INTERVIEW WITH PRAGYA NOPANY

Pragya Nopany has taught higher secondary physics for 25 years at Birla Vidya Niketan, New Delhi. Her passion to teach and the innovative ways of her teaching have earned her numerous recognition and awards, the most recent one being the prestigious National Award for Teachers - 2017 by the Government of India.

She continues to share her experiences and expertise through different platforms such as Anveshika, which is an Experimental Physics Centre established by the Indian Association of Physics Teachers to provide a base for generating interest in experimental physics in young students upto +2 level through learning by doing.

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What made you choose physics as your subject?

I fell in love with physics in my school days because my cousin Vasundhara showed me very intriguing and fun activities whenever she visited us in the summer holidays. The interest made me pursue my higher studies in physics at BITS, Pilani.

What and who motivated you to become a teacher?

Mrs. S Muttoo, my Hindi teacher, was also my class teacher in Class VIII. The way she saw in me something that I could not see in myself, how she invested her time, energy, and effort in my growth – I think that motivated me indirectly. A story on this was published in the September 2009 issue of *Reader's Digest*.

And then, I come from a family of excellent teachers, social reformers, and freedom fighters who were deeply interested in and committed to the overall growth of children, youth, and society.

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

A teacher is someone who ignites the minds and puts the learners on a path of self-learning. A quote from Sadhguru best describes my idea of a teacher: A guru or true teacher is a doorway through which a learner can walk into any room of their choice and explore.

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

I have always been driven by the challenge – what can a student do after my class, other than just passing an exam? This has made me look for strategies to develop a culture of thinking and learning by doing. Designing multidimensional learning strategies, innovative demonstration activities, and collaborative learning platforms have been my interests.

In 2012, I established the Delhi chapter of Anveshika – a unique platform of the Indian Association of Physics Teachers (IAPT) operating under the national coordinatorship of the renowned Professor H C Verma – at my school Birla Vidya Niketan. This enabled us to build a network of teachers and schools willing to change the way science, especially physics, is taught in the classroom. We designed activities and experimental challenges and organised multiple stage shows, competitions, training for teaching-learning of physics through low-cost activities in Delhi-NCR. The tremendous response to this programme made it a movement in the region as more and more teachers and students became eager to participate. Over the years, enhanced internet connectivity enabled us to expand our programme to other states of the country.

In physics, I am especially proud of designing the following:

(i) Drawing of 2-dimensional equipotential curves on *atta roti*. I was awarded by IAPT for this innovative activity.

(ii) Choose your hurdle—an optics-based competition where a laser beam is to be taken from point A to point B but not directly. Multiple hurdles involving multiple optical phenomena are to be introduced on the way, and therein lies the challenge!

(iii) A shadow-play competition where students must interpret the following lines, write a screenplay based on their interpretation, enact it as a shadow play on stage, and use at least one indigenously designed light source during the presentation.

There was a lady called Bright.
Who could travel faster than light
One day she went for a walk in a relative way
And came back the previous day!

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

The best way is to engage with students at a personal level, discover their interests and strengths, and then build on them through innovative challenges. Giving them space and time to explore themselves individually and collectively, nurturing their strive towards excellence by constant constructive feedback, and cultivating an attitude of using failures as stepping stones to growth—these go a long way in building a relationship of trust. Once this trust is built, the students and the teacher

become co-travellers in solving challenges and driving learning.

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

Oh, ask me what I have not learned! I think what I have learned is best described in this self-written poem:

I sat down to write
And asked myself
"why do they call me an excellent teacher?"

My mind said
- because of your knowledge of the subject.
But my heart said
- because of your love of children.
And then I heard my soul speak
It said- it's your faith.
Your faith in innate goodness of the children
Your faith in uniqueness of each in the human ocean
Your faith in the adventurous spirit of the young!
Your faith in the power of human endeavour!

I laughed at my soul and said
"Oh my good soul, where would I be
without your unending faith in me!
But isn't excellence a pursuit, a journey?"

It has been so exhilarating
to open young minds to possibilities...
It has been so humbling
to say 'I don't know the answer to that one'!
It has been so thrilling
To find the answer to 'that one'!
It has been so glorious
to see the 'weak' rising like phoenix from the ashes of disastrous scores!
It has been so satisfying to investigate,
to venture into unknown.
It has been invigorating to cross frontiers
and to make new ones.

It has been so good to laugh with the class and to be laughed at!

It has been so rewarding
to see quality emerging from unacceptable work!

I am a teacher because
I have a debt to repay.
The debt of a teacher
who saw in me
what I could not see in myself.
I would consider my debt repaid in full
if I can find a hidden spark
in each child
and help him to do the best
what he enjoys doing the most!
Would I then
'become'
An excellent teacher?

My most valued learning: Human potential is unlimited and continues to throw surprises.

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

In the year 2017-18, I was teaching physics to a biology section of Class XII in which most students did not pursue Maths as a subject. Their scores in the examination were abysmal, and I was dejected and at my wit's end as to how to improve their performance. During this time, I chanced across an article about 'Foldscope' – a paper-folding microscope designed by Manu Prakash at Stanford University. I wrote to Mr Prakash requesting him to send one piece; he sent 20 of them free of cost. I gave 10 of them to some of the bio students to use for exploration. The students came back with great observations, e.g., videos of pollen and micro-organisms in water magnified 240 times, the likes of which I had never seen. I thought the students deserved recognition for their work, but I also wanted them to use this for further growth. So, we organised an interschool students' workshop in which my bio students were the volunteers – they guided the participants from

other schools as to how to collect samples, how to fold the paper-folding microscopes, how to mount on mobiles, how to prepare slides, and video record the observations. It was a workshop for the students, by the students! It received all-around appreciation. Soon, the event was forgotten.

Come the year-end. To my utter surprise, where I had expected at least 12 students to fail, not only everyone passed, but the average class score in physics was 80per cent ! Moreover, when I called to find from some of the weakest students how they had managed such scores, their reply brought tears to my eyes – it was the 'Foldscope' workshop that transformed their perspective, they felt empowered individuals who could reach new frontiers. I had no idea that this small effort could make such a difference.

It touches my heart to think of the amazing transformation the students chose to bring about in themselves, little imagined when I got the 'Foldscopes' from Manu Prakash!

It taught me never to underestimate the potential of an individual and to respect the choices individuals make and commit themselves to. It only makes me think about what can I do to help a striving individual.

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

Urgent attention is required in making each educator have a vision – a vision that their role is NOT to merely explain but to ignite! I'm indebted to Professor H C Verma to give me this vision.

And then how to translate this vision into an action plan – a plan with clear identification of learning outcomes of a science lesson, practices that will enable those outcomes, and transfer of knowledge.

For physics education, how to take physics education from fear to fascination. Teachers' misconceptions in physics need to be taken up urgently. I offer my efforts through programme like 'Misconceptions in Newton's Laws of Motion,' which has been conducted online in 13 states so far and continuing.

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

Yes, I am constantly engaged with popularising science and physics through various stage shows, competitions, lectures, and webinars.

'The Story of Pendulum Clock' is one such programme – not many people know how a humble thread and a bob changed the fortunes of empires, changed the norms of societies, forever changed the way science is done!

'From Fear to Fascination' is a demonstration-based programme that endears students to physics.

'Motion Magic' is another much-liked programme that makes senior students look at motion in new ways, beyond just the equations of motion.

'Teaching Science through Stories' is yet another programme.

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

Staying connected with a large number of teachers and students, identifying their difficulties, and designing programmes to help them. Seeing their joy is motivating.

Challenging myself to new learning by accepting unusual assignments and discussions and training with stalwarts of physics and education – Satsang in short!

INTERVIEW WITH NINGMAREO SHIMRAY

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Ningmareo Shimray began his teaching profession in mathematics in 2002 at Alice Christian Higher Secondary School, Ukhrul, Manipur. In 2007, he was appointed as Science Graduate Teacher by the Government of Manipur. He was promoted as Lecturer in 2019 and is currently teaching mathematics and English pronunciations. He has received several recognitions and awards for his contributions to improve teaching-learning in mathematics which includes the National Award for Teachers - 2021 by the Government of India.

What made you choose mathematics as your subject?

Mathematics was my favourite subject right from my childhood days.

What and who motivated you to become a teacher?

I started giving home tuition while I was stuyding Class X. From then on, I was teaching mathematics throughout my academic career. I was earning and learning at the same time. And I found immense satisfaction in teaching the subject. When I looked back, after getting a government job as Science Graduate Teacher in 2007, I discovered that I was already in the teaching profession for the past more than ten years. Those long years of teaching experiences helped me to be an effective mathematics teacher.

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

Today's students are the future pillars of our nation; today's teachers are builders of our nation.

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

of teaching methods or teaching-learning materials.

In 2018, I developed a new strategy: Teaching and Learning of Mathematics for Standard I to XII. The strategy was a paradigm shift: from teaching the students how the mathematical problems are solved to teaching the students how the mathematical problems can be solved by themselves. In this strategy, firstly, the students are taught to write well (both Arabic numerals and alphabet), write fast, calculate fast and basics of mathematics (according to the standard of the students, before lesson's transaction) and then only after that the teachers start lesson's transaction in such a way that the students can solve mathematical problems by themselves.

I have recently discovered a new number system: BI-Quartet number system, which enhances the speed of calculation and also highly simplifies the calculating process of all the existing operations: addition, subtraction, multiplication, and division. The discovery of the new number system is nothing short of a major breakthrough in learning mathematics. The new number system will enlighten and assist slow learners in overcoming many hurdles and greatly enhance fast learners' performance. At present, the new number system is applied in the following areas of mathematics: 1. Addition, 2. Times tables up to 9 digits. 3. Multiplication.4, Subtraction. 5. Division. 6. Identification of prime numbers between 1 and 100. 7. Test of divisibility by prime numbers between 1 and 100.

In early 2019, I conducted a series of experiments and found that the main hurdle of learning mathematics of any standard is the lack of reading skills. Later on, I found that the lack of reading skills is the main hurdle in teaching and learning of any subject/ language of any standard and that the only way to overcome this hurdle is to learn pronouncing skills.

Towards the end of 2020, I developed the Concept of Sub-syllables for English Pronunciation which is a non-phonetic language. The concept of sub-syllables is a new system for learning English pronunciation efficiently. It has enabled us to pronounce every word in English dictionary correctly and efficiently. It indicates the silence of sounds while pronouncing some words. It identifies different words having the same pronunciation and different words with similar pronunciations. Significantly, it has enabled to write the spellings of all the English IPA. Currently, I am teaching mathematics and English pronunciation side by side, and the students are making remarkable progress in learning mathematics.

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

Everything around us contains mathematics. We have to teach mathematics to the students in such a way that they find the imparted knowledge useful throughout their lives. The most important motivational factor for the students in mathematics learning is to score 100 per cent (by the fast learners) or at least pass-mark (by the slow learners) in the mathematics test/examination. So, we have to set the test/terminal examination questions so that every student gets at least a pass mark, and some get 100 per cent. The standard of question pattern should be

gradually upgraded in accordance with the performance of the students in the classes.

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

The way I write (handwriting), teach (methodology), and speak (pronunciation) are reflected in the students' performance in the classes and tests/examinations. To bring about progressive change in our students, the teachers need to change first. For the last more than 20 years of teaching mathematics, I have been continuously trying to improve the technique of teaching the subject, which culminated in the development of a New Strategy Teaching and Learning of Mathematics in 2018, the discovery of a new number system: Bi-quartet Number System in 2019 and development of the Concept of Sub-syllables in 2020. A teacher should never stop developing new teaching techniques that are relevant to changing times and circumstances. As for me, every mathematics class is a competition for the students and an experiment for the teacher.

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

Every year on Teachers' Day, it reminds me of my past students who are now doctors, engineers, bureaucrats, and those leading successfully in various professions, which gives me immense joy and satisfaction for being their teacher. No one else can give/take away this experience of joy and satisfaction from me.

Kindly suggest some areas where you think your district/state/country needs attention concerning mathematics education.

Mathematics is a number game involving symbols and figures, and the students can only learn mathematics efficiently by performing activities. The current mathematics textbooks for Classes I to V lack the main essence of learning mathematics efficiently. I would like to point out some flaws and inadequate methods in the Class VI mathematics textbook. Regarding the test of divisibility by 4, the book says 'a number with 3 or more digits is divisible by 4 if the number formed by its last two digits (i.e., ones and tens) is divisible by 4'.The statement is inadequate because it does not cover the test of divisibility by 4 of one and two digits numbers. Similarly, the statement of the test of divisibility by 8 is inadequate. Explanation of the identification of prime numbers between 1 and 100 in Class VI (which is absent in higher standards) is inadequate. The only test of divisibility by the prime numbers 2, 3, 5 and 11 are explained (which is absent in higher standards). In learning mathematics for Class VI and above, the identification of prime numbers between 1 and 100 and test of divisibility by prime numbers between 1 and 100 play vital roles. By applying the prime factorization method, the students can quickly identify prime numbers between 1 and 100, and by applying the new number system, the students can easily test the divisibility by prime numbers between 1 and 100.

I would like to suggest that the basic concept of the set be introduced right from Class I so that the students can learn the number system very easily.

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

I was the Secretary of Longyo Education Trust, Ukhrul, which conducted District Level Open Mathematics Competition in collaboration with the district administration consecutively for five years till 2019. Each year, around 800

students of Classes V to X participated in the competition. As a result, there was a visible improvement in students' performance in mathematics subjects.

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

1. I always try to improve my technique of teaching mathematics and English pronunciation.
2. I apply both my head and heart in teaching mathematics to the students so that the students can learn mathematics with both head and heart

Opinions of stakeholders

Teaching and Assessing Mathematics through Problem Posing: The Key Concern for School Curriculum

Mathematics is acclaimed as an essential school subject. It gives increased emphasis on the use of puzzles and games to mathematize students' thinking. This facilitates in promoting greater critical thinking, evidence-based thinking, problem-solving, and other Higher Order Thinking (HOT) skills among young students. All students must learn these skills and competencies to lead their life successfully. Problem-solving is inbuilt in mathematics. In school, mathematics problem-solving is done in various forms like completing practice problems, unit exercises in textbooks, etc. However, mathematics problem-solving deals with situations asking for data and information rather than posing tasks. Therefore, there is less learning opportunity in problem posing of real-world based, leading towards problem-solving in mathematics. As a result, students are not oriented to learn how to understand problems and apply their knowledge and skills to solve problems to increase their process of mathematization. Problem posing has been recognized as a vital step of problem-solving (Singer, F. & Voica, C.,2013). However, in contrast to the importance of problem-solving in school mathematics, problem-posing has been far less noticeable in mathematics textbooks. Problem posing, the process of formulating problems based on a given situation, is a critical cognitive skill that can promote HOT skills needed for 21st-century students. Therefore, problem-posing should be embedded in school mathematics curricula and practice to bring conceptual understandings of mathematics. Moreover, 21st-century skills in mathematics have always required posing real-life and significant problems.

Singer, F. and Voica, C. 2013. A problem-solving conceptual framework and its implications in designing problem-posing tasks. *Educational Studies in Mathematics*. Vol. 83, No. 1. pp. 9–26.https://doi.org/10.1007/s10649-012-9422-x

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Empowering Students through Environmental Science Education

Hands-on, engaging science education can empower students at all levels. They gain new knowledge about the world around them, new confidence in their ability to answer questions through data collection, and new professional skills that can translate to a meaningful career. When educators infuse environmental topics into their science education instruction, additional possibilities for empowering students arise. The knowledge students acquire might help them evaluate the effectiveness of different solutions to environmental problems in their communities. Students can also gain the confidence, motivation, and skills necessary to implement those solutions. Just understanding the problem is not enough. At a time when young people are faced with a myriad of ecological, social, and economic challenges, discovering that through science, they can make a difference is very powerful.

Yet how will educators and administrators know whether infusing environmental topics into science education does indeed have an added value for students? First, assessments are needed that do more than measure scientific knowledge and laboratory skills. By gathering data on environmental attitudes, views on science, motivations to act, and civic engagement, educators can document the impact of their environmental science instruction. Assessing change over an extended period or long after instruction has occurred can be particularly valuable. Students may need time to integrate information, alter attitudes, and turn motivation to act into new behaviours. The time spent on these assessments does not need to be for the benefit of the teachers alone, although they do need to document outcomes and find ways to improve. K-12 students can be empowered through assessment, too, as they discover what they have learned and how they have developed through environmental science instruction. A win for all involved.

Numerous studies have documented the benefits of environmental education. To learn more, see the following two recent open-access review articles.

1. Ardoin, N. M., Bowers, A. W. Roth, N. W., and Holthuis, N. 2018. Environmental education and K-12 student outcomes: A review and analysis of research. *The Journal of Environmental Education*. Vol. 49, No. 1. pp. 1–17. https://doi.org/10.1080/00958964.2017.1366155
2. Kuo, M., Barnes, M., and Jordan, C. 2019. Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Frontiers in Psychology*. Vol. 10, pp. 305–305. https://doi.org/10.3389/fpsyg.2019.00305

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Conceptualising the School Science Curriculum: Some Reflections

What knowledge should constitute the school science curriculum, and what should not? What kind of content and representation should be given in the science textbook?

Would the content be in the form of a presently accepted view of the scientific concept or an exploration of the concept, considering that scientific knowledge is dynamic? Should both success and failure stories, with arguments related to the past political and sociological contexts, be shared with learners as part of historical inquiry of scientific concepts? What should be the pedagogic considerations? Questions such as these often form the basis of the thought processes of teachers and teacher educators. It is well understood that the science curriculum needs to develop scientifically, technologically, and environmentally literate persons who possess a repertoire of competencies that are important in the light of 21st-century skills. Also, many writings, such as those of Driver, et al. (1994), suggest that school students should learn science as the scientific community practices it. The NCF (2005) focuses on the need for a science curriculum that is more valid and more motivating. Looking through another lens, it is seen that the works of several philosophers of science, including that of Allchin (1999), point out that scientific knowledge is not entirely objective as modern science represents it, but it is socially and culturally embedded. In this light, indigenous knowledge would need to be integrated into the science curriculum. Further, the science curriculum cannot distance itself from social questions and issues of social justice and ethics; therefore, these need to lie at the heart of inquiry in science in schools (Levinson, 2017). Finally, the curriculum should enable learners to connect science to their experiences as lived. It may be asserted that the call is for an 'evolutionary' model of science teaching-learning that draws together thinking about the history of science and the developments in the nature and philosophy of science over the past several decades. This would perhaps be a step towards an alternative, leading to a somewhat more 'authentic' science curriculum.

Allchin, D. 1999. Values in Science: An Educational Perspective. *Science and Education*. Vol. 8, pp. 1–12.

Driver, R. et al. 1994. Constructing Scientific Knowledge in the Classroom. *Educational Researcher*. Vol. 23, No. 7. pp. 5–12.

Levinson, R. 2017. Realising the School Science Curriculum. *The Curriculum Journal*. British Educational Research Association 10.1080/09585176.2018.1504314.

NCF 2005. National Curriculum Framework, NCERT.

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