various levels.

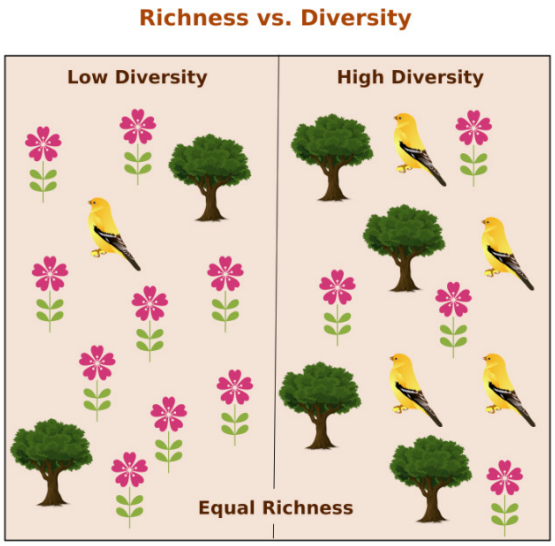
To make the concept clearer, I conduct frequent introductory field trips, during which I teach methods of species identification, some basics of taxonomy and ethical ways of animal handling, among other things. I also show them a wide variety of species and teach them how to catalogue the species systematically. This usually involves writing the names of observed species, the number of individuals of each observed species and the habitat in which it was found.

Students, in the beginning, do not understand the rationale behind the whole exercise; especially recording the number of individuals or the habitat. While the joy of watching creatures in the natural set-up is unbeatable, such field trips are expected to go beyond leisure.

After such sessions, we discuss what we observed and look for any patterns that may emerge out of the collected data, at least qualitatively. The field trips include covering multiple habitats that are fairly distinguishable into broad categories such as open habitat, closed canopy, scrub and so on. The rearrangement of data according to this rough classification then leads to discussing the 'most diverse habitat' visited.

Students go through their species checklists and most of them indicate that habitat X has a greater number of species than Y, so X is more diverse. Some other students also have an opinion that habitat X has a higher population of some species than Y, so it is more diverse. A small subset further claims to see a particular "rare" species in only one habitat and hence calls it more diverse. Here, students use the terms 'species diversity' and 'species richness' interchangeably, perhaps because they do not know the actual difference between these two terms. But... is there any difference?

Having observed a higher number of species in an area does not mean it is more diverse. It rather means that it is more 'species rich'. If one compares two habitats based on only the number of species, then such a comparison would not provide any conclusive evidence of their difference in diversity. To know if the habitat is diverse, one needs data on the relative abundance of each species. There are several quantitative measures to know if and how much a habitat is diverse, but Shannon's index is the most popular one. It essentially calculates the uncertainty in the outcome of a sampling process or uncertainty in predicting what the next species in a given area would be. There is a well-defined mathematical expression that can be found in any ecological textbook.



Students' answers to 'which habitat is more diverse', as mentioned before, are all valid but they are incomplete if treated independently. They either compare the highest number of species observed in an area, the abundance of certain (not all) species across two areas, or the mere occurrence of a rare species in a particular area. A diversity index considers ALL of these components at the same time, which species richness does not. The index is, however, only a measure of diversity, and not the diversity itself. It is just like the radius of a sphere being an index of its volume but not the volume itself! Therefore, such indices need to be treated with caution.

The confusion between species diversity and richness is more common than what I had earlier imagined, and I know this being editor and reviewer of some ecology journals. It is not a confusion only among undergrads but occurs almost equally frequently at various education levels (postgraduates, PhD and even among some scientists). Many researchers, authors, teachers, popular science writers, and educators in different sectors use these two terms interchangeably.

I have found out that this confusion occurs mainly due to the term 'alpha diversity', which is essentially taught, used and defined very loosely as the 'total number of species in an observed area'. Whittaker (who coined the term alpha diversity) himself has used this term in different and incomparable contexts. There is no common consensus over how and when to use this term to quantify species richness or species diversity. Some texts even equate 'alpha diversity' to species richness referring to it as 'alpha richness'.

If students have this confusion, it is best to clarify the difference immediately. It is best to keep the categories simpler i.e., 'species diversity' when it includes data on population, otherwise call it 'species richness'. If this distinction is not clear enough, the interpretation of data may mislead the conservationists and policymakers in deciding the priority areas for biodiversity conservation, or restoration ecologists in deciding what biodiversity to be focused on for the restoration.

I attempt to get rid of the misconception by providing them with hypothetical data that has the same number of species in two habitats but has different abundance values and ask them to judge. In such cases, if one goes just by the number of species, both are equally species-rich but not equally diverse. Teaching diversity indices in such a manner turns out to be more useful and impactful.

Postscript:

Further reading:

- Jost, L. (2006). Entropy and diversity. Oikos, 113(2), 263 – 275.
- Spellerberg, I. F. and Fedor, P. J. (2003). A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon-Wiener' Index. Global Ecology and Biogeography, 12(3), 177 – 179.

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Illuminating undergraduate research

Articles covering different aspects of doing biological research at the undergraduate level.

18

Teaching Alternate Biological Science: A research-based learning model to teach biology

Author: **Joel P. Joseph**
Date of publication: **27 Feb 2020**

Excerpt: **A young educational enterprise is engaging middle and high school students in a curiosity-driven learning experience in biology that takes them beyond their textbooks. The teachers/mentors are undergraduate and postgraduate students of biology with a flair for science outreach, who too benefit from the engagement by gaining a deeper understanding of basic biological concepts.**

T.A.B.S at Cambrionics Life Science (Photo: A.Participants learning the types of bones in the human body by solving the puzzle of a human skeleton. B. Sai Ganesh, a co-founder of Cambrionics Life Science, teaches kids to build a simple microscope to visualize zebrafish. C. TABS participants see the heart of a live zebrafish beat. D. Team Cambrionics (from left to right): Sai Ganesh Suresh Kumar VS, Raghul Jaganathan, Godwin Immanuel, Sudharshan V. Source: Cambrionics Life Science)

A group of science enthusiasts based in Chennai are changing the way biology is taught in schools. Cambrionics Life Science – an educational enterprise founded by five 20-somethings – has reached over 3000 students since its inception in 2018. At the core of their operation is *Teaching Alternate Biological Science (T.A.B.S)*, a research-based learning programme in biology. T.A.B.S mainly targets upper-primary and high school students, and to some extent, undergraduate students, to spark their curiosity for biology.

"I remember how I studied biology back in my school. We only had theory classes, where we were taught things from the textbook," says Raghul Jaganathan, Chief Administrative Officer, Cambrionics. "I visited my school some years later and saw that it was still taught in the same way." The founders of Cambrionics wanted to change this traditional format of teaching biology. The laboratory courses and the projects they pursued in their undergraduate studies made them wonder why such research-based learning models should not be introduced in schools. "I started working with the zebrafish model in my second year of B. Tech and was fascinated by it. Around the same time, I also came across BIOEYES – a European outreach group that teaches biology using zebrafish. This really inspired the concept of T.A.B.S," Sudharshan V, Chief Executive Officer, Cambrionics, says. "We then improvised by adding other model organisms in the subsequent modules," he adds.

T.A.B.S nurtures the role of a student in learning. The program encourages students to ask questions, experiment and seek answers to their questions by themselves. All the sessions are held on weekends and cover themes like microbiology, cell biology, genetics, astrobiology, forensic biology, toxicology, neurobiology, developmental biology, hydroponics, aquaponics and farming. Participants learn through hands-on experiments using different model systems including zebrafish, Drosophila, microbes, and plants. They also learn through activities like field trips, games, theatre, and puppetry.

The T.A.B.S programmes include weekend workshops, summer and winter camps, and a year-long research programme that is broken down into beginner, intermediate and advanced-level modules. While the beginner level intends to inspire students and ignite a passion for biology, the intermediate level aims to develop critical thinking, and the advanced level exposes them to career opportunities in biology and encourages them to develop scientific solutions to a given problem.

With a catchy colloquial title, one of the weekend workshop modules, *Vanakkam Biology (Hello Biology)* seems to be the crowd puller. This module, which has now reached 1300 kids in Tamil Nadu and 50 kids in Germany, gives the participants a glimpse of the world of biology. They are taught a bunch of things: to build a microscope using household amenities, to culture microbes on a dish containing a nutrient medium, to isolate DNA from fruits and vegetables, and the concept of regeneration using the zebrafish model. Forensic biology is another module that attracts a lot of students. Some of the modules of T.A.B.S cover concepts from the NCERT syllabus for high school biology. And some experiments, like the isolation of DNA are also present in undergraduate-level biology.

The participants of T.A.B.S. workshops seem to love the hands-on learning experience. "I can never forget the day I saw the heart of a zebrafish beat. This was the best session I ever had in my school days and I love biology more than ever," says Janane N, Grade 12 student, SRM Nightingale School, Chennai, who attended a T.A.B.S workshop.

Parents and teachers also seem to be inclined to send their wards to these programmes. Many have also noted that their wards' interest in studying biology and science, in general, had improved after a workshop. "I must say this is a very innovative camp. My daughter discusses whatever she learns in the workshop very elaborately and she has developed a keen interest in biology. I think this activity-based learning is very effective for children,"

says Jasmine Mary, whose daughter attended a T.A.B.S. weekend workshop.
Impressed by the T.A.B.S pedagogy, some schools in Chennai have partnered with Cambrionics to conduct the year-long T.A.B.S research programme in their schools. The partner schools include Pupil Saveetha Eco School, RMK Residential School, SRM Nightingale school, The Little Kingdom Senior School and Ebenezer Higher Secondary Matriculation School. "T.A.B.S. workshop was indeed a comprehensive hands-on experience for our students. My students enjoyed the real-life connect that the mentors offered," Sujatha Kannan, Principal, The Little Kingdom Senior School, says.

The workshops are facilitated by volunteers who are trained by the core team of Cambrionics. The volunteers are mostly undergraduate or postgraduate students in biology and allied subjects with a flair for science outreach. T.A.B.S. mentors help students perform experiments and learn from them. "My experience as a T.A.B.S. mentor has so many incredible moments. The programme has enhanced me as a student and a mentor and has transformed me into a person who believes that 'as you teach, you will learn'. Being a T.A.B.S. mentor has also helped me academically as it has strengthened my basics in the subject," says Aswini Sai Balaji, a T.A.B.S. mentor.

Cambrionics also conducts hands-on learning workshops for undergraduate students, mostly as sessions in technical fests. The *Investigate Forensics* workshop conducted at the IIT Madras Biofest was one such workshop in which 160 college students from across Tamil Nadu participated.

In its one and a half years of operation, Cambrionics has set the stage for a new pedagogy for teaching biology. The model shows great results in school kids and undergraduate students. T.A.B.S. model serves well to maximize learning with minimal infrastructure. This model could be an excellent tool for undergraduate educators in biology to get their point across in a tangible way.

Postscript:

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19

How can we teach how to read a research paper to undergraduate students?

Author: **Anuttama Kulkarni**
Date of publication: **10 Feb 2021**

Excerpt: **A lot of emphasis is given to introducing research in undergraduate curricula. On the other hand, there is little to no discussion about how to introduce the students to reading primary literature critically, or how to assess their understanding of it. Can there be a structured way of getting a regular undergraduate, who may or may not be interested in a research career, enthused about reading a research paper? How to test whether they have understood what they have read? These were the questions dealt with by the educators of the Homi Bhabha Centre for Science Education (HBCSE), Mumbai while developing a three-day module for reading research papers. In this article, one of the facilitators of the module walks us through their process.**

Photo: Pixabay

Conventionally, teaching biology in undergraduate courses involves delivering content from textbooks. This approach is inefficient for teaching how to read a research paper. Reading a research article becomes frustrating for undergraduate students when they cannot comprehend it. Hence, 'teaching', here, is about taking the frustration out and enabling learning. To that end, we used a structured and timed approach and observed encouraging feedback from the students. Additionally, their test scores indicated a good understanding of the paper by them. We would like to share our experience here.

About the initiative

Our first batch of students comprised 29 first-year undergraduate students from different regions of the country who were selected under the National Initiative for Undergraduate Science (NIUS) program of HBCSE in December 2018. The next three modules were conducted online with a total of 62 regular undergraduates in July and August 2020. Participants were second- and third-year B.Sc. students from three colleges who had chosen life sciences or related sub-disciplines as major subjects.

Roadblocks

Research paper reading is one of the most effective and inexpensive ways of introducing scientific inquiry in undergraduate courses. Yet, there are roadblocks (Table 1) that hinder the inclusion of a systematic approach to reading research papers in many of the regular undergraduate courses. While some of these problems are universal, others are more prominent in our Indian colleges and universities.

What are the roadblocks in the process of teaching how to read research papers to undergraduate students?	
University schedule	No time is allotted for reading research papers in the teaching schedule of many universities / colleges
Language	The language of a research article is very technical and difficult for undergraduate students to comprehend
Analysis	The figures, statistics and graphs can be difficult to interpret for undergraduate students
Background knowledge	The focus of a research paper is quite narrow and a background knowledge of the field is essential to understand the crux of the discovery
Student assessment	An assessment of students' understanding of a research article is not done in many university / colleges

How can we work around these limitations?

- **Choosing the 'right' paper**

Our process to work along with these limitations began with choosing the 'right' paper. We considered the following factors in making our choice. We looked for papers that were landmarks in their field, as they are excellent examples of how to practice science. We also wanted the paper to be relevant to some topic in students' curriculum to make comprehension easier. We avoided recent publications with complex techniques and statistics in the introductory session – we didn't want to burden the students with technicalities at this stage. We also avoided articles describing huge, classical discoveries, like DNA polymerase, and DNA structure/function. This was simply because the students already know about the crux of these famous discoveries and can easily guess their impact on the field, even without reading the article. Lastly, we wanted the facilitator to be comfortable with the paper. Considering all the above, the paper we chose was related to the effects of extracellular matrix on cell differentiation. The title of the article was 'Control of mammary epithelial differentiation: basement membrane induces tissue-specific gene expression in the absence of cell-cell interaction and morphological polarity', published in The Journal of Cell Biology by Streuli et al., in the year 1991. We used this paper in all of our modules.

- **Taking the 'before' lecture**

We started each of our modules with an introductory lecture to make students feel more confident about their ability to comprehend the paper. This 'before' lecture covered the background of the field, for example, cell-matrix interactions, adherence junctions, and so on. It also covered the techniques used in the paper. We also discussed what a scientific method is, what a research paper is, and why students should read it (Table 2).

Why should an undergraduate student read research papers ?
To gain a first-hand knowldege of any scientific subject and to form your own opinion. *(Four months ago, did you believe the news channel that said COVID vaccine gets a nod and imagined getting immunized in your next doctor visit?)*
To learn about the rigor of scientific method *(Now you know that 100 research papers and 10 years of work have gone into that single line about mRNA in your textbook!)*
To improve critical thinking and analytical skills *(How do you decide the next steps in your research/business management/ in making policies?)*

Table 2.

- **Dividing the paper into two parts**

After the lecture, students read the first half of the paper on their own. The next day, we asked them to answer multiple-choice as well as subjective questions about the research question addressed by the article, the

hypothesis, their understanding of the figures and the results in the first half of the results section, and the conclusions drawn from them. After the students answered the questions, the facilitator took them through the details of what they read and understood. The students were then asked to read the second half of the paper. On the third day, we conducted another test based on the second half of the paper and following that, we asked the students to lead the discussion. We think that having read half of the paper just a day before with the entire class and the facilitator encourages the students to persist in reading and discussing the rest of the article on their own. A detailed schedule for all three days is outlined in table 3.

Day and Time	Activity Design	Participants in the activity
Day 1 1 to 2 hrs	**Conventional teaching**	
	1. Teach biological concepts; e.g., cell-cell and cell-matrix junctions, cell polarity 2. Teach research methods; e.g., immunostaining, western blotting	Class activity lead by facilitator
	3. Home assignment for students: reading part I of the research paper	Individual reading
Day 2 2 to 4 hrs	**Critical reading of research paper - Part I**	
	1. Written test on Part I. The test combines MCQ's and theoretical explanations	Individual writing
	2. Discuss all figures, questions and answers in depth	Class activity lead by facilitator
	3. Home assignment for students: reading part II of the research paper	Individual reading
Day 3 3 to 4 hrs	**Critical reading of research paper - Part II**	
	1. Written test on Part II. The test combines MCQ's and theoretical explanations	Individual writing
	2. Assign one question from written test to one group of students and give them time to arrive at an answer/explanation agreed by all from the group	Group discussion
	3. Each group leads the discussion of the answer to the question assigned to them	Class activity lead by students

Increasing student participation

Table 3.

- **Assessing students- the open book/internet test**

We assessed the students for their ability to understand the research article. Hence, the questions were analytical in nature. We allowed them to keep the article and reference books, and access the internet as they answered the test. The only restriction during the test was that they do not discuss with their peers. This was a requirement for individual assessment.

Students' answers were graded using the following four criteria: if the answer was copy-pasted or irrelevant (graded — 0), if the answer revealed some / incomplete understanding (graded -1), if the answer indicated satisfactory understanding (graded-2), and finally, if the understanding was good to excellent (graded-3). Figure 1 shows an example of the questions asked and the learning outcomes of three online classrooms (n = 62) where these sessions were conducted.

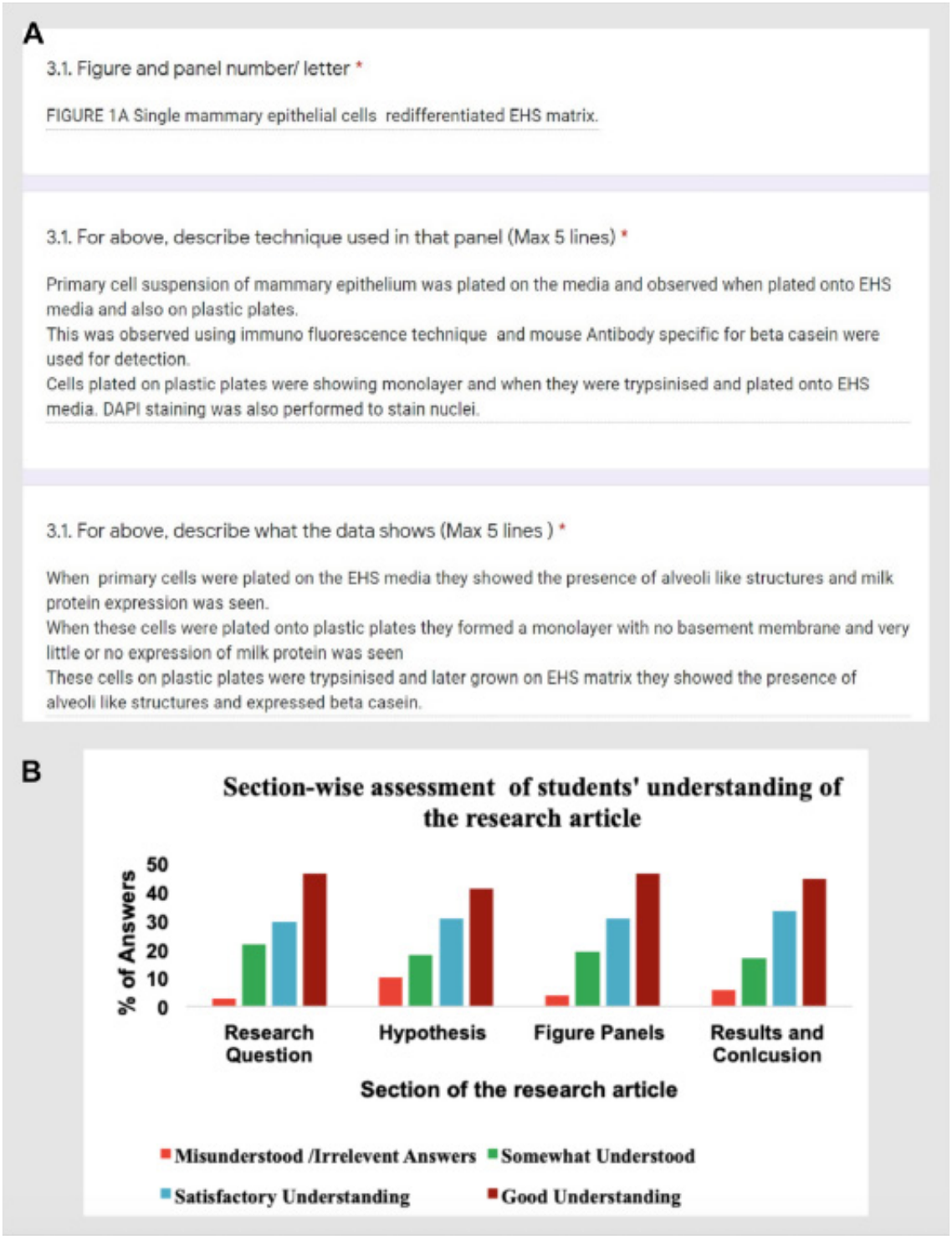

Figure 1: A. A screenshot of the answer sheet (google form) filled by students to questions based on the figure panels of the research article in Test I. B. Section-wise assessment of the students reflected by the average score of Test I and Test II during the online workshops (n= 62). Photo: Author

- **Taking feedback and improvising**

After the three days were over, we requested feedback from the students. Most of the students of our first batch rated the experience to be very good or excellent. But, while interacting with them, we realized that we had to tell them why they are reading a paper. Also, we had to cover 'all' the figures in our tests and presentations. We noticed that students would not understand the methods or the future directions/impact of the findings in detail

in a three-day schedule. So these topics were reserved for discussions and omitted from tests from the later three workshops.

In the online modules, more than 80% of the students rated the experience to be very good or excellent on all aspects. As science educators, we found the students' comments encouraging and interesting. We list some selected comments below; words in bold indicate that the students were intellectually enthused.

*"Excellent experience, the analyzing portion **induced curiosity**"*

*"This workshop has been great throughout. Gives a completely different aspect of research. Would **love to learn more!!**"*

*"It was a fun workshop; we were so influenced and motivated by the speakers. They provided [us] with great knowledge. [We] would like to attend more workshops and **would like to do the experiment in person, as it would be [better] to also have practical knowledge**. Thank you so much to all the people who made this possible. And we would like to have this one more time in future.."*

*"It was a very beneficial session. **A number of previously known concepts have become clearer**. The discussions conducted made it much better to understand a paper that I wouldn't have [understood] otherwise"*

*"The session was very informative. It was **a great exercise for my brain**"*

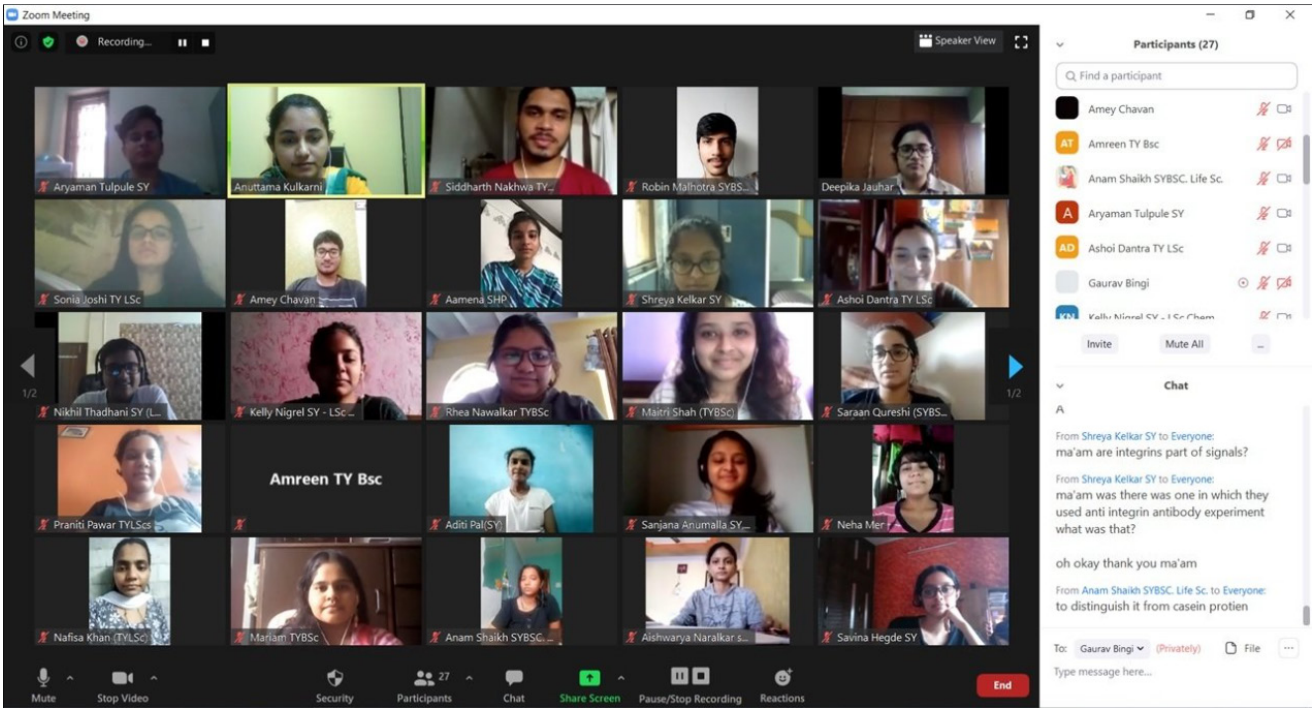

Figure 2: A screenshot of one of the sessions of a module. Photo: Author.

- **Parting thoughts**

Reading a virology paper can be very different from reading an ecology paper. An undergraduate student studies a variety of sub-disciplines of biology. 44 out of 57 students who filled out the feedback form wanted to discuss another research paper on a topic of their interest. The choice of the research paper depends a lot on the comfort

zone of the teacher/local facilitators. And to be honest, most of us are not equipped with in-depth background knowledge of all the fields.

Can we have scientists/postdoctoral researchers/PhD scholars select the right papers from their field, and record a 'before' lecture for undergraduates or the facilitators? Can there be an online resource for teaching how to read research papers? Would that minimize the need for a specialized facilitator for reading discipline-wise research papers? We would like to part with this thought for all of us.

Postscript:

Acknowledgements:

The workshop was conducted by the author and Rekha Vartak, Head, Biology Cell at HBCSE, in Dec.2018. It was again conducted in July and August 2020 by the author and Deepika Jauhar. The facilitators thank Rekha Vartak, and K.Subramaniam, Director, HBCSE, for giving them the opportunity to explore such activities. They also thank the Head of the Life Science Dept. of KC college Sagarika Damle, Head of Biotech Dept. of Vaze Kelkar college Deepali Karkhanis and Vice Principal of SIES college Manju Phadke for encouraging and allowing their students and staff to be a part of this initiative. Lastly, they thank Neha Joglekar, Aashu Vajpeyi, Bhavna Daswani, and Swapnil Jawkar who briefed them about online teaching requirements, coordinated activities and student feedback. The author would also like to thank DST, for individual financial support.

Suggested Reading:

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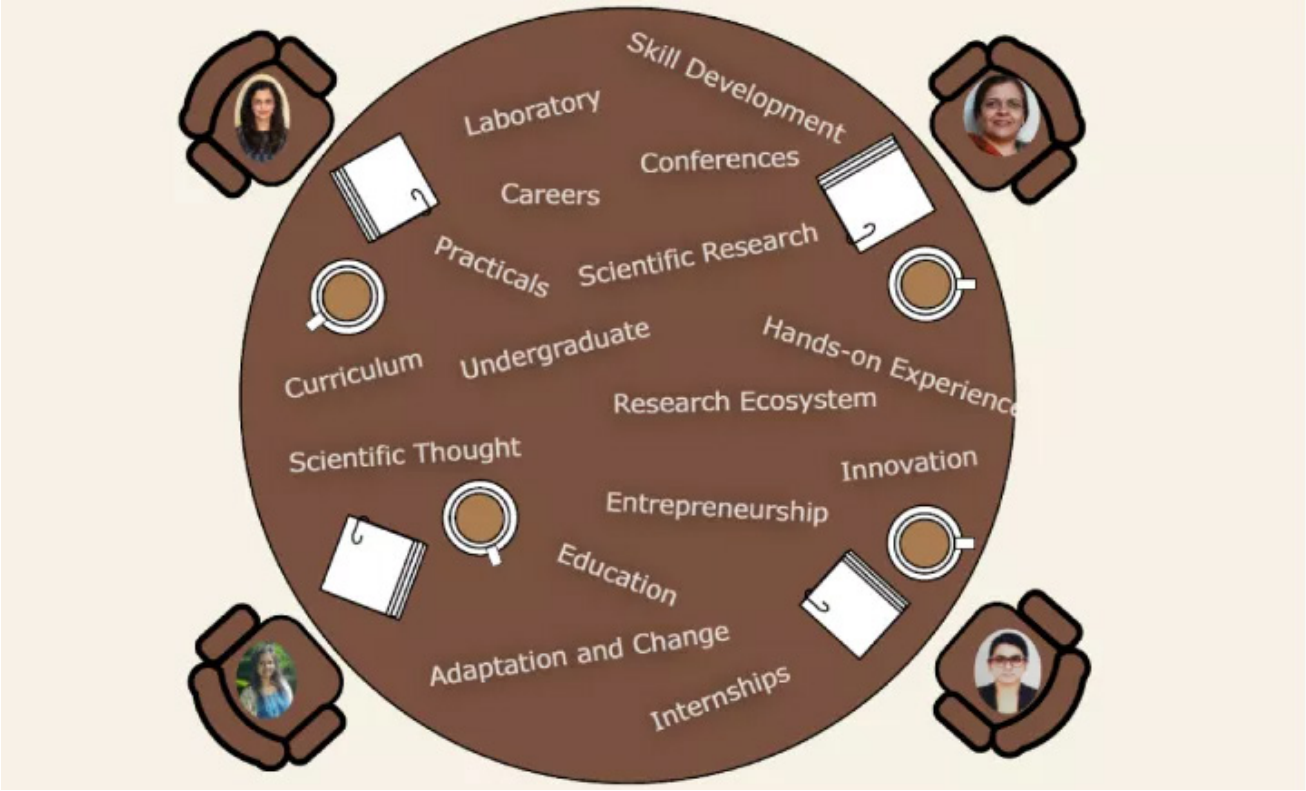
20

‘Four generations’ of scientists discuss undergraduate research in India

Author: **Smita Zinjarde, Karishma Kaushik, Snehal Kadam & Rupanwita Majumder**
Date of publication: **20 Jan 2020**

Excerpt: **The need for exposing undergraduate students to research and providing them with training in research-oriented scientific thought has been felt for quite some time in India. In this article, four generations of Indian scientists come together to discuss the present status of the undergraduate research ecosystem in India, the changes that have taken place over the last few decades, and the road ahead.**



‘Four Generations’ of scientists discuss undergraduate research in India

Across the country, there is a growing momentum to transform the undergraduate research ecosystem to introduce undergraduate students to scientific enquiry, engage them in discovery-based science, and provide them with a comprehensive understanding of research opportunities. These changes include highlighting the need for course-based undergraduate research experiences, developing concrete and practical initiatives to

bolster research at the college level, and introducing scientific writing and literature review as part of classroom teaching. So, where does the scientific and medical undergraduate research ecosystem in India stand today? What have been the tangible changes and gains? What should we identify as future priority areas?

In this article, four generations of scientists in India sit down for a round-table discussion and attempt to answer these questions and offer perspectives for the future. They come from varied educational backgrounds and have pursued (or are pursuing) their undergraduate degrees at different time periods with varied focus areas across basic science, medicine and biotechnology.

Smita S Zinjarde (SSZ), PhD, is Director, Institute of Bioinformatics and Biotechnology (IBB) and Head, Department of Microbiology, Savitribai Phule Pune University (SPPU) (Formerly University of Pune). She did her BSc followed by a Masters' in microbiology. A microbial biotechnologist with a career that has spanned over thirty years of research and teaching, she currently directs an Integrated Masters' program at IBB.

Karishma S Kaushik (KSK) is a physician-scientist who, after her MBBS and MD, earned a PhD in a basic science research group. She currently leads an interdisciplinary research group at IBB, SPPU which studies infection microenvironments, and engages undergraduate students with independent research projects.

Snehal Kadam (SK) has a dual five-year BS-MS from the Indian Institute of Science Education and Research (IISER) Pune. She currently works as a research assistant with Karishma S Kaushik. As part of her work, she actively guides undergraduate students in the group with their research projects.

Rupanwita Majumdar (RM) is a second-year student in the five-year Integrated Masters' program at IBB, SPPU. She is looking forward to an undergraduate research experience to understand what science in the laboratory is like.

The Conversation

SSZ: I did my undergraduate degree in microbiology back in the late eighties. At the time, as much as we would have liked, we did not have a research project at the bachelor's level in the curriculum, although we did have one at the Masters' level. What was the research ecosystem like during your undergraduate studies?

SK: In my BS-MS dual degree program from 2013 – 2018, the curriculum in the advanced years (3rd and 4th years) did allow students to formally take up research projects in areas of interest. These projects could also be credited and in biology, were evaluated in part, by a poster presentation. This approach allowed me to participate actively in departmental research and honed my research presentation skills.

During this period, I was given a substantial amount of freedom to work in the laboratory, design experiments and execute them. I consider this opportunity to have played a major role in helping me understand what original, scientific research in the laboratory is like. The institute encouraged undergraduate participation in various

scientific competitions, conferences and internships over the world. This led me to an internship in my 3rd year at the National University of Singapore, where I eventually did my master's thesis.

However, given that I was at a predominantly research-focused institute, I wonder what the undergraduate research ecosystem is like at public universities and teaching institutes. Maybe Rupanwita can shed more light.
RM: Being a second-year student, I have not been a part of any research project so far. While I have been seeking opportunities for hands-on research internships, these opportunities require a commitment of at least two months, which often is not possible due to overlaps with the coursework. At IBB, SPPU, I will get this opportunity during the third-year project that is a part of the curriculum. This will be a one-year in-house research experience with regular evaluations, a final presentation and thesis submission. This is something I am looking forward to. Moreover, I am also excited about the final semester research project, for which I have the flexibility to work in a research laboratory of my choice in India or abroad.

KSK: This is heartening to see, Snehal and Rupanwita. With my background in the medical sciences, I bring a different angle to this. In my experience, as a medical student from 1999 – 2005, there were no provisions for research in the medical curriculum. Looking back, this was a huge lacuna in the education system, given the critical role that translational research plays in healthcare.

The primary focus of medical education will always be to train treating physicians. However, for medical advances, the system needs to build a resource of physician-scientists. Given that India has no formal MD-PhD dual degree programs, this complete lack of exposure to the basic sciences and research in medical education is limiting. I gained exposure to scientific research and laboratory skills during my MD in Clinical Microbiology, and that set me on the path to becoming a physician-scientist.

"The undergraduate research ecosystem in India has improved since the late eighties, allowing more students to participate in research projects as part of the curriculum. However, medical education is still trailing behind when it comes to providing basic research opportunities to physicians in training."

SSZ: Since we had no formal research project in the Bachelors' program, laboratory practical sessions were my first exposure to hands-on experiments. Do you think they contributed significantly to your understanding of science?

SK: Practical sessions were my first hands-on experience in the laboratory as well and they taught me to troubleshoot failed experiments. However, practicals often do not recapitulate all aspects of scientific research, get restricted to defined protocols, and could involve large numbers of students. Despite this, in my undergraduate training, some practical sessions were adaptive. I still remember our first biology practical, where we were asked to disassemble a microscope and put it back together again. This simple yet innovative task sparked a curiosity in the class, and maybe we could include more such discovery-based, open-ended experiments for practical classes.
I would think your practicals are also a fun, learning experience, Rupanwita?

RM: Yes, definitely. Till the second year, practical sessions are the only way we can perform hands-on experiments. I think that practicals are essential for students to learn basic experimental techniques and get well-versed in equipment handling. However, I would like to see them provide students with more individual exposure, in addition to group-based learning activities.

KSK: In medical college, laboratory practical sessions were detailed and informative, but often focused on replicating previously known results or experiments. While this was important to understand concepts, they should be extended further to include at least some component of discovery-based research. This would, albeit in a limited way, expose medical students to research tools such as designing experimental protocols, troubleshooting, analysing results and referring to original scientific literature.

"Detailed and informative practical sessions are essential for students to learn basic experimental techniques and understand concepts; however, they need to be extended to include discovery-based research components and provide more individual exposure."

SSZ: It seems apparent from our discussion, that integrated courses offer research exposure to students at the undergraduate level, unlike previous conventional courses. In your opinion, what aspects can be further improved to leverage this advantage?

SK: For undergraduates, not only is learning hands-on research skills important, but it is also critical to develop scientific thinking to ask and answer scientific questions. For this, the curriculum could in some way enable undergraduates to follow a process where they play a role in framing a research question, understanding scientific literature related to the question, and finally designing experiments to answer the question. This would give students a more realistic glimpse of the research world. Would you agree, Rupanwita?

RM: I agree with you, Snehal. Based on feedback from my seniors, I feel that we undergraduates do not have an understanding of how research projects really work – for example, the timelines involved and the pros and cons of a certain model system or area of work. This would be very useful in helping us chart our career paths and decide our future research interests.

KSK: Given the complete lack of research exposure in the medical curriculum, we need to start with including a research component. Certain subjects lend themselves well for exposure to basic, applied or translational research, such as microbiology, immunology, pharmacology, pathology, biochemistry, and physiology. Creating a place in the curriculum to include a short-term research project in any of these areas could provide valuable exposure. This would train medical students to understand and probe a biological concept in detail, identify missing links and develop strategies to effectively fill such gaps. Further, doing this in collaboration with a basic research institute or university would provide exposure to original scientific research and enable cross-pollination of ideas.

"The undergraduate research ecosystem can be further improved by introducing processes to help students develop scientific thinking in addition to learning hands-on research skills, and allowing medical students to perform short-term research projects in collaboration with basic research institutes or universities to probe biological concepts in detail."

Concluding insights and ways forward

SSZ: It is very encouraging to see this progress in the undergraduate research ecosystem. The recent trend towards integrated and dual degree programs provides the opportunity to integrate research projects at an earlier stage in the curriculum. In our experience at IBB, SPPU, this not only provides students with hands-on laboratory skills and exposure to experimental science, but it has also resulted in several undergraduate students finishing their degree with authorship on an original research publication. This certainly distinguishes them when they are applying for future academic programs and opportunities. While research integration at an early level certainly helps students on the academic career path, do you all think further curriculum changes need to include exposure to non-traditional (non-academic) research opportunities? What are other priority areas going forward?

SK: To support students choosing non-academic research paths, such as in industry and biotech entrepreneurship, undergraduate participation in industry-driven conferences, exposure to biotechnology start-ups and entrepreneurship grants, and possibly even a brief research stint in the industry would be the possible next steps.

RM: I agree that it is important to further leverage the flexibility and time that integrated and dual programs offer to maximize students' exposure and experience. A practical way forward could be to have active organizations like placement cells that connect students to such projects in their local ecosystems, both in industry and academia, thereby helping create a network across the undergraduate community in India.

KSK: While it may take a while to formally incorporate research opportunities in medicine, I have noticed a change in the mindset of medical students. Since my return to India, several young medical and dental students have approached me seeking research internships, to discuss research career opportunities, and understand the career path of a physician-scientist or physician-researcher. Recognising this, it is an appropriate time to revisit the basic medical education curriculum and proactively create scope for research opportunities via small-scale projects, and internships and stints at research institutes and biotech start-ups.

"Integrate research projects at an earlier stage in the curriculum, increase undergraduate exposure to non-academic research paths, create active organizations to connect undergraduate students to the local research ecosystem, and create scope for research opportunities in the basic medical education curriculum."

In conclusion, it is evident that the undergraduate research ecosystem in India has undergone major transformations through the years, and has notably, recognized the importance of incorporating scientific research into teaching practices. However, for these changes to become an integral part of the education system, it would be critical to mandate an original research experience across all undergraduate courses. In traditional three-year courses, this could be done by introducing a short in-house thesis towards the end of the course. For colleges and universities with limited laboratory facilities, a tie-up or collaborative effort at the institute level with other well-equipped universities can help bridge the gap.

Postscript:

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https://indiabioscience.org/columns/education/four-generations-of-scientists-discuss-undergraduate-research-in-india

21

Understanding interdisciplinarity, multidisciplinarity and transdisciplinarity

Author: **Madhumitha Krishnan**
Date of publication: **20 Sep 2021**

In education, research and innovation today, we often hear the terms “interdisciplinary” and “multidisciplinary”. Many of us may use these terms without understanding what exactly they mean. In this article, we will explore the meaning of these terms, and also try to understand the significance and need for a newer term called “trans-disciplinary”.

As described by Choic and Pak, “**Interdisciplinarity** analyses, synthesizes, and harmonizes links between disciplines into a coordinated and coherent whole. ”**Multidisciplinarity** is defined as viewing the same object from the viewpoint of different disciplines.To further understand these concepts let us take the example of a common substance we are all aware of, and understand the interdisciplinary and multidisciplinary approaches towards studying it. The substance we shall talk about is water.

How would we understand water from different perspectives?

If you were to ask a person from the discipline of chemistry how they view water, their explanation would probably be on the lines of water containing 2 molecules of Hydrogen and 1 molecule of Oxygen; or that the pH of water is neutral.

If the same question was posed to a physicist, they would probably explain the theory of refraction associated with water, the concept of resonance, surface tension etc.

If the same question was posed to a biologist, the first thing that would probably be explained is how 70% of the human body is made up of water, and how it is an essential part of survival itself.

If the same question was posed to a musician, they would probably explain the sounds associated with water, such as the soothing gurgle of a stream or the loud angry gushing sounds of a waterfall that could be converted to appreciable tones.

If the same question was posed to an artist, they would describe the form they see, of it having ripples, being fluid in nature, transparent etc.

And so on and so forth.

Now in the **interdisciplinary** approach, the understanding of water would combine the views of different disciplines. For example, the biochemistry of water would involve how the combination of 2 molecules of hydrogen with a molecule of oxygen has a particular reaction in nature with other substances, or how it helps the survival of living beings by its reactions. A biophysical explanation would probably be how the blood in the body applies a particular pressure due to its nature of being fluid etc.

On the other hand, a **multidisciplinary** approach to water could be, for instance, in the context of a town planning its management of water resources. A combination of disciplines such as geography, architecture, political and social sciences would all come together to devise an appropriate water solution for the town, with each still functioning within the purview of their specific disciplines.

Regardless of the approach, the final purpose of all these disciplines remains the same, which is at its very foundation, a method process by which to view and observe nature. For the majority, the language used to explain the two approaches is also more or less the same: logical and quantitative. However, since time immemorial man has observed nature and captured it in languages that we are no longer familiar with. In these languages, the methodologies used to view nature are completely different from what we consider standard nomenclature today. This brings us to an approach called **trans-disciplinarity**, which is the study of nature across different ideologies or philosophies.

One such trans-disciplinary view would be combining the view of art and music of nature with the normal view. The discipline of art or music does not fall into the framework of understanding utilized in physics, chemistry or biology. While the base framework of all these sciences would be the atomic theory, an artist would rarely utilize the atomic theory to represent nature. Similarly, a musician would not require an understanding of atomic theory to create tunes but would utilize certain principles that converge across these disciplines.

Let's go back to our example of water: in a **trans-disciplinary** approach, the physics of resonance would be utilized in understanding the tonal quality of sound expressed by a musician in a symphony. With an artist, the concept of refraction from physics would converge with their understanding of representing a scenery that includes a water body. In this manner, the understanding of nature across disciplines adds value to both.

Another example of a trans-disciplinary approach would be understanding nature through the principles of Ayurveda along with those of contemporary vocabulary. Centuries ago, before the invention of microscopes, how did a person view or learn about nature? Mostly using their sense organs of sound, touch, sight, taste and smell. This led to a philosophy that understood nature in a completely different manner. The basic components or building blocks of nature were based on what could be perceived by the individual, which are called the Panchamahabhutas or 5 states/fields of nature which are essentially translated to *Akash* (space), *Vayu* (air), *Agni* (fire), *Jala* (water) and *Prithvi* (earth). Similarly, nature was described by the characteristics that were felt, seen and experienced by people that led to the *Dravya guna shastra* or the methodology of describing substances in the universe. Taking the example of water, it would be described in the following manner: a tasteless substance, that is liquid in nature, causing a sense of moistening, that is cold in thermal property and with a nourishing effect on the body. These as we can immediately see are comparable to the physical, chemical and biological explanations of water.

Now let us see another view of the same substance water. When water is in the form of ice it would represent the Prithvi (earth) *Mahabhuta*; when the same water is melted, it would form the Jala (water) *Mahabhuta*; when the same water is boiled, it would transform into the *Agni (fire) Mahabhuta* and when the water is converted to water vapour it would become the *Vayu (air) Mahabhuta*. The same water would therefore have completely different characteristics and pharmacological effects on the body based on the principles of *Ayurveda*, while the atomic view of the water would be constant in all these forms. Hence, there are certain areas of convergence and certain areas of apparent divergence. But neither view is wrong.

Wouldn't comparing these different ideologies of water give us a better understanding of the substance itself? Hence the trans-disciplinary approach would be a step forward in further understanding nature from truly different perspectives.

Postscript:

Further Reading

- https://www.researchgate.net/p...
- https://www.academia.edu/26721302/The_Nature_of_Transdisciplinary_Research_and_Practice

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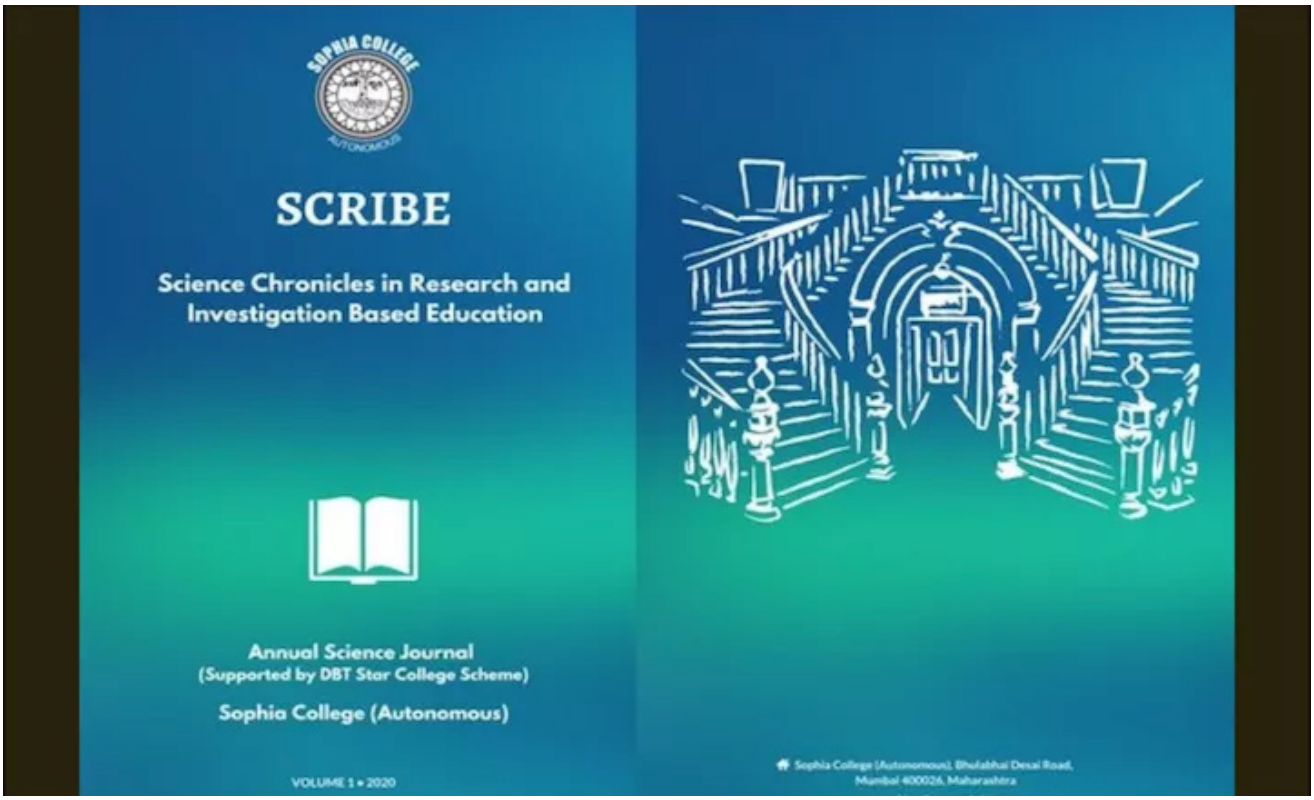
22

Getting an in-house science journal up and going – an academic adventure

Author: **Bhavna Daswani & Hema Subramaniam**
Date of publication: **06 Jan 2021**

Excerpt: **Science writing is a skill that takes a lot of practice to hone. So why not start early? The faculty of Sophia College (Autonomous), Mumbai, decided to give their undergraduate and masters' students the full experience of writing and publishing an article, by starting their very own scientific journal. Here's an article about their journey, in their own words.**



Front and back cover images of the 1st issue of SCRIBE. Photo: Authors

Many science students may be budding writers and future scientists but often do not have a suitable platform to showcase their talent at the undergraduate (and perhaps even Masters) level. Yet others may be so used to technology-driven concise language constructs (SMS and texting short terminologies) that language skills would need to be honed. With this in mind, we, the faculty of Sophia College, Mumbai, felt the need for our

very own science journal. SCRIBE — Science Chronicles in Research and Investigation Based Education — our annual inter-disciplinary in-house science journal was born. SCRIBE was inaugurated by our Principal in a formal ceremony attended by staff and students on National Science Day, February 28, 2020. Here, we share our journey from conceiving the idea to the publication of the first issue. The journey involved many periods of ups and downs, but it was all eventually worth it as we believe that it was a stepping stone in promoting science writing amongst students.

Our Journey

The idea of starting a science journal in the College was seeded by Medha Rajadhyaksha, the then Vice-Principal (Science), in 2016, and the initial plan was to publish the first issue as part of the College's Platinum Jubilee celebration. Although the attempt was on to coax the students out of their inertia, not much moved. The idea was revived by Yasmin Khan (current Vice Principal — Science) in 2019.

We met in the staff canteen one lazy Saturday afternoon in November 2019 and pledged to bring the journal to life. We decided that our mandate was to keep the journal 'in-house' and student-oriented to foster science writing in our students. We knew this adventure would have its share of uncertainties, and though it would be an uphill task to review and make it publication-ready by the semester end, we were sure about one thing – plagiarism was totally unacceptable. We began on a high note with brain-storming sessions, formulating an editorial committee with both staff and enthusiastic students, and putting up flyers consisting of instructions for authors on all possible notice boards. We convened a meeting to teach students about different types of articles and encouraged them to write. After this came the waiting period (to receive articles), and what a long period that was!

The first deadline was a complete disappointment with only a few articles in our inbox. At this point, we could still not see light at the end of the tunnel. This was not an assignment that we could dangle marks as an incentive, and over that, the exams were approaching, fast. We appealed to students again to write (some of us would even catch students in corridors and nag them to write). We then received some excellent contributions from our Masters' students from various science departments. This encouraged undergraduate students to follow suit. The second deadline was a happier time with our inbox filled with articles. But now a new challenge was awaiting us – editing.

We were fortunate to have three brilliant Masters students – Avni Rao, Binita Vedak, and Saunri Dhodi Lobo as part of the core editorial team who took on the work in all earnestness (they later received certificates for their hard work and dedication). We scrutinized all the articles for plagiarism, grammar, the accuracy of scientific content, and of course, references (which, as one can imagine for first-time writers, were all over the place). Authors were returned their articles with suggestions to revise and re-submit for publication with new deadlines. We were thrilled to see revised write-ups from all categories of articles. Finally, on February 28, 2020, we published the first issue.

It was worth all the effort. There were categories such as "research articles", under which students reported their research data; "review articles", through which students would put forth their understanding of topics selected by them; "trends in science", elucidating a few recent research avenues; "Nobel prize 2019", discussing the story of people behind the award; "from Indian labs" giving a flavour of a few prominent laboratories in India; "history of science", to give a historical perspective to discoveries; "ecological concerns", to address sustainable

development; mini-reviews; book reviews; editorials "from the student's desk"; crossword puzzles; biodiversity pictures, etc. The cherry on the cake was an 'Invited Article' by a senior eminent scientist and alumnus of our College.

Reflections

It is important to remember that not everyone is a born writer – writing is an acquired form of learning. Additionally, the process of writing inculcates in the authors the art of searching for relevant content, organizing, summarizing, and articulating thoughts and ideas with a certain flow and creativity. It also enables critical and higher-order thinking. Hence, although our newly founded journal does not yet stand on par with well-established and renowned journals, it is a step towards promoting this art of science communication. This is why our college also conducts a certificate course on 'scientific writing' for first-year undergraduate students.

In our opinion, the editorial team of our journal was ideal, consisting of an assortment of faculty and students. The faculty editors oversaw the editorial process and ensured quality, while the student editors not only gained experience in the editorial process but also encouraged other students to be potential authors. It must be emphasized that the interdisciplinary nature of the journal facilitated students to read and appreciate topics from all sciences. In all, we felt that the endeavour was a success from the students' point of view, even though on the faculty's part, it involved a lot of time and effort between the teaching schedules.

Looking back, we realize that there is room for improvement. So, for the next issue, we are striving to put into place the process of 'peer-reviewing'. Also, every article will have a faculty author associated with the student author; a step that will foster a mentor-mentee bond, and ensure the quality of the article prior to submission.

Overall, an in-house journal is not only a platform, but also an opportunity to hone students' writing skills at an early stage, which goes a long way in their ability to articulate ideas, making them aware of the publishing process, and indeed boosting their confidence. Along with the joy of knowledge dissemination, we hope that this journal may be a stepping stone for students to adopt a scientific temper.

As undergraduate research is being encouraged in our country, this kind of platform gives students the encouragement to steer their research work towards successful completion. While it lifts the pressure on undergraduate students to publish in renowned journals, it gives them a glimpse of what lies ahead. This may even open up new possibilities for those who had not tapped into their interests in writing. Whether they make a career in research or science journalism/editing, or even if they choose a completely different career path, they would be well-versed in the nuances involved in science writing and also publishing.

Postscript:

Acknowledgements

The authors are grateful to Medha Rajadhyaksha (ex-Vice Principal – Science), Yasmin Khan (Vice Principal — Science), and Madhavi Kaji (Head, Dept. of Biochemistry), for being an important part of the journey. We acknowledge the support from Star College Scheme, Department of Biotechnology, Govt. of India, for undergraduate research. Bhavna Daswani acknowledges the support from Department of Science & Technology, Govt. of India, under the Woman Scientist -A (WOS-A) scheme.

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/getting-an-in-house-science-journal-up-and-going-an-academic-adventure

23

Strategies for productive faculty-undergraduate research assistant partnerships

Author: **Andrea Phillott**
Date of publication: **27 Nov 2019**

Excerpt: **Andrea D. Phillott, Professor in Environmental Studies at FLAME University, Pune, Maharashtra, conducts research in the field of marine biology, conservation and education. In this article, she writes about how researchers can effectively engage undergraduate students in research, and how this can benefit both faculty and students.**

Most academic review, promotion, and tenure processes value scholarship, often in the form of research and publications, over teaching and service despite most faculty feeling that the majority of their workload comprises the latter. Some of the pressure that faculty feel to maintain their research productivity can be alleviated by partnering with undergraduate research assistants (RA).

Unlike student interns, who are often required to complete projects for credit and, therefore, have a greater responsibility for study design and analysis, student RAs can be asked to focus on projects designed and coordinated by the faculty and in their area of interest, which is likely to result in publications or other scholarly works.

However, the potential benefits of collaborating with undergraduate RAs are often ignored because of faculty concerns about the amount of time that mentoring requires and low student motivation and preparedness to work as an undergraduate researcher.

Some apprehensions about partnering with undergraduate RAs can be alleviated by the personal satisfaction of mentoring new researchers and understanding how to maximise the benefits of working with undergraduate RAs. Faculty and graduate students/postgraduate researchers responsible for mentoring RAs can use the strategies described below to increase the likelihood of a rewarding and productive partnership.

Learn the characteristics of a good mentor

While faculty often measure the success of a research partnership through project progress or production of a conference presentation, publication, or other scholarly work, students are more likely to reflect on how they felt during their experience as an RA. Faculty should become familiar with evidence-based learner-centred practices, such as those described in this article, and utilize them while mentoring student researchers instead of just relying on their own experiences. This is especially relevant when recruiting and retaining students from minority communities as undergraduate RAs. It can also be helpful for faculty to read about the characteristics that undergraduates consider important in a mentor.

Choose an undergraduate RA who will be an effective partner

High motivation, curiosity, creativity, and attention to detail may be better indicators of a productive RA than a high GPA or strong academic performance or completion of a course which develops knowledge or skills relevant to the research topic. You should also consider specific project requirements, such as being available at particular times of the day or being proficient in the use of specific research tools (including software) and methods. Recognize that individual student interests may not directly align with your area of research, but the partnership can still benefit you both if it results in their personal and professional development and your project's progress.

Establish expectations

Discuss specific project goals and objectives, methodology, responsibilities, and timelines, and consider outlining expectations for you both (or the team if more than one undergraduate RA is contributing to the same project) in a formal research agreement. As undergraduate RAs may be new to research, a research agreement provides detailed descriptions of what is expected of them and an opportunity to ask questions about responsibilities that they may not completely understand. Preparing the agreement and discussing it with RAs also helps the faculty thoughtfully consider what they are expecting to be completed within the allocated timeframe and their own responsibilities towards the RA. The template available in the supplementary information for this paper provides a starting document for faculty who have not drawn up such an agreement before.

Build rapport with your RAs

Informal conversations during which faculty demonstrate a genuine interest in their RAs' lives, interests and classes by giving them their undivided attention, actively listening to what is said, asking questions, and being sympathetic and empathetic, help strengthen a student's feelings of being recognized as a valued partner.

Provide training and scaffold opportunities

Undergraduate students are less experienced (but not less talented) than graduate students. Start new undergraduate RAs with low-stakes tasks (e.g., searching for and summarising literature, routine lab methods, data entry) and build to high-stakes activities (e.g., conducting interviews independently, analysing and interpreting data, designing novel surveys or lab methods) as their experience and confidence increase. This may take time and potentially patience, as well as repeated explanations or demonstrations.

Be an engaged research partner

Regular weekly or biweekly meetings allow faculty and RAs to track project progress, discuss findings, and address potential problems early. Discuss the work to be completed by each of you between meetings. Project progress can be held up both by students not completing required activities and by faculty failing to provide resources, instructions, or feedback. The last should be constructive and identify what has been done to the required standard as well as point out areas that need to be improved and suggest strategies to do so.

Back-up research documents

Make sure that copies of all research documents are regularly saved to a cloud platform (like Google Drive, Dropbox or similar) to which all relevant researchers have access. Hard copies of interviews, questionnaires, field and lab notes etc. can be scanned or photographed and uploaded to a file hosting service. Word processing files, datasheets, databases, visual images, code, sources used in literature reviews, presentation files etc. should also be shared. Ideally, all project resources should exist as soft copies in two locations (at least one in a file hosting service). If an RA is unexpectedly absent for a long period of time or leaves the project, progress can be maintained if you have a recent copy of everything they have been working on.

Demonstrate time management tools and strategies

Undergraduate students have fixed class schedules, a course workload that varies over time and can increase unexpectedly, family and social commitments, and may also have a job. Despite their commitment, RAs may take longer than expected to complete tasks according to the project timeline. Introduce students to some of your favourite apps and tools for managing time, avoiding distractions, and managing tasks (some examples here if you don't use any and are curious). A physical reminder, as simple as a project outline on a whiteboard, or the more visually appealing Gantt Chart or Kanban Board, in a mutual workspace, can provide motivation and help

in project management.

Despite good planning and previously steady progress, RA productivity may decline during their busiest assessment periods at the middle and end of the term or semester. It is better to acknowledge this and build it into the project schedule (remember that you may be similarly busy with grading at this time). If students still need to log a certain number of hours per week during these periods then suggest they complete more mundane tasks that don't require critical thinking or as much attention to detail. Remember to schedule rest periods between project phases and be understanding of other demands on their time.

Provide developmental opportunities

Although faculty opinion of when RAs should be named as coauthors can vary, students who have made substantial contributions to a research study and manuscript preparation should be included as co-authors or even first authors. Mentored faculty-student research partnerships are more likely to result in publications if undergraduate researchers remain engaged for more than one year and faculty find enjoyment in and are committed to research with undergraduates. If opportunities for student authorship are limited by time during project duration or manuscript preparation, undergraduate RAs could instead present a component of the study at a conference. Faculty should be proactive in identifying suitable conferences and helping procure funding for RA attendance.

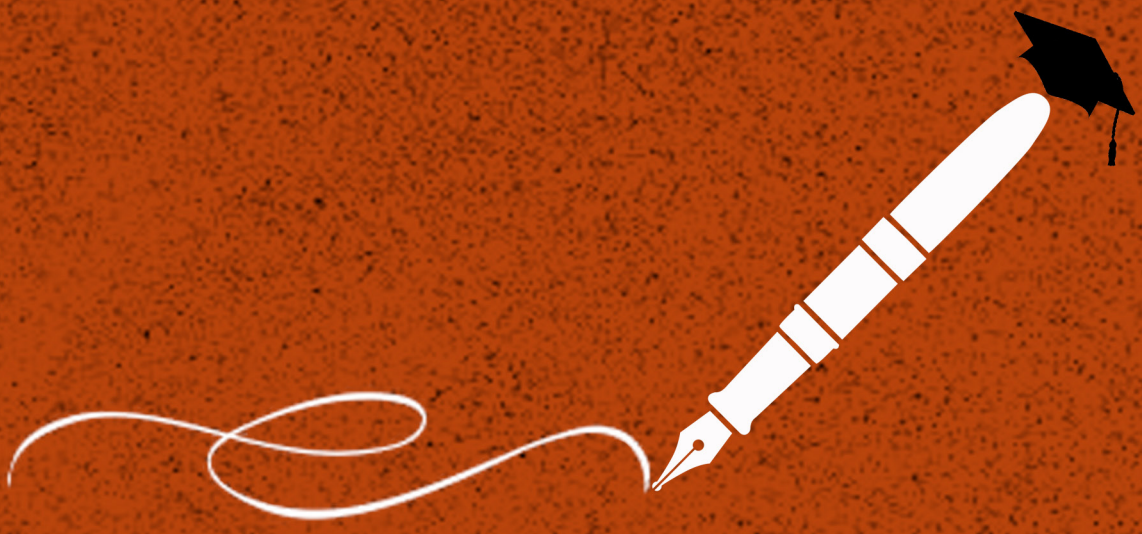
The strategies described above will help faculty be 'good' mentors who care about the experiences of RAs and provide due reward for their efforts. This will be of benefit to both faculty research productivity and student personal and professional development and may potentially help in recruiting future undergraduate assistants. But the personal reward for faculty should not be overlooked. Engaging with undergraduate students outside course-based work and in situations where less formal conversations can occur leads to a deeper understanding of their motivations, aspirations and concerns. This carries over into every aspect of academic life, and results in more empathetic instructors and informed advocates for student support and resources, in addition to more productive researchers.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/strategies-for-productive-faculty-undergraduate-research-assistant-partnerships

Virtual learning

Articles and a webinar highlighting the potential and challenges of virtual learning. This section tries to capture online education as it happened during the COVID-19 pandemic and its role in the 'new normal' times.



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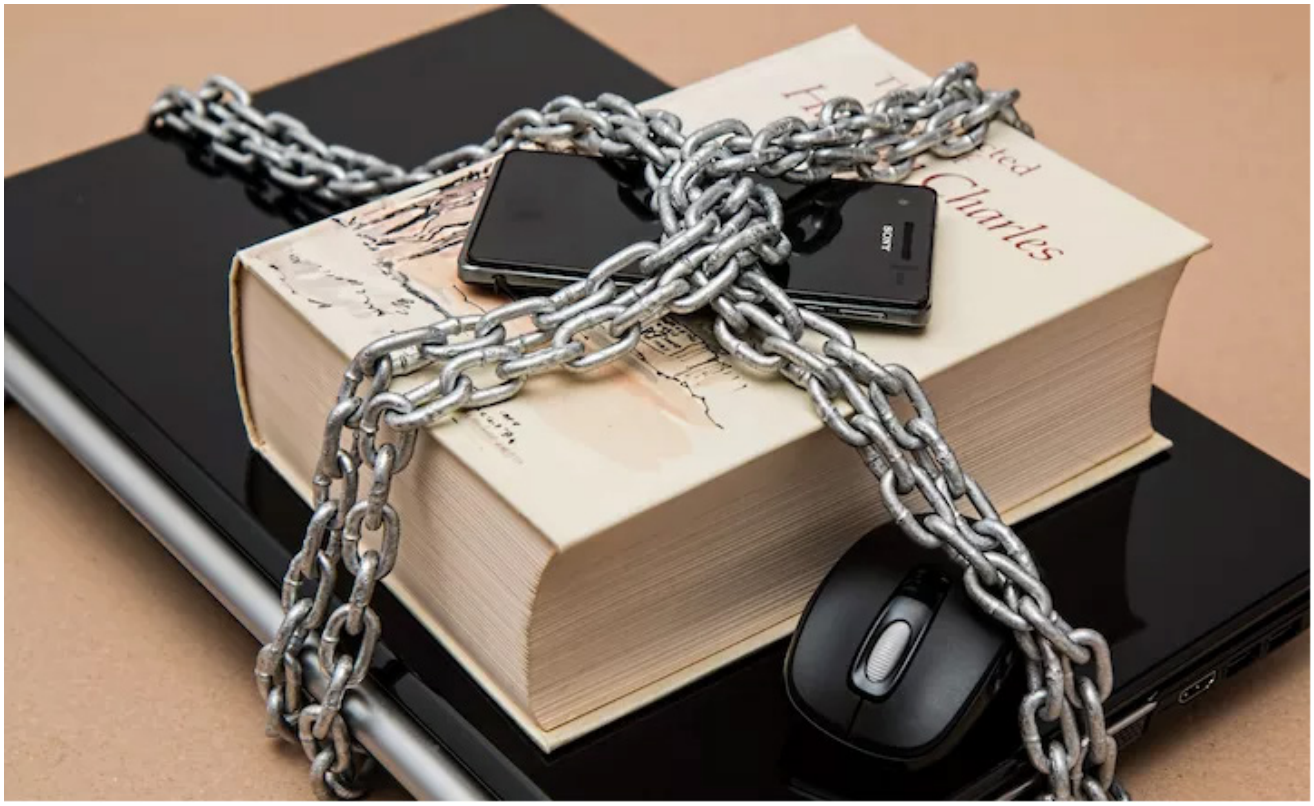
Online education in India – the good, the bad and the ugly!

Author: **Prashanthi Karyala & Sarita Kamat**
Date of publication: **23 Sep 2020**

Excerpt: **Online education comes in shades of grey. In this article, educators, Prashanthi Karyala and Sarita Kamat, bring the voices of teachers, students and parents from across the country to the fore, as they highlight the good, the bad and the ugly faces of online education in India, and the need for inclusive education policies.**



Online Education in India (Photo: The electronic devices and the book represent the online and physical modes of learning, respectively. They are loosely chained, indicating difficulties but with room for solutions. Their physical proximity symbolises the necessity for blended learning in the future. Source: Pixabay on Pexels)

With educational institutes closed due to the COVID-19 pandemic, the government has been encouraging online education to achieve academic continuity. Most high-end private and public institutions have made the switch smoothly using online platforms such as Zoom, Google classrooms, Microsoft teams, etc., while many still find

it a herculean task. The challenges of online education are multifaceted. It is time that we Indians, as a society, understand the realms of online education – in India, for India.

The Good

Online education allows for learning something beyond the norm. A learner has access to unlimited topics and global experts in niche subjects – something otherwise not affordable or imaginable for many. Online programs allow people of a wide age group to learn at their own pace, without inhibitions, and without compromising on their other responsibilities.

With the emergence and spread of COVID-19 in India, online education has trickled down to the most basic level — schools and colleges! When asked about their experience with online teaching, a student from a college in Bengaluru said, "The online option is a need in this pandemic situation. It has brought education to us without us going anywhere, and it is more flexible". Probably, students are finding it a welcome change from strict schedules and long-distance commutes to attend classes. For some others, who find learning in large classes intimidating, this may be a less stressful option. Many teachers are making the best of this situation by exploring new methods of teaching and assessment.
This is encouraging. But the moment online education moves from an optional to the only form of learning, and that too long term, the bad and the ugly slowly become evident. India is beginning to get a taste of this now.

The Bad

Using the internet for entertainment is common, but for online lessons is a big challenge. Teachers may not be well-versed in creating digital content and conveying it effectively online. A sudden expectation from them to upgrade, and from students to adapt, is unfair.

Body language and eye contact, which are important cues for the teacher, are difficult to perceive in an online class. "I do not receive continual feedback in the form of students' reactions during online sessions, which reduces the effectiveness of teaching", says a college teacher in suburban Mumbai. How many students have paid attention in a class? Of those, how many understood the lesson? Is the teaching pace alright? Are some students getting left behind? These questions arise even in traditional classrooms, but they are harder to address in online classes. A parent of an 8-year-old attending a private school in Gurgaon says, "There shouldn't be online classes for such young kids. Their concentration span is small and they do not pay attention after a while." The 8-year-old added, "I hate them (online classes)!"

Even college students seem to value the in-class physical learning experience much more than a virtual one. Many acknowledge that phones can be very distracting. In addition, science and technology programs often include hands-on laboratory sessions, dissertation projects and field trips to complement theoretical studies. This aspect of learning is severely limited in online education.

Finally, education is not just about subject knowledge but also about developing social skills and sportsmanship among the students, which is built over years. Relying solely on online education may hinder the holistic development of children, and many may underperform later in their professional and personal lives.

The Ugly

While India enjoys a wide geographic and cultural diversity, it also suffers from a huge socio-economic divide. Only a small part of the Indian population has access to online education right now. Interrupted power supply, weak or non-existent internet connectivity, and unaffordability to buy necessary devices are major concerns. "In a Class of 40 students, after two months of online classes, around 20 students regularly attend class with whatever device and connection they have. Around 5 – 8 students are completely absent to date and the rest are fluctuating", says a school teacher in Ratnagiri in Maharashtra. A teacher in a government-aided school from the small town of Chamba in Himachal Pradesh says, "It is a frustrating experience to engage students of lower classes in online mode. There are network issues on both teachers' and students' ends".

To deal with internet connectivity and device availability issues, 'classes' in many places are happening via sharing of videos by teachers over WhatsApp or YouTube so that students can watch them at their convenience. This too, however, comes with difficulties in understanding the lessons and promotes rote learning. The same is true of pre-recorded sessions aired on the television (e.g., Swayam Prabha DTH channels) and radio (audio lessons, through All India Radio), although they do cater to a wider student population that cannot avail live online classes.

That is not all. With limitations of livelihood in a family, the first ones to receive a blow are often girls. In a recent survey of 733 students studying in government schools in Bihar, only 28% of the girls had smartphones in their homes, in contrast to 36% of the boys. These smartphones almost always belonged to male adults, often being lesser accessible to girls than boys, and half of these families could not afford internet data packages. Therefore, lessons aired on television were the main option for a majority of the students participating in this survey. However, girls were found to spend a disproportionately longer time on household chores than boys, which often overlapped with the time of telecast of these lessons. Such gaps in education could worsen the already wide gender gap in employment in India.

Students with disabilities are among the most dependent on in-person education and hence least likely to benefit from distance learning. A survey by Swabhiman (an NGO working mainly in Odisha), in association with the National Centre for Promotion of Employment for Disabled People, indicated that 73% of the students with disabilities had concerns regarding the availability of study material in appropriate formats. Also, 79% of their teachers were apprehensive about teaching effectively without the use of touch to students with learning disorders, autism and low vision. The lack of effective education may further aggravate the high dropout rates of these children from schools (nearly 50% pre-COVID) in developing countries.

Uniform and effective online education in India — what is being done and what more is possible?

There is a global recognition of the need for inclusive education policies during the pandemic. To make online education more effective, accessible and safer, various online resources (links listed below), training programs and schemes have been developed by the Government of India for students, teachers and educational institutions. The teaching community has come together to form a nationwide informal and voluntary network of teachers, called the Discussion Forum of Online Teaching (DFOT), to discuss different aspects of online teaching, and create repositories of essential resources.

Cutting-edge technologies like artificial intelligence (AI) could open new possibilities for innovative and personalized approaches catering to different learning abilities. IIT Kharagpur has collaborated with Amazon Web Services to develop the National AI Resource Platform (NAIRP), the future possibilities of which include monitoring eye movement, motion and other parameters for better teaching and learning. Google has also indicated future support for AI-based education in India.

Parting thoughts

Online education opens up a lot of possibilities for students and teachers alike. Yet, it may also widen the inequalities in the socio-economic fabric of India. All our policies and interventions with regard to online education should strive to be inclusive. Good vision, sincere efforts and time will show India the way ahead.

Postscript:

Links related to online educational resources:

PM eVIDYA

National Repository of Open Educational Resources

e-Pathshala

Swayam

NPTEL

MHRD

National Digital Library of India

Find related articles on the IndiaBioscience website using this link:

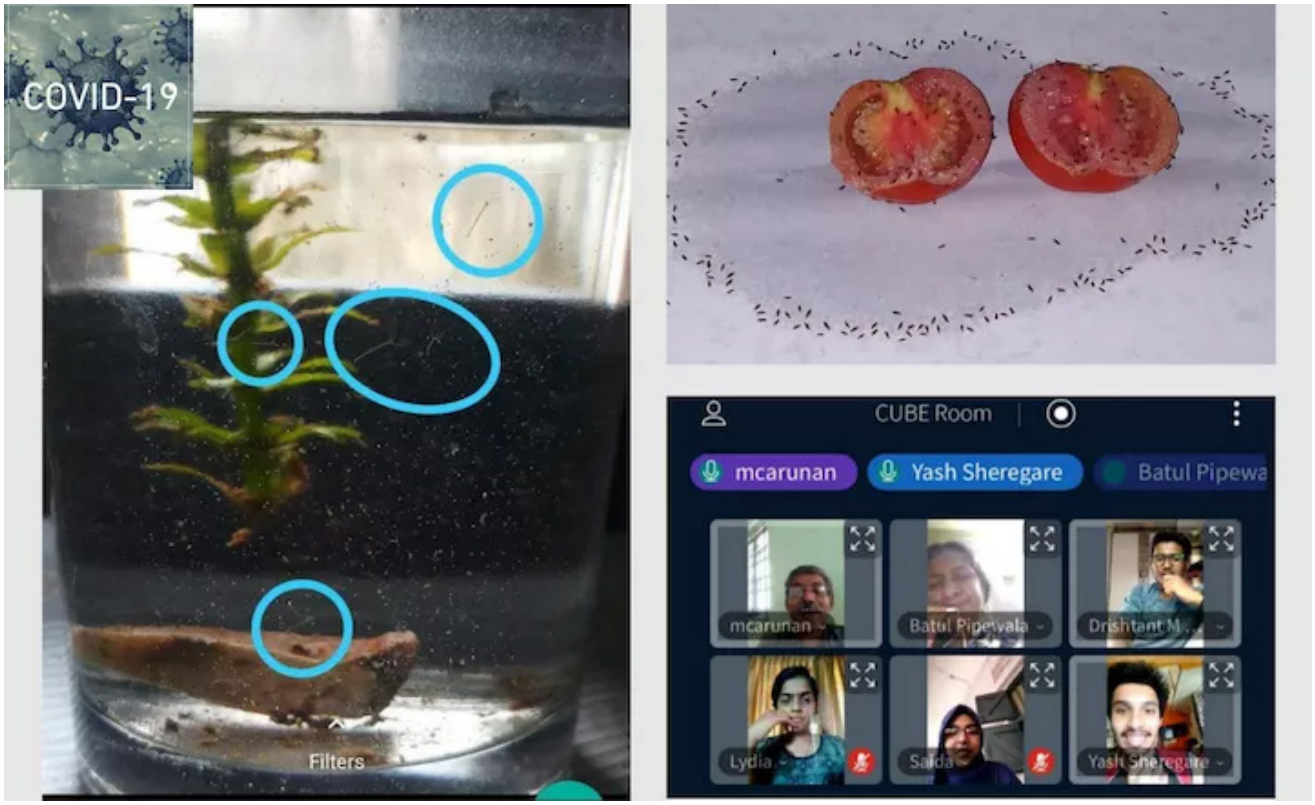
https://indiabioscience.org/columns/education/online-education-in-india-the-good-the-bad-and-the-ugly

25

Undergraduates in lockdown: Sustaining research projects with CUBE Home Labs and chatShaala

Author: **Meena Kharatmal, Nagarjuna G & Kiran Yadav**
Date of publication: **23 Oct 2020**

Excerpt: **The pandemic and the consequent lockdown have disrupted classes and access to labs at educational institutions across the country. However, for the undergraduate students of the CUBE program, the lockdown has been a boon. Instead of losing hope, these students have set a precedent by finding creative ways to continue working and learning along with their peers by developing the CUBE home labs and the CUBE chatShaala.**



The CUBE Home Labs and chatShaala (Photo: Abhijith Vinod, Aswathy Suresh, authors)

The CUBE (Collaboratively Understanding Biology Education) program at the Homi Bhabha Center for Science Education (Tata Institute of Fundamental Research) is a project-based science education program. It is designed

to cultivate a scientific attitude within students in a collaborative and conversational learning environment. Formerly called the Collaborative Undergraduate Biology Education program, though most of its participants are undergraduate students and teachers, school students and teachers also join as and when feasible. The program is now eight years old and has gathered participants from several parts of the country in this period. It runs through its centres in Ahmedabad, Asansol, Assam, Bengaluru, Bhind, Chandigarh, Dehradun, Delhi, Faridabad, Goa, Gurgaon, Gwalior, Hyderabad, Indore, Jharkhand, Kanpur, Kochi, Kolanchery, Kolkata, Kozhikode, Meerut, Moradabad, Mumbai, Mysore, Nellore, Patna, Raigad, Ranchi, Sapekhati, Silchar, Thiruvananthapuram, Thrissur and Visakhapatnam.

In this program, the participants work collaboratively on simple experiments using model organisms, like fruit flies, earthworms, snails, *Moina*, butterflies, *Hydra*, rotifers, *C. elegans*, and *E. coli*, to observe their features and study biological phenomena, like olfaction, circadian rhythms, regeneration, hypoxia, biodiversity, etc. Students then discuss their observations with their peers, in the lab and on social media.

With the lockdown, the labs became inaccessible to the students. However, this did not discourage them from continuing their engagements. This article is based on our conversation with six undergraduate students who with their mentors and other students from across the country are dedicatedly working towards a shared learning experience and making effective use of the lockdown time. We take a look at their 'new normal' mode of learning through the CUBE home labs and the CUBE chatShaala.

CUBE Home Labs

The CUBE home labs feature frugal methods to culture and study different model organisms, right in students' homes using locally available and easily accessible items, e.g., transparent plastic or glass bottles, tissue papers, water, milk, fruits, vegetables, soil, leaf litter, etc. (Figure A). Even the model organisms are obtained from local surroundings. The students' mantra, as Saida Sayyed put it, is, *"whatever things we need, we break it down to what is its function and can it be replaced by things available at home"*.

The mantra helped! Within the first few weeks of the lockdown, students were able to trap native fruit flies, take soil samples for nematodes, etc. from their localities. For culturing and isolating the soil nematodes from soil samples, students used boiled potato slices and a drop of curd/milk in place of 2% agar and bacteria. Students (Aswathy Suresh among others) collaboratively worked out a substitute for the standard fruit fly medium, called TRSV, using tomato, rava (sooji/semolina), sugar and vinegar, which are easily available ingredients. They used a pressure cooker as an autoclave.

Figure A: Images of the CUBE Home Labs. (1) A tomato used as a bait for attracting fruit flies. (2) Media bottles containing the TSRV medium for fruit flies. (3) Moina culture bottles. (4) Isolation of nematodes from soil samples using a boiled potato as the medium. (5) Soil nematodes growing on potatoes (6) A vermipit layered with gravel, soil and vegetable waste, and having ~15 earthworms. (7) Earthworm culture bottle with a punctured cap to allow proper aeration, holes drilled in the bottom to collect vermiwash. (8) Hydra culture in a glass, with about 7–8 Hydra kept near a window and fed with Moina once a week. [Photo: (1–2) Aswathy Suresh, (3) Drishtant Kawale, (4) Anshu Kadam, (5) Batul Pipewala, (6–8) Abhijith Vinod]

An exciting development was the use of a mobile phone camera in place of a microscope. The non-access to microscopes had been one of the major concerns for the students in the initial weeks of the lockdown. However, they overcame this obstacle by using a drop of water over the camera lens of their mobile phones and using a magnifying glass as an external lens to further magnify the images. *"Just basics of microscopy (physics involved!) and common sense, and it happened!"* said student Drishtant Kawale. Students were able to identify the features of wings, proboscis, etc., of fruit flies using this hack as shown in Figure B.

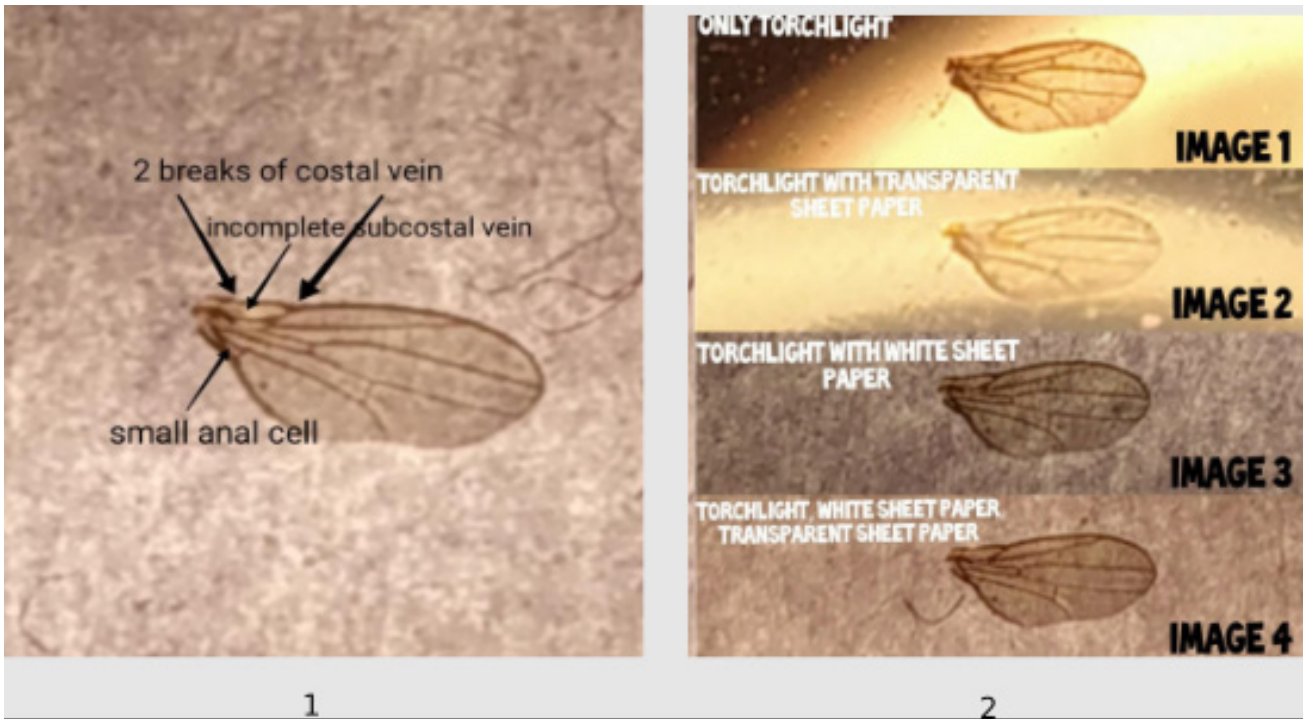


Figure B: Images of fruit fly wings as seen from a mobile camera. (1) Image shows a labelled wing. (2) Images taken under different conditions. [Photo: Aswathy Suresh]

Today students are sustaining their cultures with daily maintenance (housekeeping) work. The *Moina* culture is given drops of milk every day and its population has now increased to 400! Tomatoes are used as bait each day for studying the circadian rhythm in fruit flies. Using the homemade medium, the CUBE centres in Mumbai, Patna, Kerala and Kolkata are maintaining their fruit fly stocks successfully.

Some students are already conducting their experiments in addition to maintaining their culture of model organisms. For example, a group of students have progressed in their observations of circadian rhythms in fruit flies and compared these observations (e.g., graphs of day and night cycle in fruit flies) with their peers from other parts of the country (Figure C). Some students are working on studying the effects of hypoxia (low-oxygen condition) on *Moina* by setting up control and experimental cultures (though faced with challenges discussed below). *"To be honest, this lockdown has been a boon to the CUBE Community. We have witnessed the upcoming of the CUBE Home Lab Movement"*, says Kawale.

Challenges

Though productive, managing a CUBE home lab has not been without challenges. As students used boiled potatoes as media for nematodes, their challenge was to maintain them for a long time without any fungal growth. Observing nematodes just 1 mm long without microscopes was another challenge. However, students Lydia Mathew and Anshu Kadam explained how this challenge was resolved by using the full zoom feature of a mobile camera — an idea that came from discussions with other students. In hypoxia experiments with *Moina*, students found it difficult to estimate the amount of dissolved oxygen in the dechlorinated water used for culturing *Moina* — a task that requires chemicals and relevant glassware that were not accessible to the students due to the closure of shops. Although these challenges have hindered some of their wet lab work, students are seeing this as an opportunity to study the literature and design experiments through online discussions.

CUBE chatShaala

The CUBE program is engaging students with feedback mechanisms even during the lockdown. In addition to the home labs, about 30 students from across the country and their mentors meet daily (for about 3 hours) for discussions in an online forum called CUBE chatShaala. The forum runs on the BigBlueButton webinar platform (a free and open-source software) hosted on HBCSE's server.

The chatShaala is a conversational learning mode where students talk about their work progress, challenges, goof-ups, designing experiments, model organisms, and so on. Several hot topics in biochemistry, molecular biology, developmental biology and neuroscience get touched upon during these discussions, including the biology of the COVID-19 outbreak and its causative agent SARS-CoV-2 (Figure C).

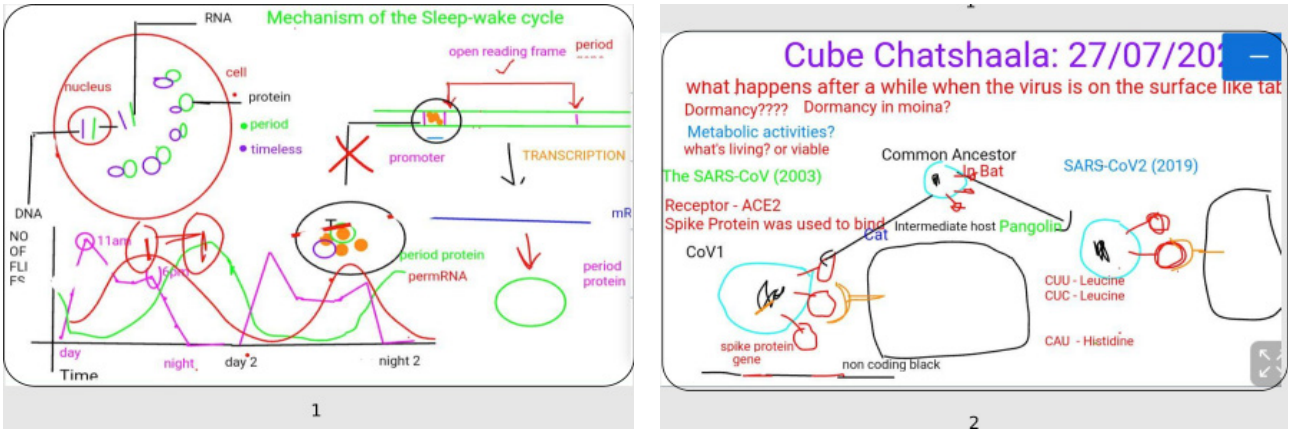


Figure C: Virtual whiteboard discussions in CUBE chatShaala. (1) Discussion on circadian rhythms in fruit flies. (2) Discussion related to the novel coronavirus. [Photo: authors]

By engaging in the CUBE chatShaala, students have even developed an e-book on fruit flies based on their discussions using the platform. "Engagement with peers [and] mentors on CUBE chatShaala has been extensive, exciting and very helpful", said student Yash Sheregare. Interested people can join the CUBE chatShaala and participate in the discussions, and can follow the blogs related to CUBE Chat. A profile of the CUBE chatShaala is shown in Figure D.

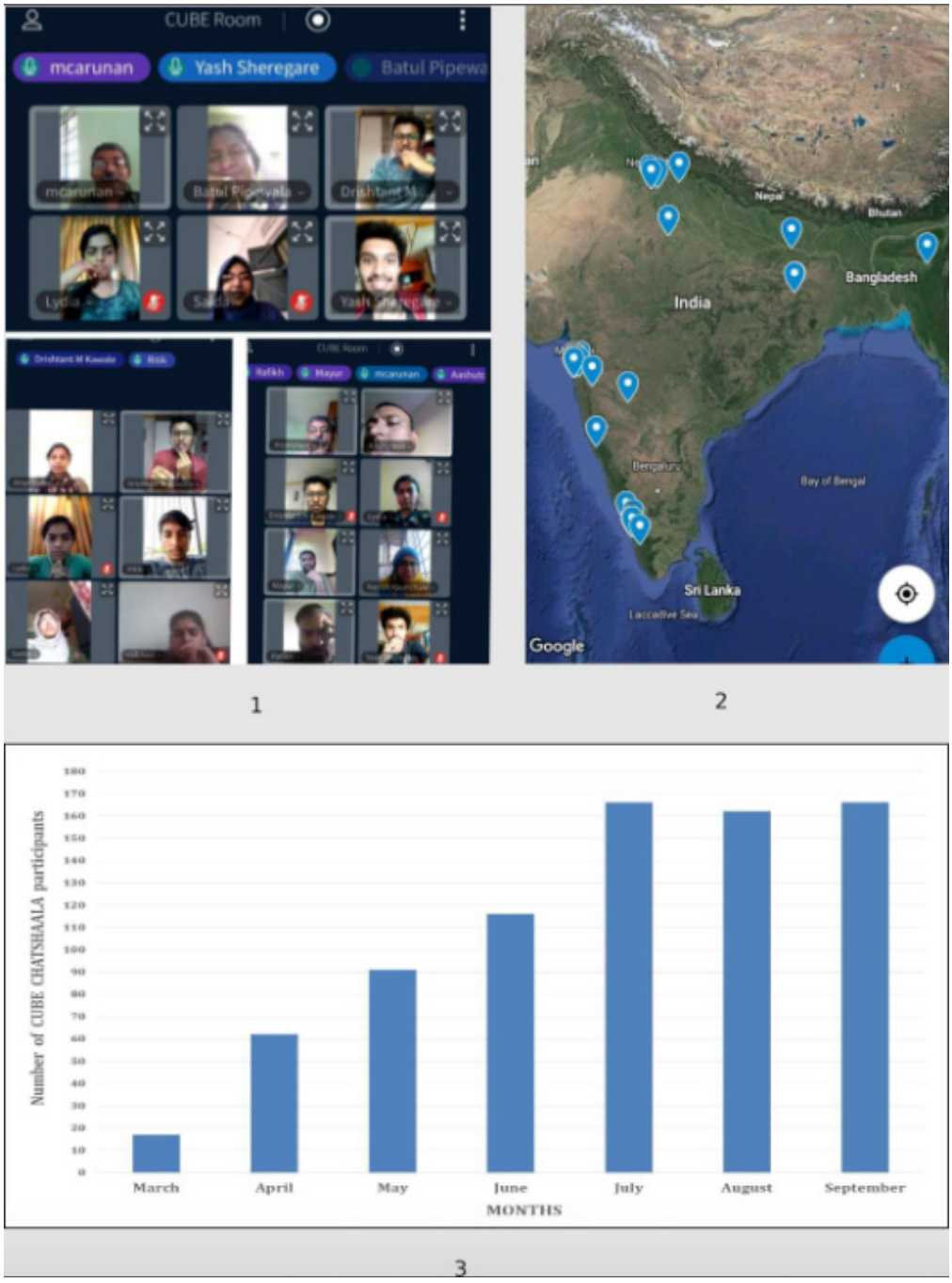


Figure D: Profile of the CUBE chatShaala. (1) Students participating online. (2) Map showing CUBE centres. (3) Graph depicting increasing participation by the students on the platform during the lockdown. [Photo: authors]

Advice to Peers

Based on their experiences, students of the CUBE home labs and chatShaala have some advice for their peers whose lab-based engagements have got disrupted due to the pandemic and who were not able to develop their home labs. They urge them to utilize their time by studying the literature, which would help them immensely when they conduct experiments later. They reiterate the importance of finding alternatives, or *'jugaads'*. *"Collaboration is the main key!"* says Mathew, explaining how collaborations can help in data collection, developing ideas, research questions and more.

Community Engagement

In addition to their research activities, students have also been working towards educating people living in slums about the pandemic, the infection, the importance of frequently washing hands with soap, wearing masks, myths about the disease, etc. Students are keenly attending webinars and talking to mentors for developing their scientific skills.

Parting Thoughts

The undergraduate students have developed and sustained an exceptional research platform in the form of CUBE home labs, and integrated it with the CUBE chatShaala, for not only working on their experiments but also keeping their model organisms alive! "*Lockdown has helped us in improving ourselves in our research work. In fact, we learned that nothing can stop our research! We have alternatives for everything. We can do research wherever we are. Possibilities are there around us. We need to get there*", said Mathew. This conversation with the undergraduates is evidence of their 'new normal' mode of learning.

Postscript:

Students in Conversation and their Affiliations:

Anshu Kadam — NES Ratnam College of Arts, Science and Commerce, Mumbai, Maharashtra

Aswathy Suresh — Sree Narayana College Nattika, Bottukadavu, Kerala

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Digital literacy in the midst of an outbreak

Author: **Charu D. Rawat**
Date of publication: **22 Apr 2020**

Excerpt: **The COVID-19 crisis and the physical distancing measures to control it have forced educators to connect with their students remotely. As a result, digital tools have become a necessity, not just an accessory, in their pedagogical toolkit. In this article, Charu Dogra Rawat, an educator at Ramjas College, New Delhi, and a digital literacy champion provides an overview of some of the online platforms and resources that can help educators engage with their students in a bidirectional teaching-learning process, even remotely.**

Engaging in the teaching-learning process digitally (Photo: Pranjal Gupta)

I was recently reminiscing about the year 2015- the year when I became aware of the importance of digital tools in teaching. An advanced week-long course in digital literacy at Edinburgh College, Scotland introduced me to

a variety of digital tools that could be used in pedagogy. Thanks to the course, my digital toolkit was no longer limited to just PowerPoint presentations. I strongly felt the power of "anywhere, anytime" learning. On my return from Edinburgh, I quickly organized "Digital Literacy Teacher Training" at Ramjas College, University of Delhi. I wanted not only to disseminate the acquired knowledge to my colleagues but also to infuse new energy into the customary pedagogy. To my disappointment, few matched my enthusiasm. Many of the participants found digital literacy intimidating as it appeared to threaten their professional existence.

Even now, 5 years later, the employment of digital aids in pedagogy is very limited and faces many challenges. Apart from the not-so-receptive-to-change mindset of the stakeholders, inclusion and the spread of digital tools in pedagogy are hindered by 'digital drought'- the scarcity of infrastructure and resources for digital dissemination of knowledge. Joined with it is the low digital literacy of both the students as well as teachers. Though they may be well accustomed to technology, they have limited to no knowledge of how to use it in learning. For some teachers, not being very tech-savvy adds another layer of complexity.

Today, however, we find ourselves in midst of a crisis — the global outbreak of COVID-19, and a nationwide lockdown to contain its spread. This has necessitated the teaching-learning process to run remotely. The only way for teachers and students to interact is through digital platforms. The medium that was once considered just an aid and accessory has suddenly become the only option available. It's a time of 'digital awakening' in education.

Here, I list some free (with restrictive usage) and open-source digital platforms and tools (most of them are tried and tested) that can help during these challenging times to keep us connected with our students and ensure uninterrupted bidirectional teaching and learning.

Learning Management Systems (LMS) — Many schools, colleges and institutions have LMS in place. It is basically a virtual ecosystem of academic staff, students, management, as well as the institution's IT department that supports the development, delivery, assessment, and management of courses. For the ones who do not have LMS platforms, Moodle or Canvas can be employed. Teachers can set up "Courses" – workspaces where they can add learning resources, enroll students, disseminate information, assess learning (grading), communicate, interact and co-create content. Activities such as populating a wiki, generating a glossary, developing information databases, and discussion forums allow students to attain higher-order thinking skills in analyzing, evaluating and creating information.

Online Classroom — For simpler, day-to-day class activities, Google Classroom comes in very handy. The platform can be used for making announcements, sharing resources, collecting assignments and grading. One can sign in with a non-institutional google account, create a classroom, share the classroom code with students who then join the class, and that's it. You are good to go.

Live Class — Nothing can beat the face-to-face live interaction of a classroom. This can be achieved virtually by video conferencing, for which platforms such as Google Meet, Microsoft Teams, and Zoom are available.

G Suite for Education and Office 365 run Google Meet and Microsoft Teams, respectively, for free for schools/colleges through the institution's administration. In case one wants to run a virtual class personally, Zoom comes in handy which offers to host a meeting of up to 100 participants with 40 min limit on group meetings (for the time being, the 40 min time limit for educational institutes has been lifted due to the COVID-19 crisis). During the live class, features supported by these platforms such as "Share Screen" for making the slides visible to the students, as well as "In-meeting Chat" for students to type in their questions/doubts can be used.

While Google Meet and Microsoft Teams are safer to use when run by institutions, there have been security issues with Zoom meetings. The Cyber Coordination Centre (CyCord), under the Union Ministry of Home Affairs (MHA), has issued an advisory on the secure use of the Zoom Meeting Platform by private individuals, which should be followed.

Pre-recorded Video Lectures – If it's not feasible to run live classes, lectures can be pre-recorded and shared with students. High-quality lecture videos are recorded in recording studios where proper lighting, good microphones, better cameras, and technical experts are present. After recording, the videos are edited and then made available on YouTube. Video lectures can also be recorded personally with a mobile or camcorder (choosing a quiet place, neat background, microphone close to the mouth and blocking off all natural light). They can be edited using video editing tools (the simplest being the Windows Movie Maker) and uploaded on personal YouTube channels, which can then be integrated into LMS, or shared on Google Classroom. Indeed, one doesn't have to record lectures but can also use/share pre-recorded lectures available online under the Creative Commons(CC) copyright licenses.

Online Courses/Live Lectures/Online Learning Resources — Major enforcement of digitalization in the Indian education sector came in the year 2017 when the Government of India launched SWAYAM, SWAYAM Prabha and National Academic Depository (NAD). Subsequently, the National Digital Library of India (NDLI), which hosts 47,917,213 learning resources (as of 21 April, 2020), was launched in the year 2018. The resources include books, theses, audio and video lectures, etc.

SWAYAM is a Massive Open Online Courses (MOOCs) initiative. Nine national coordinators have been appointed to produce and deliver the courses. I have been associated for the past 5 years with one of the Centers, Consortium for Educational Communication (CEC), for undergraduate education. In addition to the SWAYAM courses, CEC makes content for the Vyas Higher Education Channel and manages 10 SWAYAM Prabha DTH channels for 24X7 learning. The live lectures broadcasted on the Vyas channel are uploaded on YouTube for "anytime, anywhere" learning. Their nationwide appeal can be estimated by the acknowledgement I got for one of my lectures on YouTube (recorded in Delhi) from a student in Bhubaneshwar, when I went there to attend a conference.

According to a 2017 study by Google and KPMG, India – one of the leading providers of financial and business advisory among its various other roles – online education in India is expected to grow from 0.25 billion USD (2016) to 1.96 billion USD by 2021, with a 52% Compound Annual Growth Rate (CAGR). The growth drivers of online education are its cost-effectiveness, availability of quality education to potential students, increased internet penetration, and growing smartphone user base, to mention a few. Digital literacy thus becomes an important skill to be acquired to harness the potential of online education fully.

The list of tools described here is not exhaustive and there is a plethora of such platforms/tools that can be utilized in education. I shall write about more digital tools in my next article. May we consider these challenging times as an opportunity to digitally update pedagogy so that when we are re-installed after the crisis is over, we come forth as technology-enabled, improved versions of ourselves – Charu Dogra Rawat 2.0.

Postscript:

Also read:

Online education will be a game-changer for India, says JNU Vice-Chancellor

How the Covid-19 pandemic has thrown education around the world in a loop

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Find related articles on the IndiaBioscience website using this link:

https://indiabioscience.org/columns/education/digital-literacy-in-midst-of-an-outbreak

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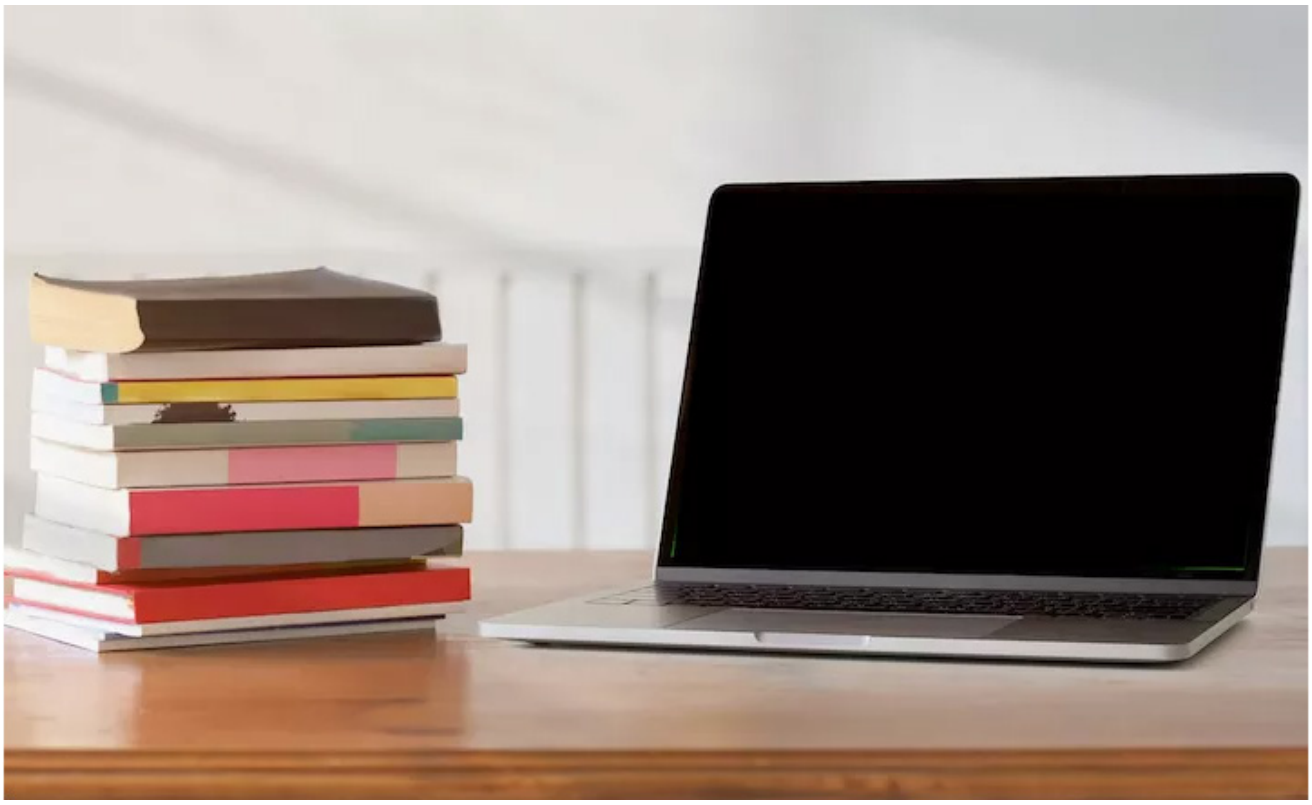
Massive open online course-inspired education

Author: **Lakshmy Ramakrishnan**
Date of publication: **25 Apr 2022**

Excerpt: **Experiments and practical lab work, considered indispensable for training in biology, came to a standstill when educational institutions and laboratories shut down in the wake of the COVID-19 pandemic. In this article, researcher and educator Lakshmy Ramakrishnan describes how Massive Open Online Courses, or MOOCs, could offer students exposure akin to lab work, even looking beyond the pandemic.**



Life science students gain skills and experience by working in labs. The Covid-19 pandemic placed limitations on experimental work for not only PhD students and researchers but students of undergraduate and postgraduate courses as well. Some of the challenges included, uncertainty over when students could resume or complete lab experiments, difficulties associated with maintaining cell culture and lab animals, inability to process and analyse data, unpredictable access to labs because of restricted logistics, and delays in procuring reagents and

materials due to supply chain issues.

Owing to the forced transition into remote learning, educators were strapped with the unprecedented job of having to cater classes that were equivalent to the wet lab. Some educators opted to incorporate literature reviews, whilst others offered bioinformatics-based project work and virtual simulations as a substitute. For instance, a study carried out at Stockton University describes a virtual lab exercise that involved teaching students about PCR and gel electrophoresis using a SARS-CoV2 theme. It was found to be useful in enabling students to understand basic molecular biology as well as bioinformatics concepts. A few also began to include massive open online courses (MOOCs), which are typically popular among engineering students, in the life sciences classroom.

MOOCs, delivered through various online learning platforms, provide courses taught by experts to almost any part of the globe, offer a great deal of flexibility, a wide range of subjects, and provide students with the option to gain course completion certificates that are recognised by various educational institutes. They are curated with videos, tutorials, discussions, reading material, and assessments.

MOOCs are also suitable for life science students looking for a substitute for wet labs. Some notable examples include,

1. MITx offers courses on molecular biology, where students can learn how to design experiments to test DNA replication and repair hypotheses and learn how to interpret data from such experiments.
2. 'Biochemistry, Biomolecules, Methods and Mechanisms' is another course offered by MITx that enables students to understand how protein structure is determined, how to interpret graphs, plot behaviours, and calculate constants related to enzyme function.
3. The 'Quantitative Workshop on Biology' is a course that enables students to write Python, MATLAB, and R code, aiding in the analysis of biological data as well as instructing students on how to examine protein structure with PyMol. HarvardX offers a similar course in programming and data analysis with MATLAB, with an emphasis on application to biology and medicine.
4. A course that is relatively popular with students is 'BioStatistics,' offered by DoaneX, which upon completion will enable students to design experimental, quasi-experimental, and observational studies, as well as learn how to collect, analyse, and interpret data using appropriate statistical tools.
5. A challenging field is microscopy, where image analysis is a serious concern for students from non-engineering backgrounds. EPFLx offers a course, 'Image Processing and Analysis for Life Scientists,' which covers core concepts from image acquisition to image filtering, and segmentation, using open-source solutions, ultimately enabling students to work independently on information-rich images. Johns Hopkins University, through Coursera Inc., offers 'Fundamental Neuroscience for Neuroimaging,' which is designed for clinical practice and basic research and pertains to the principles of neuroimaging methods and introduces concepts necessary for a basic understanding of neuroimaging applications.
6. State University of New York offers a course that enables students to master Big Data analytics using real datasets, including Next Generation Sequencing data, in healthcare and biological context.
7. One of the key areas that require systematic honing is academic writing. Stanford University offers its trademark course, 'Writing in the Sciences,' which is entirely devoted to equipping students with the necessary skills to write manuscripts, grant proposals, and general science communication.

Taking into consideration the nature of the course content, assessment methods, and financial factors, students may benefit from custom-made online courses. Educators can design their own online courses tailor-made to suit their own students. Educators can even incorporate different academic exercises to provide holistic content.

For instance, videos of lab demonstrations and virtual simulations can be combined with data sets and quizzes to keep students engaged and provide opportunities for discussions with peers. A challenging area for students is data analysis. Online course content that involves analysis of literature, particularly that of the methods and results sections on select topics, can be a great tool to incite critical thinking. This would enable students to closely examine the techniques applied and determine the robustness of experimental data. Exercises such as these would empower students with the know-how of methodically and clinically assessing data that is presented before them, either their own work or that of their peers. Designing courses that involve a combination of these methods would be greatly beneficial to students and would enable them to develop well-rounded research prowess.

In light of the Covid-19 pandemic, MOOCs turned into a saviour, at least to the lucky few who had the right devices and internet speeds to access them. But the growing popularity of MOOCs is a testament to the changing demands in education. Students who are looking to further their education or enhance their skill set have unique requirements and the MOOC platform is able to provide tangible benefits, such as versatility, lower financial burden, as well as a unique learning experience.

Leaving aside the necessity of online learning, which was brought about by the pandemic, and its role as a substitute to wet labs, education right now and in the future is likely to involve blended learning, i.e. a combination of online and face-to-face instructions. MOOCs do not have to be restricted to the pandemic scenario; instead, they can be utilized to introduce innovative teaching methods, provide a platform for students with a more flexible, broadened, multi-dimensional approach to learning, and can offset the burden that future challenges to education may bring about. Additionally, it can act as a balance to a relatively rigid university curriculum.

The main disadvantage posed by MOOCs is the attrition rates, the limited scope for personalised courseware, limited faculty interaction, as well as the digital divide. This can however be substituted through traditional classrooms. MOOCs can therefore form part of existing curricula and still provide well-structured, highly effective courses.

Recent studies indicate that there was an increase in enrolments in MOOCs offered by Coursera Inc. and Udemy Inc., with Coursera enrolling ten times more people in 2020 than in 2019. The majority comprised undergraduate students and professionals seeking to improve their technical skills. In contrast to previous studies, it was observed that there were greater instances of students completing the course and obtaining the necessary credentials to advance their career goals. This suggests that students have begun to embrace the benefits of the internet age, enabling them to learn any subject without spatial and temporal constraints.

There is ample scope for redefining online education, taking inspiration from MOOCs. A revamping will aid in the development of transferrable skills, ultimately enhancing employability in research and development sectors, like health, nutrition, pharmaceuticals, food processing, textiles, biomaterials, and agriculture. Collectively, as we move towards a period of reinvention of the education industry, it must be borne in mind that whilst learning is an active process, the way we channel education to our students also requires dynamism.

Postscript:

Find related articles on the IndiaBioscience website using this link:

https://indiabioscience.org/columns/education/massive-open-online-course-inspired-education

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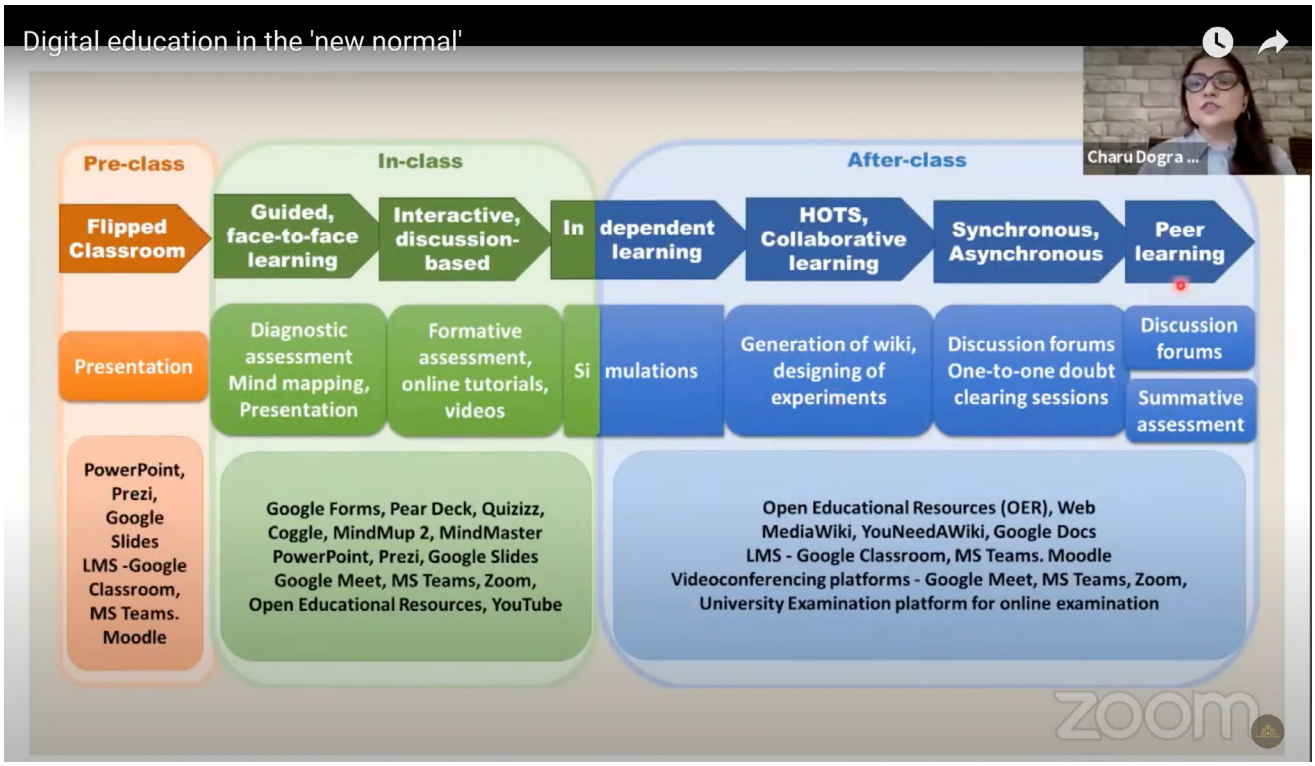
Webinar: Digital education in the new normal

Author: **Poornimai Abirami G P**
Date of publication: **21 Oct 2021**

Excerpt: **This webinar, featuring award-winning educator Charu Dogra Rawat, aims to inform educators in higher education institutions on the importance of digital tools and how to incorporate them in lesson plans for effective learning. School teachers may find it useful too.**



A screenshot from the webinar.

The conventional offline mode of pedagogy underwent a complete transformation during the pandemic when it took to an online mode. This came with its advantages and disadvantages. Despite the disadvantages, like the reduced interpersonal interactions, and difficulty in accessing stable high-speed internet or manoeuvring new software, the availability of a myriad of online tools with boundless potential to make learning immersive and lasting makes the online mode unavoidable, even post-pandemic. Hence, the online mode may persist in the

new normal, albeit in a blended mode of education (BME), where, some of the online interactive pedagogical tools go hand in hand with the offline classroom setup. Charu Dogra Rawat, in the webinar "digital education in the new normal", explains how inquiry-based learning (IBL) can be elegantly knitted into the blended mode of education.

Inquiry-based learning is a pedagogical approach where students are made to learn by enquiring about the subject from different angles. As Rawat explains, IBL starts even before the actual class, where the students are presented with an inquisitive context, like a problem, capable of stimulating them to start enquiring about the topic they are about to study in class. This sets the stage for effective learning to take place during the actual class, which can happen online or offline. During the class, the educator facilitates learning to consolidate the key concepts and establish a firm understanding of the same using mind maps, flow charts, etc. Finally, by giving after-class assignments (for example, creating a wiki, making a video, designing experiments, or having discussions with peers), followed by assessing, providing feedback and rewarding the same, the entire module of inquiry-based learning comes to an end.

Using examples from her own classroom, Rawat describes how, in the blended mode of learning, educators could facilitate learning – before, during and after the class – by making use of online pedagogical tools, like simulation software, pedagogical games, online quizzes, etc.

Rawat identifies time management and digital literacy as the two major challenges of inquiry-based learning in the blended mode. She says that planning and framing modules beforehand greatly aid in facing these two concerns. Planning has to be done keeping the time availability in mind and the time available can be broken into bite-size pieces. Also, while including the online pedagogical tools, Rawat recommends teachers be choosy, keeping learning objectives in mind.

With some efforts and by following inclusivity, Rawat believes that the digital barrier that exists in a classroom can be minimised. To get a detailed picture of inquiry-based learning in the blended mode of education and examples of relevant resources for educators, watch the recording of the webinar: https://youtu.be/cLxna-SI4Oo

Policies and practices

Articles and webinars that critically examine current practices and policies in higher education institutions.

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In a rat race for certificates

Author: **Hansika**
Date of publication: **28 Jun 2021**

Excerpt: **Receiving a certificate after an immersive learning experience or a job well done can be quite gratifying. But is a free-for-all distribution of certificates without evaluating the recipients justified? Are we chasing (or worse, fueling) a culture where certificates seem to trump learning gains? This article highlights the systematic spread of falsehoods associated with certificates in the Indian education system and the ways in which students can be protected from it.**

During the first year of my BSc, I was selected to work on a project under the "Delhi University innovation projects" scheme. The idea was to equip students with research training at the hundred or so colleges that fall under Delhi University. Of the three mentors for the project, two left the college within three months. The only remaining collaborator used the funds to buy equipment for his lab and then left. In the end, all I had was

memories of our team trying to extract volatiles from medicinal plants by boiling them in a flask. We scavenged chemicals and worked without proper equipment and safety gear. Nothing was standardised. The resounding naivety of our methods, unfortunately, became obvious much later.

I had spent two summers on this project. I felt I had learnt nothing, but I wanted to add this to my CV to get a leg-up on future applications. This did not prove easy with all of the grantees being absent. I approached the principal's office to request her signature on a piece of paper attesting to my participation. After three days of camping outside of her office, I triumphed. I got what I thought would be the only thing I had to show to prove my enthusiasm for science — a certificate.

Cut to 2020 – 21, Twitter is bursting with online webinars and questions about the availability of certificates abound in the comments. Confused, wide-eyed and desperately lacking in mentorship, Indian undergraduates flit about from online workshops to webinars seeking a certificate for show of merit.

The discomfort of traditional education systems, unilateral evaluation criteria, and general instability in India's colleges contributes to a dampening of community morale. Our undergraduates feel obliged to prove, even during a global pandemic, that their interest in science is genuine and active through a trail of certificates.

Why do college-goers seek certificates at all?

It is possible that students today feel that a certificate for attending a seminar or a webinar compensates for a lack of practical knowledge and skills. Stuti Budhiraja, an engineering graduate, shares that she was among the many students who joined societies for the sake of adding a line to their CV. But she was never proud of it. She goes on to say, "This is especially more common to students who did not have access to internships. So, this may be the only low-hanging fruit to talk about to a recruiter in the interview during placements."

Small institutes and colleges worsen the problem by encouraging chasing certificates in multiple ways. Some colleges allow making-up attendance with the representation of the college in sports tournaments. If one wants to be compensated for missed attendance or retake a missed test, one must produce certificates of participation or get the professor in charge to issue a letter at the end of the year. Registration slips, tickets, and check-in passes are usually not admissible as proof; one needs it to be legitimised by the faculty or the principal of the institute where the event was held.

> ***"Extra-curriculars help to distinguish yourself from peers within the same league of marks...but only after you meet every other qualifying criterion - marks, rankings, courses, skills, etc."***

Feeding on the desire for certificates, many private and governmental set-ups advertise certificates to attract audiences. If certificates are an essential tool to assess individual students for future opportunities, this encouragement makes it a vicious cycle. Many event organisers, however, find themselves uncertain about the perks of incentivisation for webinars and 1 – 2 day workshops. Offering certificates may boost participation, but given the lack of rigorous assessments, how would one judge learning?

Smita Jain, IndiaBioscience, expresses disappointment over a flood of emails enquiring about receiving certificates for one-off informational webinars. "It will be even more difficult to assess the level of understanding

of an individual by e-certificates that everyone has access to! Organizations should think twice before distributing free certificates in order to attract an audience," she says.

What about paid courses and virtual workshops, should they end in certification? With a lack of provision for internships in curricula, clashing academic calendars, and now a global pandemic, many students are unable to apply for summer internships. Some government and for-profit enterprises have tried to address this with virtual-only workshops. The perks of certification make a difference to the motivation of participants and organisers alike when it comes to pricing.

Jain warns of possible issues with their operation, "A business model to impart training by academic institutions, especially to generate funds, in return for a sub-standard training is not at all ethical. However, an associated fee becomes acceptable if the training provided is of high quality and helps a person gain experience and skills. It should be a conscious effort of the mentors and decision-makers at the systemic level to work in favour of the trainees who are spending their money in order to gain a skill."

Should a certificate be the only reason to participate in extracurricular activities?

"At the Indian Institute of Science (IISc), Bengaluru, no certificates are given for extracurricular activities. One must do it purely out of interest," says Rajas, a recent graduate of the BS-MS programme at IISc. "For instance, I was involved with Pravega (the annual fest) for 2 years straight in different positions, but Pravega does not offer certificates to volunteers." The neck-breaking focus on academics and the cut-throat competition leads to seclusion. Some students seek solace in films, music and dance groups, allowing for a few hours for banter and creative expression.

I asked a few professionals if certificates for extra-curricular activities made a difference in their success. They were either researchers in training or people who left STEM for other avenues.

Stuti Relan left science to pursue an MBA from IMT Ghaziabad in 2015. She was promptly placed in a top company in 2017. She confesses that certificates did not prove very helpful, but she did enjoy exploring and participating in extempore. "Extra-curriculars help to distinguish yourself from the peers within the same league of marks... but only after you meet every other qualifying criterion – marks, rankings, courses, skills, etc." She adds, "Your skills take precedence; being a jack-of-all-trades and master-of-none doesn't quite help. Since debate was my claimed forte, 3 – 4 wins allowed me to make a solid case for it."

"A strong, yet simple statement of purpose and a cover letter written with honesty and clarity go a long way."

Juhi Arora is a PhD scholar at Pennsylvania State University in her fourth year. She told me she felt like she was missing out by not being active in extracurricular activities, but soon realised they were not at all important for her professional goals. "The selection committees look for candidates capable of independent critical thinking and problem-solving. One's SoP, recommendation letters and research experience matter the most. Publications are a big boost. So, maximising internships, conference presentations and writing reviews is key to making a good impression."

Certificate-chasing is becoming a cancerous culture, which may be up to the education sector to thwart. Since these can sometimes come at a heavy cost and tell us very little about the individual's quality of learning, they might be incorrect proxies for merit.

To stand out, there are alternatives to seeking certificates. Upskilling through online courses with open access to educational materials could be the way to go. If it's a job application, "A strong, yet simple statement of purpose and a cover letter written with honesty and clarity, go a long way," advises Jain. She also suggests being active on networking platforms such as LinkedIn to seek experts and ask career-related doubts.

Can the evaluation process for higher studies be made inclusive and reasonable in their consideration of candidates? The burden falls on a community of evaluators and rigid selection committees to shake off comfortable definitions of 'an excellent candidate' and look beyond scores and certificates. When asked about authentic sources for evaluation when being considered for a professional role, Jain adds, "Unless a prior supervisor or colleague writes a letter of recommendation, with an in-depth account of the personality (qualities and characteristics) and skills (capabilities), the document holds no value. The selection committee should demand inclusion of very clearly defined pointers in the recommendation letter (apart from what the person wishes to include in the letter) to judge candidature."

To be inclusive, the higher education system would have to focus on capacity building, increasing access to hands-on courses to complement theory and organising internships for large swaths of the student population. Until every student has equitable access to these opportunities, a change of evaluation criteria across the system may be a saving grace.

The National Education Policy 2020 states the intent to improve higher education through the formalisation of the above remediations. It makes provision for a 4-year curriculum, wherein one year could be dedicated to research and lead to the "award of a bachelor's degree with research" on completion of a research project.

This would help level the playing field by allowing for more students to access skill-building and receive exposure to potential career possibilities, navigating the increasingly competitive terrain for most fields and enriching their knowledge in ways only hands-on, immersive learning can. However, potential problems could arise due to a lack of clear implementation plans and mentorship practices in Indian academia.

It's been six years since my undergraduate studies were completed. To this day, nobody has asked to see my certificate for the science project. There is no way of even knowing if it has contributed to helping me acquire any opportunities. I believe it came up during PhD interviews in India, but nobody was interested in hearing more than a brief description of what the project was trying to do. I wish they had asked me more, so I could illustrate just how desperate and tenacious I was towards building a career in science.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/in-a-rat-race-for-certificates

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India's UG-STEM scholars: A demographic dividend waiting to be harnessed

Author: **Ritika Mukherji**
Date of publication: **08 Feb 2021**

Excerpt: **India produces approximately 1.88 million STEM graduates every year. This large prospective scientific workforce suffers from the absence of a streamlined process to access empirical work opportunities in the form of internships, volunteering, mentorship or entrepreneurship. Ritika Mukherji argues that by not tapping into this demographic dividend, the country's academia and industry are losing out on a massive semi-skilled workforce.**

If one is smitten by science in middle school, it is because the subject is all about exploration, creativity, fascinating projects and mostly 'fun while you learn'. This application-based worldview of science is what motivates most students to think of pursuing it as a subject beyond school.

But by the time a student is enrolled in an undergraduate (UG) science programme, a bit of that excitement gets dampened as science is learnt from photocopied and online study material, some books and a smattering of lab practicals (Note: thanks to the COVID-19 pandemic, even the lab experience has taken a beating this year). There are exceptions, of course, such as the Indian Institutes of Technology (IITs) or the Indian Institutes of Science Education and Research (IISERs), which have transformative learning atmospheres. But such learning hubs account for just a small fraction of the entire UG science ecosystem.

Sandwiched in between school and postgraduate level education, UG education does not seem to have undergone much structural or pedagogic change over the years in India. School education has evolved significantly in the last decade as schools adopt new-age learning and teaching methods. At the postgraduate level too, many new opportunities for extra-curricular learning, internships and fellowships now exist to engage the minds of science students. Steeped primarily in curricular learning, the UG science ecosystem is in need of an infusion of life so that young adults, bubbling with creative energy, do not fall out of love with the subject.

Nowadays, many STEM-UG students come armed with basic skills in computer coding, social media handling, market research and survey methodologies, communication, presentation and documentation. In the first year of UG, they quickly learn skills such as basic lab techniques and scientific literature search.

"The UG science ecosystem is in need of an infusion of life so that young adults, bubbling with creative energy, do not fall out of love with the subject."

However, this large prospective scientific workforce suffers from the absence of a streamlined process to access empirical work opportunities in the form of internships, volunteering, mentorship or entrepreneurship. Conversely, by not tapping into this demographic dividend, the country's academia and industry are losing out on a massive semi-skilled student base, keen on hands-on learning early in their scientific career. This also assumes importance in light of India's new skill development initiatives (Skill India Mission) and vocational learning opportunities arising out of the National Education Policy, 2020.

What work opportunities mean to UG students

Work experience at the UG level helps students become more confident about their decision to study science. It gives them a true experience of what being in science, along with all its joys and frustrations, really means. Working in a lab or with a group of researchers actively pursuing a hypothesis teaches the student many vital life skills alongside area-specific skills. Work experience helps students identify their strengths and unexplored careers, and understand which skills might be in demand and how those skills can be honed. It primes young students towards a professional environment and teamwork.

Many describe their first (and often only) UG internship or fellowship as an eye-opening, stimulating experience. They come with an interest in the subject and many times leave with a purpose. These experiences help students gauge whether they are cut out for the field or not.

"Work experience helps students identify their strengths and unexplored careers, and understand which skills might be in demand and how those skills can be honed."

Interning at a research lab in academia or industry, a student can gain knowledge as well as recognition for his/her work. Such collaborations are generally hands-on and last for nearly 4 to 8 weeks, sometimes more. Students may also receive a stipend or certification for their work, which adds value to their career records.

Volunteering, on the other hand, can take many forms. It is a more flexible collaboration where the student can offer to work with a group of professionals on some aspect of their work that he/she finds interesting or is experienced in. This generally culminates in a letter of recommendation that facilitates the student's admission to higher education institutes or future employment.

Mentorship is a flexible and deeply enriching exchange, where the student may or may not actively work with a mentor but gets career guidance and direction in the mentor's area of expertise. Many STEM-UG students also come up with start-up-worthy projects and ideas, and could benefit from entrepreneurship guidance from incubators, funders or industrial houses.

A UG science education without work experience is like reading only the abstract and the discussion portions of a manuscript. When a student actively engages in even a small part of the research process, it's like regaling in the deeper knowledge of the methods, the design of the scientific study and its results.

A UG student's journey towards gaining work experience

Generally, when students reach the middle of their second year, they start looking into postgraduate courses and their eligibility criteria. This is when the importance of work experience dawns upon them. Postgraduate science courses involve lab rotations, writing dissertations and application of scientific knowledge in research-based work. Most premier colleges, both in India and abroad, prefer students with prior work experience. They give priority to students who may either have worked in laboratory settings or participated in activities such as communicating science, volunteering or organisational efforts involving the scientific community.

The search process requires the UG student to actively research his/her niche areas of interest. For example, a zoology student may be able to explore research areas in quantum biology or biophysics. The next step involves looking for the right person/researcher/academic with whom the student wishes to work. These two initial steps are very crucial in the search for the dream work opportunity. A suitable intern must then be able to express succinctly his/her understanding of the work of the mentor or opportunity provider. This involves writing a professional email that showcases the student's preliminary research and interest in the subject.

The challenges in tracking opportunities

It would be worth chronicling the first two years of my UG science learning to illustrate the challenges. As I enrolled on a three-year Bachelor of Science (Zoology) course at Delhi University, helpful seniors and teachers primed our batch for the years to come – the first year would be the easiest, the second tough in terms of syllabus, and the third toughest in terms of both syllabus as well as planning for the future. Accordingly, I set out to plan such that I could engage in co-curricular and extra-curricular activities in the first and second years (possibly

also learn a new language), and by the third year learn a set of new skills and gain some work experience.

I expected that all my peers would also think similarly and that we would collaborate as well as compete with one another in this quest to learn more and be better. However, it did not turn out that way.

Just graduated from school, UG science students are absolutely new to the world of advanced science education, research and its application. Emerging from a system that runs on strict discipline and an emphasis on scoring high, UG students in India are not well equipped for exploring ideas beyond the classroom or communicating with potential mentors, teachers or seniors from whose experiences they might learn. From being disciplined, taught and handheld by teachers mostly specialised in handling children, they graduate to a free teaching environment where teachers are specialised in their subjects but the onus of learning and seeking opportunities falls on the student.

Therefore, most of my classmates and I had no inkling of what sort of work experience we might be able to look for. The most common form of work experience seemed to be an internship. However, getting one was not easy.

"Emerging from a system that runs on strict discipline and an emphasis on scoring high, UG students in India are not well equipped for exploring ideas beyond the classroom or communicating with potential mentors."

Fresh into college, in my first year, I took time to understand and adjust to the world of UG education. I was also involved in several extracurricular activities, so by the time I was able to scout for internship opportunities, all internship or research fellowship applications (among the very few available for first-year students) were closed. Despite studying in a college ranked number one in the NIRF, and having a stable internet connection at home, it took me three days to list the available opportunities, and in the process, realise that I had missed most deadlines.

However, I did not want to give up. I set up an active search and managed to land two work positions with directors of eminent labs, one in India and one in Germany. Although I did not get any certification from these mentors eventually, the knowledge and experience I gained were beyond my imagination. It not only opened up my world to the evidence-driven rigour of the scientific enterprise but also how scientific research can be monotonous, stimulating, frustrating and enriching at the same time.

Global versus Indian scenario

From then on, I began exploring and creating a repository, listing out various research and learning opportunities the world over (thanks to COVID-19, learning is no longer confined to national boundaries, and even UG students can dream of conversing with global scientific leaders on a Zoom call). During this activity, I noticed that in many countries leading in scientific research, e.g. USA, Germany and UK, UG research and work experience is as commonplace and important as postgraduate or PhD level research. With numerous national-level summer and visiting programmes, and research fellowships, these countries have designed efficient information channels not only for the sciences but also for interdisciplinary and application-based learning.

Although there are some UG-level programmes in India, their number, magnitude, and visibility are no match to those in other science-faring countries. In an era of global open learning, when students can easily begin to explore their interests and work areas at the UG level, it is important to make the UG work experience system more efficient and accessible.

As part of the Placement Cell of my college, I noticed that very few internship opportunities needed scientific capabilities or interests. Similarly, very few science higher education institutes in India list work experience opportunities on their websites. I get approximately five calls every week from UG STEM students inquiring if I know of any work opportunities or internships. I can seldom answer them satisfactorily.

Some websites that collate information on scientific research opportunities do exist in India. However, they either focus on a very specific area of science (thus reducing the scope for imagination, creativity and interdisciplinarity) or focus mostly on postgraduate and higher-level research.

Thus there is a great need to streamline and organise the process of informing students about the existing opportunities by making them more accessible and visible. The need for creating a centralised hub where UG STEM students can learn all about the whats and hows of securing work experience and mentorship opportunities is evident.

In essence, India needs to harness the power of her UG STEM student community, ready to broaden their worldview while they prepare to take fledgeling steps into the scientific research and entrepreneurship ecosystem.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/opinion/indias-ug-stem-scholars-a-demographic-dividend-waiting-to-be-harnessed

31

Science education in Marathi at HBCSE

Author: **Rohini Karandikar**
Date of publication: **16 Apr 2019**

Excerpt: **For the last four decades, the Homi Bhabha Centre for Science Education (HBCSE) has been steadily pushing science education for primary and secondary school children in both rural and urban areas, through the medium of innovative activities and publications in multiple Indian languages, including Marathi, Hindi, Urdu and English.**

Students displaying their model of rainwater harvesting during a summer camp

Homi Bhabha Centre for Science Education (HBCSE) is a constituent unit of the Tata Institute of Fundamental Research (TIFR), founded in 1974 by two TIFR scientists, V. G. Kulkarni, B. M. Udgaonkar and R. G. Lagu. It began with the aim of improving science education at the school level in the country, for which it received its initial

funding from the Dorabjee Tata Trust.

Afterwards, based on the performance of the projects undertaken in the first few decades, the Department of Atomic Energy (DAE) provided space and funds to build a separate campus for HBCSE. In its initial years, HBCSE functioned out of a Bombay Municipal Corporation (BMC) school of Nana Chowk, Mumbai. In October 1992, the centre shifted to its new building at Anushaktinagar, Mumbai.

Since the last four decades, HBCSE has been conducting activities which can be categorized as Research in Science, Technology and Mathematics Education (STME), Teacher Professional Development, Material Development, Science Popularization and Olympiads in Science & Mathematics.

The scope of these activities ranges from research in STME to improving STME based on the research findings, conducting orientation programs/workshops to interact with teachers and students, developing textbooks and other co-and extra-curricular material in science and mathematics at the school level, and selection/training of young students to participate in International Olympiad Programmes.

In its early days, HBCSE conducted projects for teachers as well as for students from BMC schools, where the medium of instruction is Marathi. These projects were aimed at strengthening the pedagogical knowledge of teachers in science and mathematics and improving teacher-pupil interactions. Some projects were also aimed at enhancing students' engagement in science, developing co-curricular materials, and designing low-cost experiments and activities for science and mathematics education in Marathi.

Since then, HBCSE has worked in collaboration with the education department of Govt. of Maharashtra and conducted various educational projects to improve teaching-learning processes in the classroom. Some of these past projects include the BMC Project, SC/ST Project, The Language Project, Non-Formal Education Project, Solapur Project, Ashram School Project (Residential schools run for tribal children), Sarva Shiksha Abhiyaan, etc.

All of these projects provided HBCSE with field-based experience and helped it develop tools and educational material for STME. After the devastating earthquake in Latur district in 1993, HBCSE took the responsibility of assembling a low-cost experimental kit and distributing it to 40 schools in earthquake-affected areas of Latur.

Currently, for the majority of projects, HBCSE uses English, Hindi and Marathi as a medium of interaction in science education. In this article, I shall describe a few past and ongoing projects and resources developed at HBSCE in the Marathi language.

Shanka Samadhan

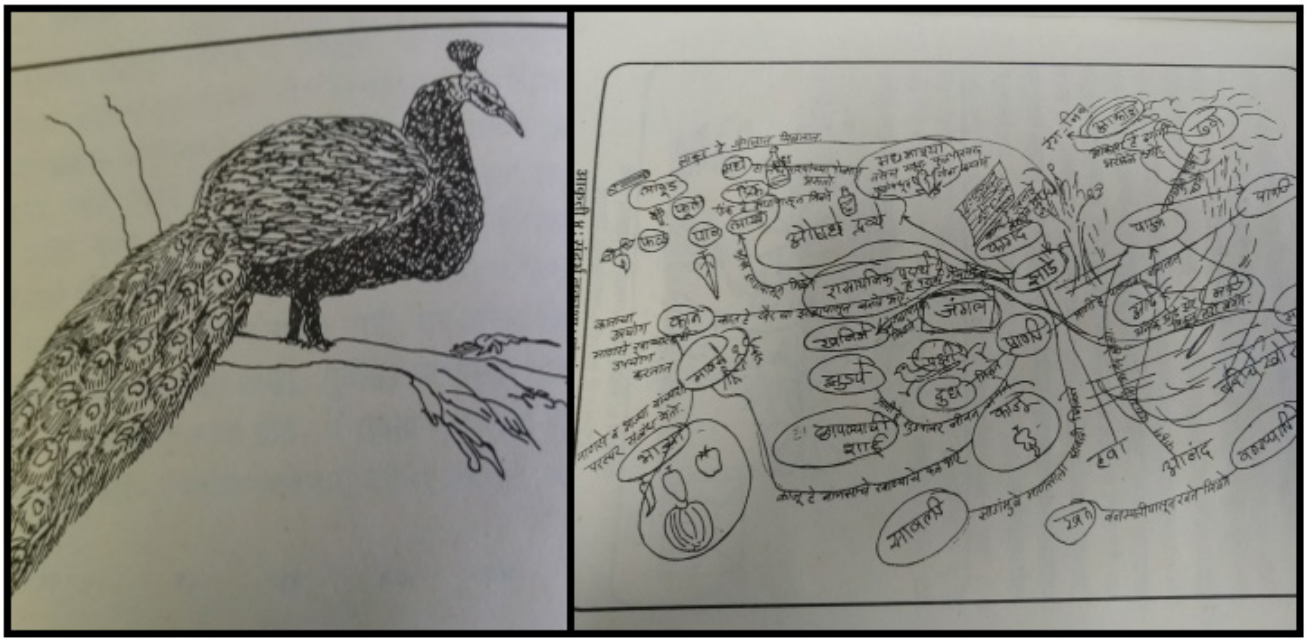
While interacting with school children, educators from HBCSE realized that if encouraged, children ask many interesting questions. Thus, an activity named '*Shanka Samadhan*' was initiated in Dec 1974 in which children would send questions on a postcard to HBCSE and educators from HBCSE would respond personally to the child. This initiative received an enthusiastic response from the children and these question-answer pairs were published under a feature '*Shanka Samadhan*' in Kishore, a magazine published by Balbharati, Pune. *Shanka Samadhan* appeared for nearly 25 years in Kishore.

Diagnosing Learning in Primary Science (DLIPS)

Every child observes nature and is curious about it from a very young age. Diagnosing Learning in Primary Science (DLIPS), a project undertaken by HBCSE during 1993 – 96, sought to understand children's spontaneous conceptions about nature. Students from grades 5 and 6 from two tribal schools (*ashramshalas*) and one urban school were involved in this project.

From the interactions with the students, researchers from HBCSE observed that there was a clear mismatch between students' understanding and concepts mentioned in textbooks. For example, many children found it difficult to distinguish between living and non-living things. According to them, the sun, the moon, clouds, and water were 'living'. The students identified seeds as 'non-living', but were aware that they would become 'living' when sown into the soil.

Tribal children possess a rich knowledge of flowering and fruiting trees, medicinal herbs, use of plants in food and construction, wild animals, etc. Compared to what's in their textbooks, everyday observation and use of plants have a greater influence on these students. The students also drew beautiful and realistic pictures of animals with remarkable attention to fine details. When asked to draw a context map of living and non-living things from a forest, one child drew an amazingly detailed map.

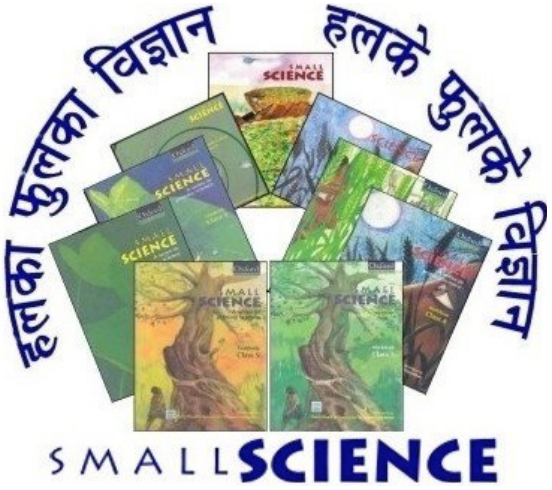


Drawing of a peacock and context map of living and non-living things from a forest by different Ashramshala students (DLIPS Project report)

The DLIPS project report is available online in Marathi and English for teachers/educators on HBCSE website. The report suggests activities for teaching and provides pointers for discussion on everyday observations from nature.

Publications

HBCSE has published a large number of curricular and popular science books for propagating STME among school children as well as for general readers. These include *Halke — Phulke Vidnyan* (Small Science), *Stri-Purush Bhed ani Vidnyan* (Gender and Science), *Ganitachya Gujgoshti*, *Aapli Suryamala* (Our solar system) and *Kutuhal* (How and Why) series among many others.



Small Science Curriculum

One of HBCSE's best-known publications is the curricular book series, Small Science for primary school level, which was developed after years of research, analysis and field trials and introduced as a science curriculum for grades 1 – 5. These innovative books aim to develop observation, language (oral and written), design, creativity and quantitative skills in children. The series includes a textbook, a workbook and a teachers' handbook.

Small Science books were originally written in English and then translated into languages like Marathi, Hindi and Urdu. In these books, researchers have used child-friendly language and illustrations that can attract children's attention. Several teachers have adopted this curriculum in their schools and have provided strongly positive feedback. Small Science books in all four languages are available on the HBCSE website and can be downloaded freely. The hard copies of all HBCSE publications are also available for sale.

Participatory Action Research

Currently, HBCSE is running a longitudinal project called School *Science Research and Development — Participatory Action Research (SSRD-PAR)* for students of a nearby Marathi-medium school. 'Participatory Action Research' implies that the improvement of a community is the primary goal rather than furthering the research interests of academics. In this project, HBCSE members are working in collaboration with science teachers. This project started in 2015 with a division of grade 3. Since then, HBCSE has been designing lesson plans, low-cost experiments and worksheets for children who are currently in grade 6.

Left: HBCSE main building; Right: Students looking through a pinhole camera designed by them in a classroom session

A part of this project is a summer camp where 15 – 20 students of the participating school (currently, grade 6) visit HBCSE for a period of one month and engage in activities involving creativity, outdoor engagement and design which may not be a part of their regular curriculum.

In the summer camp, children enjoy composing poems, stories, making stop-motion animation videos, making their own compost, and more. The summer camp also provides HBCSE members with an opportunity to try a particular lesson plan with fewer children before it is implemented in a bigger classroom of about 70 children. The lesson plans and worksheets are designed in collaboration with the science teachers.

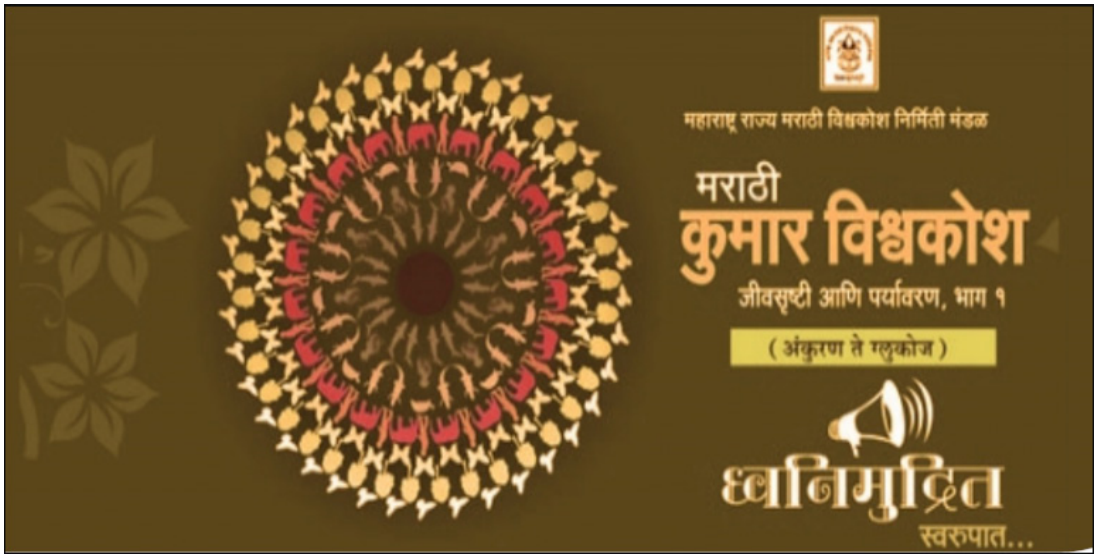
The project has seen an upsurge in children's participation and classroom interaction, especially when environmental aspects are discussed. The children and parents from other classes, which are not involved in the project, have shown a keen interest in using lesson plans, worksheets and activities developed in this project.

These lesson plans, activities and worksheets are currently being compiled to design a teachers' handbook in environmental science for grades 3 – 5 on the basis of the Maharashtra State board syllabus (*Parisar Abhyas*). This booklet covers a wide range of themes, e.g., food, water, our surroundings, family and values, the human body, etc. HBCSE members feel that they can enhance the interaction among children and teachers using this constructivist approach in environmental science education across the state.

Kumar Vishwakosh

Recently, HBCSE and Maharashtra Rajya Vishwakosh Nirmiti Mandal worked in collaboration to design and produce a junior encyclopedia called Kumar Vishwakosh (volume 3) of Jeevasrushti Ani Paryavaran (Biology and Environment). This volume of Kumar Vishwakosh is freely available online. This encyclopedia explores concepts normally taught in grades 9 -12.

A team of HBCSE members and several teachers from Maharashtra have worked on this project since 2007. There will be about 1,100 entries in this encyclopedia and it will be published in four volumes. The descriptions in the encyclopedia are presented in simple and lucid language. All entries are accompanied by vivid colourful pictures and photographs. As an approach towards inclusive education, this encyclopedia is also printed in Braille and is available in audio format.



At HBCSE, while sometimes the material has been produced in Marathi and then translated into English, at other times, it has been the other way around. The number of books sold as well as the viewership of the website suggests that these efforts have a large reach. Thus, HBCSE takes a synergistic approach towards material development and language to improve STME and enable its spread far and wide.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/science-education-in-marathi-at-hbcse

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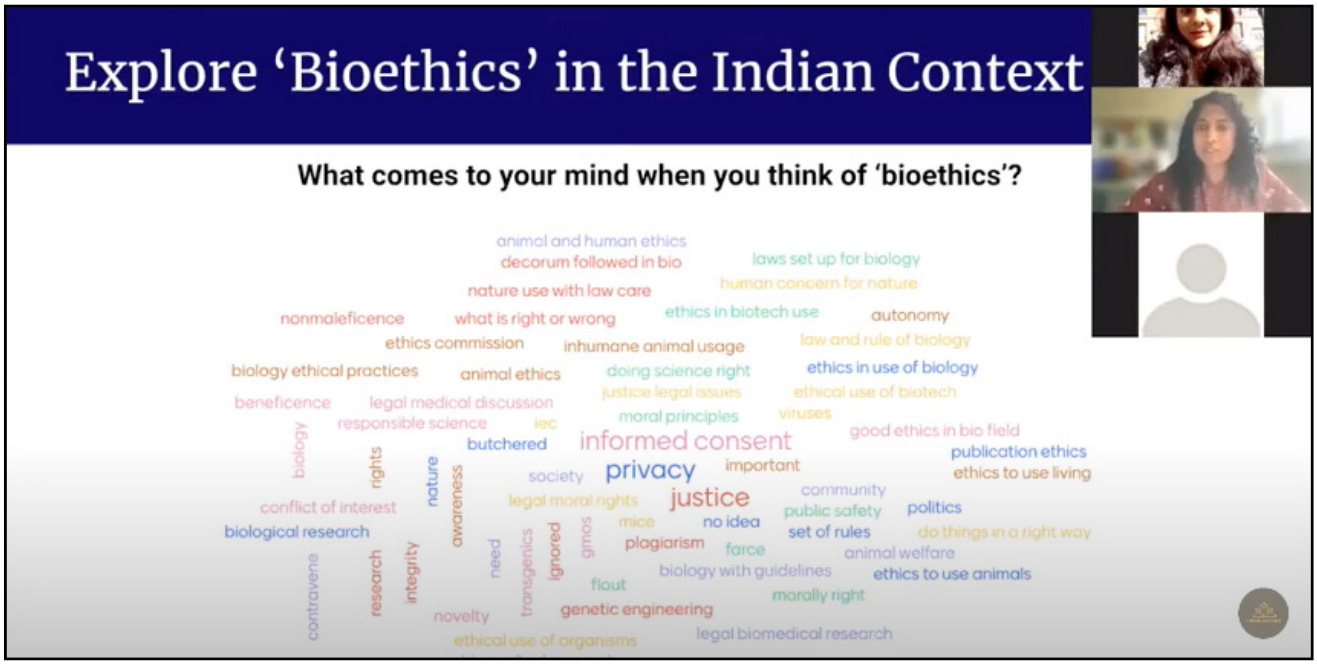
Webinar: Explore bioethics in the Indian context

Author: **Poornimai Abirami G P**
Date of publication: **28 Jun 2022**

Excerpt: **This webinar explores the concept of bioethics, which is value-laden, by using perspectives from social and cultural anthropology, practical ethics, science practice, and policy decisions. The speaker drew examples from the public health realm in India to discuss and observe that 'bioethics' should not be limited to mere protocol compliance but should guide science practice.**



A screenshot from the webinar.

Ethics simply means you shouldn't do something to others that you do not want others to do to you. Treating all living organisms equally, with respect, lies at the heart of bioethics from which all the rules and regulations emanate. Bioethics encompasses clinical, research, environmental and public-health-related ethics. In this webinar, Saveetha Meganathan, Senior Scientist at the Tata Institute for Genetics and Society sheds light on what exactly is bioethics and how to uphold it while executing biomedical research.

With the aid of a few examples from history (the Nuremberg trial and Tuskegee Syphilis experiments of 1945-1946 and 1932-1972, respectively) Meganathan explains how the fence of bioethics has been breached in the past. Also, with the aid of present examples in the Indian context, which includes the cervical cancer screening trial and the Human papillomavirus vaccination program, which took place during 1998-2015 and 2009-2010, respectively at various places in India, she discusses ethics dumping, which involves developed countries making use of the unawareness and lack of properly framed laws in the low-middle-income countries (LMIC) to exploit and execute things that are unethical in their own countries.

According to Meganathan, bioethics shouldn't be a set of inflexible rules, once framed and followed throughout, but rather the policymakers, researchers, clinicians and everyone else involved should have clarity over what forms the core of bioethics and the final conclusions should be drawn via discussion and deliberations whenever and wherever necessary.

To learn more about bioethics, watch the recording of the webinar
https://youtu.be/0miaqeOIz3M

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Webinar: Importance of networking

Author: **Poornimai Abirami G P**
Date of publication: **24 Jun 2021**

Excerpt: **This webinar was an effort to explain the importance of networking for the betterment of education in the country and encourage more educators to venture into this activity. It featured eminent speakers such as Shakila Shamsu, former Officer in Special Duty (National Education Policy), Ministry of Education; L. S. Shashidhara, Dean of Research and a Distinguished Professor at Ashoka University, Sonipat; and Mayuri Rege, DST-Inspire Faculty, Ruia College, Mumbai.**

A screenshot from the webinar.

Networking is a very powerful tool, which can be very beneficial not only to educators but also to the institutions they belong to, their students, and the whole networking community. At the national level, there are numerous steps taken by the Government of India (GOI) to facilitate networking and harness its potential to the fullest extent. In this webinar, panellists Shakila Shamsu, L. S. Shashidhara and Mayuri Rege discuss "the importance of networking". They share their views on and experiences with networking, and offer solutions to the common

hurdles faced by educators in the process of networking.

According to Shamsu, "a network is a community of people who come together agreeing to disagree". She says that networking opens grounds for brainstorming sessions where topics and ideas can be revisited and the final outcome is a blend of ideas from various sources. Inclusivity is one of the major attributes of networking, and treating every individual equally with respect dissolves the invisible barriers while networking, says Shamsu. Though language is currently one of the major hurdles of successful networking, it can be overcome by innovative solutions, like making use of illustrations, images, etc., she says. She showcases the efforts of the GOI to promote networking among educators from different institutes and to make quality education equally accessible to students all over the country with the aid of networking.

Shashidhara too opines that while networking benefits the educator, the major beneficiaries are the students of the educator. While learning how to network from their supervisors, students also enjoy other benefits like sharing equipment, grants, chances to explore how research is done in different parts of the globe, etc. Educators should never refrain from networking and should be proactive about it, says Shashidhara. It should happen spontaneously, whenever and wherever possible, and educators should make the best use of any gathering, not waiting for a proper set-up to form a network, he says. According to him, being open-minded and selfless are vital for successful networking.

While Shashidhara emphasizes the benefits of in-person networking, Mayuri Rege highlights the advantages of networking online. According to Rege, networking can be best compared to travelling. Like travelling, where people get to meet new people and come in contact with new cultures, new ideas, and new perspectives, which later can be incorporated into their own lives, networking benefits us in getting in touch with new people and new ideas. Online platforms like Twitter and LinkedIn are very useful in creating networks and teachers and researchers should make use of them to form their own networks, says Rege. Being original in our approach and knowing what is exactly needed from the person with whom we are interacting are some of the tips for networking effectively, she says.

To know more about the panellists' views on networking and its value to the educational community, and answers to some very interesting questions from the educators in the audience, please watch the recording of the webinar: https://youtu.be/afGjf4r4tDY

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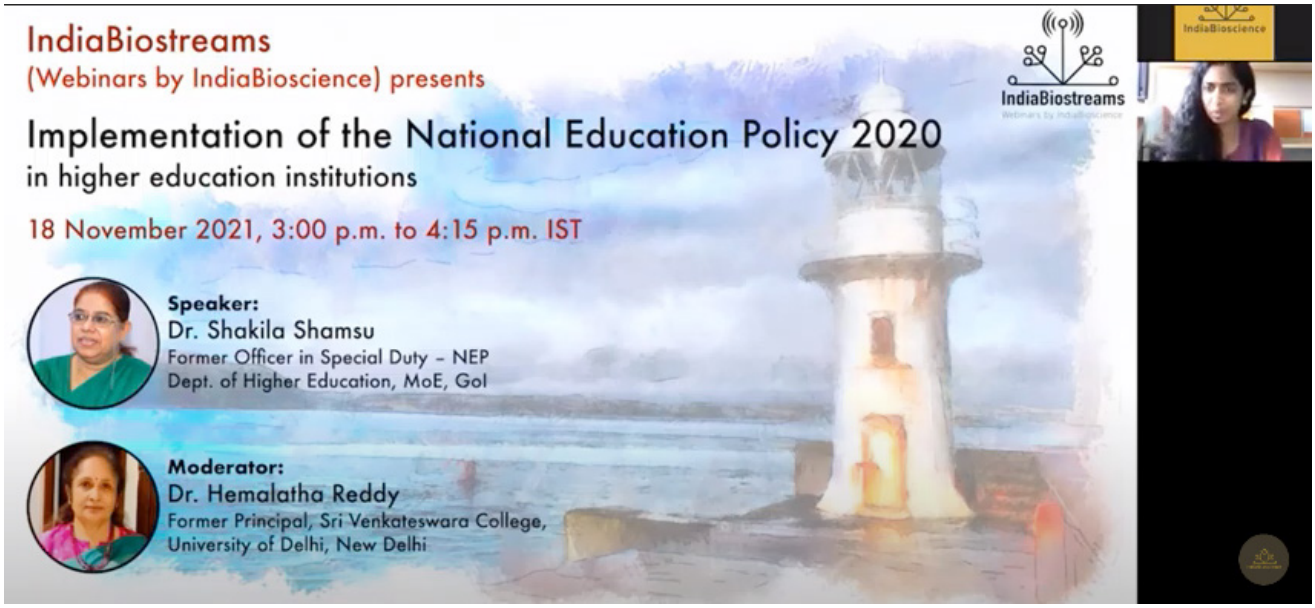
Webinar: Implementation of NEP 2020 in higher education institutions

Author: **Poornimai Abirami G P**
Date of Publication: **18 Nov 2021**

Excerpt: **The NEP 2020 is becoming a reality in several states across India. The challenge now is to find a way to implement it in a practical manner, which puts us on track to achieving its goals of revolutionizing the education system in India. In this webinar, Shakila Shamsu, former Officer on Special Duty (NEP), Ministry of Education, delved into some of the necessary measures and changes for a successful implementation of NEP. The session was moderated by Hemalatha Reddy, former Principal, Sri Venkateswara College, University of Delhi.**



A screenshot from the webinar.

The National Education Policy 2020 has been framed to get the youth of the nation ready to face the challenges of the 21st century, to go through the process of learning joyfully, and to make sure that every individual, irrespective of his/ her background gets benefitted out of the NEP equally. In this webinar, moderated by Hemalatha Reddy, the speaker Shakila Shamsu elaborates on the key points of NEP, the challenges in implementing NEP, and how they could be tactfully overcome.

As Shamsu explains, the NEP proposes changes at all levels of education, ranging from pre-, middle- and high-school to under- and postgraduate levels, as a strong foundation is essential to build higher levels of education. It also emphasizes experiential learning over traditional rote learning methods. Shamsu further describes what the policy envisages at the level of higher education, such as the option of regional languages as the medium of instruction, the academic bank of credits, multidisciplinarity of courses, multiple entry and exit points along a course, and more.

One of the key goals that the policy envisages is the development of MERUs (Multidisciplinary Education and Research Institutions). Speaking about the implementation of this goal, Shamsu notes that though this cannot be achieved overnight, higher education institutions must put efforts to gradually transform themselves into multidisciplinary institutions and that the faculty have a role in achieving this goal. She strongly encourages educators to embrace the idea of multidisciplinarity and shed their inhibitions and biases about their disciplines. She says, "a discipline does not get fossilized when it interacts with other disciplines", and such an interaction is essential for it to evolve and stay relevant over time. For instance, if biology has to stay relevant as a discipline, it needs to understand its ramifications with social sciences, engineering, language, and other disciplines, she says.

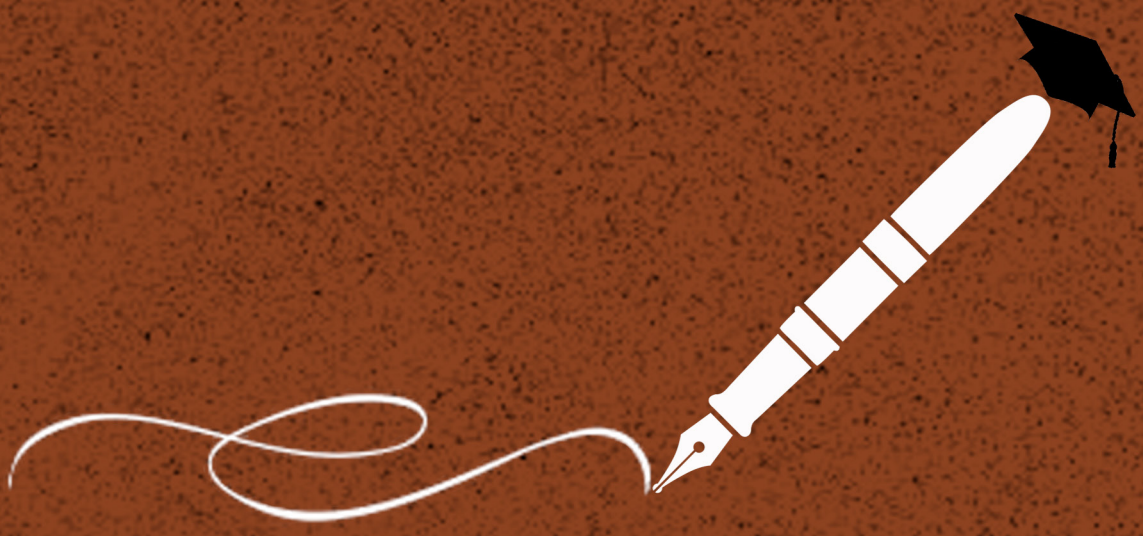
Shamsu also points out the need for students to upskill and reinvent themselves to adapt to the changing needs of the 21st century. This is particularly important in light of upcoming technologies, which may take over some of the jobs that humans are currently delivering, she says. She adds that the teaching-learning process students and teachers engage in should help students develop skills necessary to re-invent themselves, such as communication skills, networking skills, teamwork, and crisis-handling skills. The educators must transform the way they teach in the classroom to facilitate such skills and not merely disseminate information, she says.

To find out what Shamsu says about how small institutes could adopt NEP; how NEP can be brought to life post-pandemic; how pre-planning and time management are key for effective discussion-based learning; how assessment methods should be tailored for the success of the NEP; and more, check out the Q and A session of the webinar.

Please find the youtube link to the entire webinar here: < https://youtube/R00aoT0z_eA>
Also follow the discussion on this topic on our discussion forum: https://discuss.indiabioscience.org/t/national-education-policy-nep-2020/1701

Mental health

Articles and a podcast series discussing mental health in academic environs and proposing ways to de-stigmatise it.



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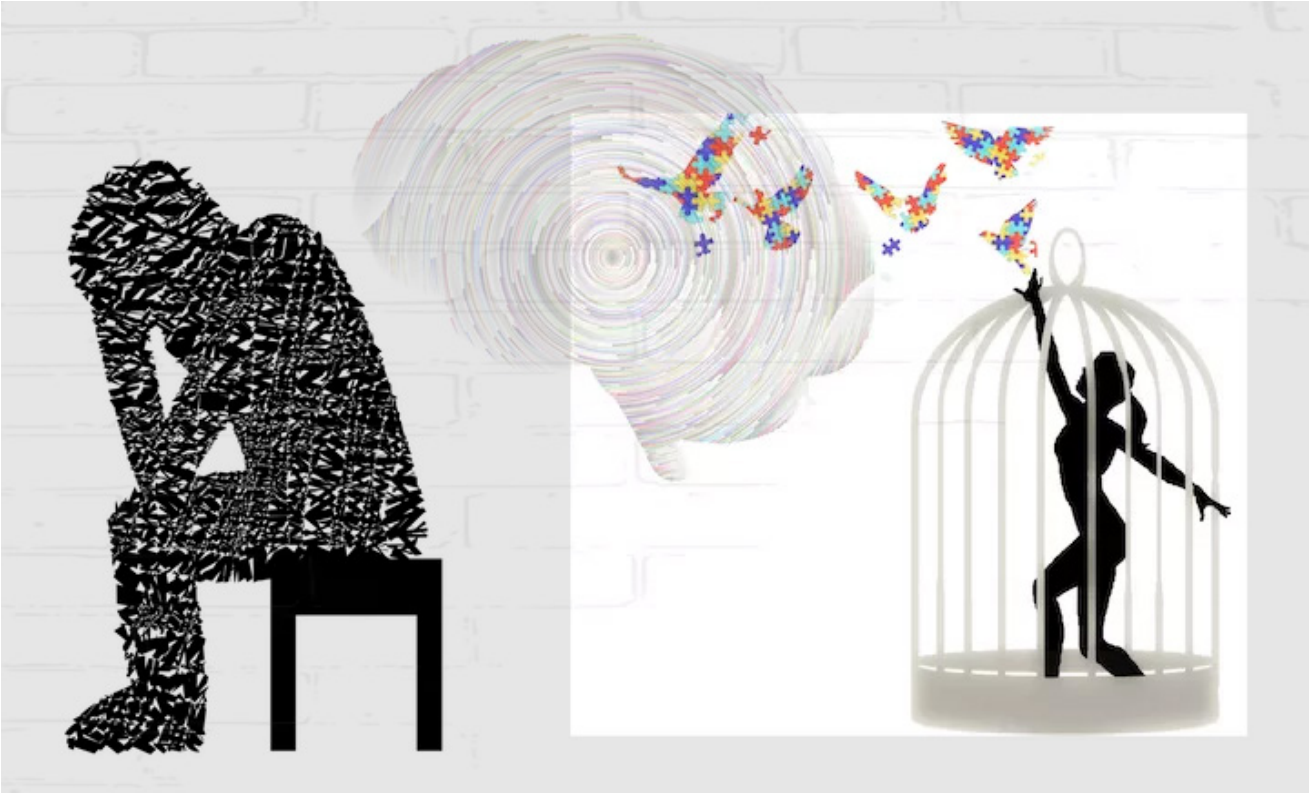
De-stigmatizing mental health care in India: a way forward

Author: **Anushka Banerjee**
Date of publication: **29 Oct 2021**

Excerpt: **The stigma surrounding the term 'mental health' is especially severe in Indian culture, where any deviation from the so-called 'normal' is viewed with a negative pair of lenses. Why do people hesitate to seek help? Are there enough mental health professionals in our country? Is information about mental illnesses easily accessible to the public for them to make informed decisions? What is the way forward? These are some of the issues that Anushka Banerjee, a Junior Research Fellow at the Department of Psychiatry, National Institute of Mental Health and Neurosciences, Bengaluru addresses in this article.**



"Oh, so you work with crazy people, do you? I hope you don't end up going mad along with the rest of them!" chortles a distant relative, upon hearing that I work at the National Institute of Mental Health and Neurosciences (NIMHANS). I sigh and choose not to take his words to heart. Statements like this one are commonplace in

India, where insensitivity, myths and misrepresentations around mental illnesses are a dime a dozen. Talking about mental health continues to be heavily stigmatized in India, where people worry more about what their neighbours will say rather than their doctors. A sharp rebuttal is usually enough to silence self-styled jokers who choose to make fun of people struggling with mental health disorders. But what happens if patients themselves choose not to see a doctor, because of this stigma?

Dhruva Ithal, a clinician-researcher in the Department of Psychiatry at NIMHANS, says that patients are usually extremely hesitant in seeking medical advice for mental illnesses. "Most people are generally unable to muster up the courage to visit a doctor until their situation becomes quite dire. Patients suffering from psychosis (a condition which causes people to lose touch with reality; e.g., schizophrenia) usually approach doctors only when they see their loved ones being affected by their behaviour. Patients with neurosis (a class of mental disorders that is characterized by feelings of distress; e.g., depression or anxiety) are hesitant to see a doctor because they don't believe their problem is serious enough to warrant a visit to the clinic," says Ithal.

Another reason for delays in seeking medical attention may be when symptoms in a patient coincide with gender stereotypes prevalent in our society. For instance, a woman's excessive cleaning (a symptom of someone with obsessive-compulsive disorder (OCD)) or a man's addiction to alcohol may be perceived as 'normal behaviour'. In reality, however, a person battling with addiction cannot stop at will, similar to someone with OCD preferring neatness. Both conditions can be extremely distressing for patients and their families, and require medical intervention. But patients themselves, and people around them, may not deem medical intervention as necessary in such situations (as stereotypes dictate that women should actively keep their households clean, and drinking in men is common).

As a psychiatric social worker at NIMHANS, Anand Jose Kannampuzha has encountered many types of myths pertaining to mental disorders. "People try to 'explain away' their symptoms in different manners. Patients suffering from addiction issues will make excuses for their behaviour, like saying it is 'a way to deal with stress'. Patients with psychosis often believe in spiritual or religious reasons for their behaviour. Some think they are possessed by a supernatural force. Others believe that their families are cursed, and generation after generation will suffer the same consequences when this 'curse' could simply be a heritable condition being passed down from parents to their children," he says.

The idiosyncrasies of select individuals lead to staggering collective consequences. The National Mental Health Survey of 2015 – 16 revealed that "nearly 15% of adults in India are in need of active interventions for one or more mental health issues".

A foundation for public healthcare systems pertaining to mental health has existed in India, but it needs to be further developed. The Government of India introduced the National Mental Health Program in 1982 to develop manpower, modernize departments for mental health specialities in medical colleges, provide aid to upgrade mental hospitals, and set up district mental health programmes.

A comprehensive report from 2011-12 on the state-wise status of schemes shows that many states succeeded in providing citizens with access to psychiatrists, suicide prevention clinics, and counselling. However, several district mental health programmes were shut down after running for a few years. It may have been difficult to recruit trained professionals due to a severe shortage of mental health professionals in the country. In a 2019 letter to the editor of the Indian Journal of Psychiatry, psychiatrists from NIMHANS estimated that there are only 0.75 psychiatrists per 100,000 persons in India, when ideally, it should be between 3 – 5. Findings such as

these, and from the National Mental Health Survey, led to a revamping of the National Mental Health Program, with the introduction of the Mental Health Care Act of 2017. This act aims to recognise and protect the rights of people with mental illnesses. It allows people to make decisions regarding their health, given that they have the appropriate knowledge to do so. It also decriminalized suicide attempts, in order to provide people with opportunities for rehabilitation. Such steps are a welcome option for patients to have a voice in their psychiatric treatment and general mental well-being.

To go forward from here, an important facet is the provision of comprehensive and easily accessible information. Both Ithal and Jose agree that spreading awareness about mental illnesses is the best way to prevent myths from spreading. "There should be primary centres in towns and villages, where people can approach doctors easily," says Ithal. Jose adds, "The reach of social media is incredible. A lot of information is spread even in small places through mediums like films, WhatsApp and Facebook. I think it's important that the correct information about mental illnesses be provided through these agencies." Many people might be unaware of the provision of such programmes and schemes, either due to a lack of information or misrepresentation of mental illnesses in our society. This could be one of the reasons that many of the programs were unable to run long-term.

Addressing the importance of easily accessible and understandable information about current research being done in this field, V. Sowmya, a doctoral researcher in the Molecular Genetics Lab at NIMHANS, says, "I have seen patients being much more open to the idea of treatment once we explain the intricacies of the illness to them and tell them about the research we do. The hope that we may someday be able to treat these disorders using data we collected from them makes them understand the importance of their contributions." She also stressed the need for more qualified healthcare professionals and primary mental healthcare centres in small cities and towns. "It often becomes difficult for patients and their families to travel to institutions like NIMHANS for follow-up appointments, which often leads to discontinuation of the treatment," she says.

It is extremely important that awareness and information about mental illnesses penetrates not just our cities and towns, but also the most remote villages. Pertinent information, access to treatment, and starting conversations about mental health cannot be limited to just metropolitan cities. India is on the brink of a mental health crisis and it is important for government programs, non-government organizations, professionals, and local volunteers to come together and make sure our citizens are informed about what they are experiencing and that help is right around the corner.

Postscript:

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/indian-scenario/de-stigmatizing-mental-health-care-in-india-a-way-forward

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Lessons from a mental health workshop in an undergraduate college

Author: **Charu D. Rawat & Sagnik Das**
Date of publication: **21 Nov 2019**

Excerpt: **An important component of fighting the battle against the mental health epidemic is creating accessible forums to raise awareness. Charu Dogra Rawat (Assistant Professor, Ramjas College, University of Delhi) and Sagnik Das (Student, Ramjas College, University of Delhi) write about a two-day workshop in their college which brought to light many of the mental health-related issues that students face, and allowed them to collectively brainstorm solutions on an open platform.**

Lessons from a mental health workshop in an undergraduate college

While the world celebrates the discovery of life-saving drugs and vaccines for diseases that have claimed innumerable lives, a new broad-spectrum ailment has already taken over the stage of global concerns. This

ailment has symptoms that are hard to diagnose, conditions tough to stabilise, and cures that are completely temporary in nature. This global pandemic that is responsible for over 800,000 deaths every year is "Mental Distress" — a medical condition where an individual fails to realise his/her own potential, cannot cope with the stress posed by daily life and is unable to make a full-fledged contribution to his/her community.

As per the reports of the World Health Organisation (WHO), about 20% of all children and adolescents worldwide are in mental distress. In this era of spine-chilling terrorism, brutal wars and conflicts, failing economies, devastating man-made and natural disasters, and different forms of human rights violations, mental health degradation and its cure is of profound interest to the global community.

Countries like India, with a flourishing population within the age group of 12–30 years, witness some of the worst cases of mental health distress as the youth lies at the centre of most of the problems stated above. Hence, awareness and evaluation of mental health in youth-rearing centres such as schools, colleges, and other educational institutions are of utmost importance.

Realizing this profound need and aiming to enable students to open up about mental health-related issues, The Wellness and Counselling Unit of Ramjas College, University of Delhi, in collaboration with the Department of Biotechnology (DBT) funded Star College Project, Ramjas Chapter (Department of Zoology), organised a two-day mental health workshop in September 2019.

This was one of the first such workshops to be organised in an undergraduate college in recent times. It attempted to shed light on three main mental health topics – (1) *Psychological Capital Efficacy*, which focussed on the realisation of the emotional and psychological potential vested in every individual which is essential for success, (2) *Loneliness*, which discussed the global pandemic of lack of efficient communication among individuals at the personal level and its widespread impacts on one's life, and last but not the least, (3) *The trilogy of mood swings, anger and stress*, which discussed the interconnection between these three issues and how to mitigate them.

The workshop witnessed overwhelming participation with more than 300 participants, including not only students but also teaching and non-teaching faculty, reflecting the dire necessity of such awareness campaigns.

When asked about why they wanted to attend this workshop, some participants stated that they wanted to find strategies for dealing with the stress they have been encountering, some mentioned that they were curious to find out whether they are stressed or not, and some quietly admitted that they were hoping to find others with similar issues who will be sensitive towards them. Some students were enthusiastic about the availability of platforms where they might be able to pose questions that have been troubling them but have gone unanswered as they had no one to ask them to.

Based on the idea that every individual is like a fresh canvas, which they paint themselves, the workshop was named "The Jolly Portrait". It aimed to counter one of the most prevalent stereotypes associated with mental health workshops (that impedes many individuals from attending them) – that they are gloomy affairs. The idea of painting a "jolly portrait" was implemented with sub-events such as "The Happiness Meter" – a fun-filled self-assessment of one's mental health, and "The Wishing Tree" wherein participants wrote their wishes on a piece of paper with an open heart and unfurled them to the world by tying it to a tree.

Navin Kumar, Associate Professor (Psychology), Dr Bhim Rao Ambedkar College, University of Delhi, presented his ideas and suggestions on living with proper psychological capital efficacy. He talked about various mental health challenges commonly faced by students such as peer pressure, fear of not doing well in life, homesickness, dysfunctional families etc., and together with the students tried to identify the key combat areas and probable strategies to 'fight and win' in these. He put forward the need to balance thoughts through conscious efforts, especially when faced with difficult choices (e.g., choosing a career stream or direction, or agreeing or disagreeing with their parents' choices).

B. N. Patra, Assistant Professor (Psychiatry) AIIMS, Delhi, enlightened the gathering on the emerging pandemic of loneliness which flourishes in spite of growing lists of friends on social media. He discussed the impacts and causes of this phenomenon and remedial measures that can be taken against it. He also stressed on the distinction between 'being alone' and 'feeling lonely' so that the participants could voice their inner fears of feeling the latter. The session brought to fore the emptiness that many in the audience felt.

Glimpses from the workshop (clockwise from left: The Wishing Tree, workshop attendees, Naveen Kumar, Saumya Tandon)

Later that day, Soumya Tandon, Associate Consultant (Psychiatry), Sir Ganga Ram Hospital, Delhi, hosted an interactive session on the interconnection between mood swings, anger and stress and possible ways to tackle them. She again gave the participants an open space to present their doubts, dilemmas, fears, reasons for their stress, reasons for their anger, and any other chaos that might plague their minds.

Many of the participants opened up to interact with the speakers and emphasised the need to address such issues with greater affection and maturity. Arunima Das, a student pursuing MA (Political Science) remarked, "The conduct of the mental health event was a really appreciable step. It was a wonderful experience attending it and enlightening ourselves with the much-needed talk of the hour. The topic is either shrugged off with callousness or much worse, romanticised by many, in the meanwhile depriving it of the much-needed attention it demands.

Keeping a check on our mental health is as important as looking for and treating our physical injuries. So, people should come forward with more such awareness programs and events that will be beneficial to us all."

Manoj K. Khanna, Principal, Ramjas College, who believes that physical health and mental health are intertwined and both should be equally taken care of for better productivity, envisages the college hosting more such workshops and regular counselling sessions for students as well as the faculty. He also stressed on the need for greater communication between human beings.

As educators, we interact with a heterogeneous group of young students and witness various facets of their day-to-day struggles while trying hard to balance our own lives. So, in addition to the subject knowledge that we are imparting, we should attempt to nurture a good mental state in students so that they can imbibe that knowledge in a more efficient and useful manner. The workshop provided an apt platform to facilitate this and going by the presentations, interactions, discussions and feedback, we strongly felt the importance and the need for holding more such events to help each other in moving towards building more efficient, unstressed, resilient and happier selves.

The stigma related to mental health is severe and unless mitigated, mental distress shall continue claiming lives bearing enormous potential. The need to open up about one's problems, nurture an effective mindset, and interact effectively and affectionately, are the qualities that the present generation and the posterity must inculcate. Support groups, open discussion sessions etc. are some of the ways for people with mental distress to engage in introspection and mitigation of this devastating ailment.

This workshop has ignited a spark to address the burning issue of mental health with sensitivity and maturity. Hoping to keep the flame lit, the event concluded with the hanging of wishes on "the Wishing Tree"- a humble attempt to understand and communicate with ourselves.

Postscript:

Some of the other articles in the Mental Health Series:

- You don't have to be'crazy' to be doing a PhD!
- Wake up academia, it's a brand new mental health patient
- Sowing the seeds of a long-term mental health study in an Indian population
- Speaking up: Ending the culture of silence

Find related articles on the IndiaBioscience website using this link:
https://indiabioscience.org/columns/education/lessons-from-a-mental-health-workshop-in-an-undergraduate-college

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Mind Matters in Academia – for faculty (a podcast

Date of publication: **21 Nov 2019**

Excerpt: **Mental health is a serious concern in academia, across the world and at all levels of professionals. There is an increasing global push to acknowledge and bring discussions on mental health to the forefront ('out of the closet'), and seek and share individual and collective solutions to support and promote the mental well-being of academic professionals. Taking the initiative to create awareness and de-stigmatize mental health will be vital to making science in India a more inclusive and supportive place.**

This discussion addressed issues around mental health, particular those that are relevant to early and mid-career faculty. Featuring Sandhya Visweswariah, Maitrayee DasGupta, Imroze Khan and Hansika Kapoor, this discussion was moderated by Karishma Kaushik and Mayuri Rege.

MH-02 | Mind Matters in Academia - for Faculty | Part 1 of 4

In part 1 of this conversation, the panellists and moderators talk about the challenges faced by a new Principal Investigator.

MH-02 | Mind Matters in Academia - for Faculty | Part 2 of 4

In part 2 of this conversation, the panellists and moderators talk about the challenges faced by a new group.

MH-02 | Mind Matters in Academia - for Faculty | Part 3 of 4

In part 3 of this conversation, the panellists and moderators talk about challenges around 'research funding' and 'organisational culture'.

MH-02 | Mind Matters in Academia - for Faculty | Part 4 of 4

In part 4 of this conversation, the panellists and moderators discuss barriers to getting help.

Please find the link to this podcast here:
https://indiabioscience.org/indiabiospeaks/mind-matters-in-academia

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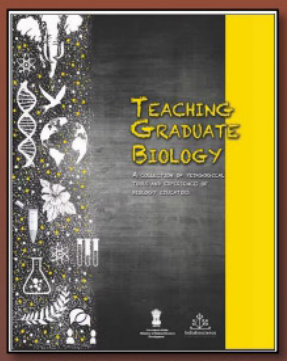

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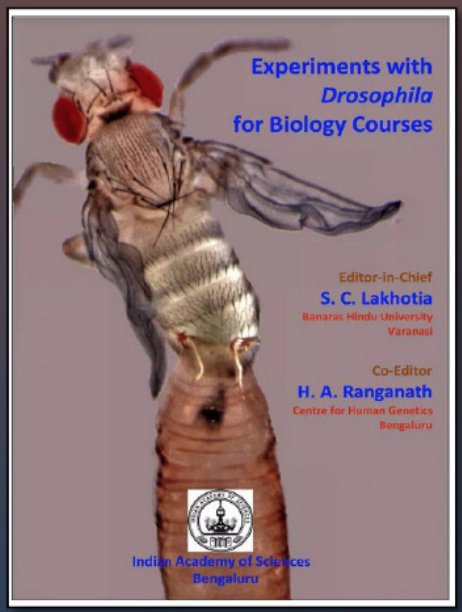

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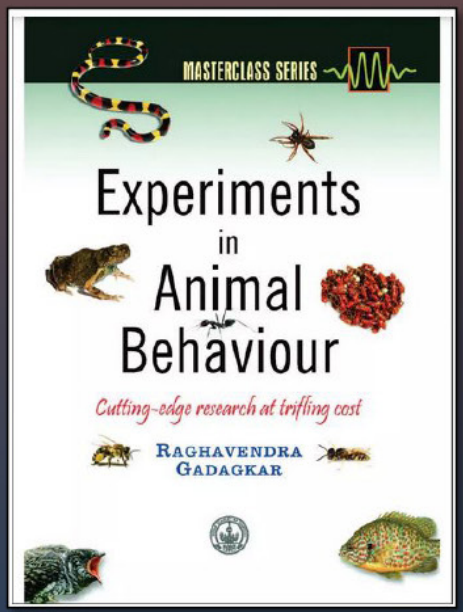

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