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Special Theme

Physics Education Research - The Time is Now!

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Abstract. The main objective of this article is to provide insight into the field of Physics Education Research (PER) for readers who may be unfamiliar with it. My journey to graduate school after a 30-year career as a physics educator in India, where I established a home laboratory for designing physics experiments and conducted workshops for students and teachers, plays a central role in this narrative. Given this background, this article is, in part, a story of my lived experiences and personal evolution as a student, teacher, and now a researcher.

PER has now emerged as a distinct sub-field of Physics, drawing upon well-established methods of Educational Research. It is well-documented that adopting research-based strategies to education enhances learner experience in addition to furthering students' academic success.

There exists a compelling need for physicists to engage with PER. This imperative extends to both educators, who primarily teach, and active researchers in the field of physics. Physics educators at various levels, from schools to universities, should continually reflect on their teaching methods, evaluate curriculum designs, and develop effective assessment strategies. In this context, I have labored into my own experiences, and elaborated on issues which physics educators may generally confront.

Furthermore, it is important to formulate policies to encourage school and college teachers, curriculum designers, educational institutes, policy makers in the government, and other stakeholders to collaborate and evolve systems that would improve the teaching-learning process.

Promoting specialized research within the field of education, particularly focusing on specific disciplines, and concurrently establishing valuable and pertinent professional development avenues for teachers can significantly boost the skill development of the nation's STEM workforce in the 21st century.

1. Introduction

It is a fascinating coincidence that I was invited to contribute this article just when I commenced journey in Physics Education Research (PER) at Purdue University. My association with APT dates to early 2015 when I first attended (late) Dr. S.V.M. Satyanarayana's Theoretical Physics lecture series. I have always regarded APT as a trailblazer in pushing the boundaries of physics education, and it is an honor to share my experiences and thoughts

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here. Considering APT's reach across students and teachers in Kerala and beyond, I believe the initiatives of APT would mark a turning point in the country's efforts towards improving physics education.

In the United States, where I currently reside, PER has moved far from being viewed merely as a nascent and nebulous research area. PER has fast evolved into yet another highly regarded sub-field of physics, so much so that many universities have departments specializing in PER. Some - including mine - even have 'laboratories' allocated to them. The Physics department here at Purdue University awards a doctoral degree in PER, which I hope to obtain in about two years from now. It is worth noting that a PhD student in PER must meet all the requirements expected of a physics doctoral student specializing in areas like Atomic Physics or Quantum Computing. The difference lies in the research thesis, which focuses on Physics Education. Pursuing a PhD in PER does in no way mean a dilution in the content expertise that is expected out of a physics doctoral student. Though there is ample evidence that PER has had a positive impact on physics departments in this part of the world, there is also the humbling realization that there is much work ahead. Educators here are continuously innovating and introducing new practices into the classroom while also assessing the effectiveness of existing ones. It is worth sharing an unforgettable quote, the source of which I am unable to recall but have carried with me for several years:"In education, one can never stagnate. You either move forward or fall behind."

I am least surprised that APT has taken this important step towards gathering, and reaching out to, an audience for PER. The highly intense theoretical physics workshop-series, coupled with the several experimental ones it had launched way back in 2014 would, in all probability, be the first ever in India. APT has an assembly of renowned and inspiring teachers to lead these workshops, and I am certain that APT will benefit greatly from their insights and guidance.

About a year ago, in his Independence Day speech, the Indian Prime Minister emphasized the importance of innovation and science, rallying behind the slogan 'Jai Anusandhan, Jai Vigyan.' It is to be appreciated that APT has set the ball rolling for innovation in physics education by selecting PER as the theme for this edition of its magazine. I would urge APT to follow up on this edition with a series of workshops, discussions, and talks on PER. Perhaps an online discussion on a few journal articles on PER could be a good starting point. The good news is that PER is well established in many parts of the world. Schools and colleges can adopt many of the successful practices, by making suitable modifications as may be locally relevant, and study if similar strategies yield desired beneficial outcomes. Teachers could start out, in their own small way, by trying out new methodologies in their classrooms. I am sure, as people start experimenting and gain confidence, a movement towards PER will take shape.

2. My experiences as a student

By and large, at least from my personal experience and observation, physics education in India has a skewed emphasis on rote learning, for perhaps purely historical reasons. The predominant mode of instruction relies on standard textbooks and lectures, with laboratory experiments often stuck in traditional, cookbook-style approaches. There is inadequate focus on problem-solving and critical thinking, except perhaps at a few select universities.

During my university days, teaching primarily revolved around lectures, with limited meaningful student engagement. One notable exception to this approach was that of my teacher, (late) Prof. Ananthan (Founder and President, The Physics Society, Chennai), whose influence played a pivotal role in shaping my journey in physics. Most teachers struggled to infuse vitality into the classroom. Examinations often relied on memorization, with the syllabus closely resembling past exam papers. The laboratory experiments were rarely aligned to the theoretical concepts that were discussed in the class, so much that the laboratory experience seemed to be designed for an entirely alien subject. I vividly remember my bewilderment during my first-year undergraduate course while performing the meter-bridge experiment. I had no clue why one may have to move the 'jockey' along the wire or why the galvanometer magically showed zero upon moving the jockey to a particular point on the wire or when and why the plug in the high-resistance box may need to be plugged in. When I inquired with the laboratory professor about the intricacies of that experiment, all I could elicit was the dispassionate response: "you will learn in your final year course." Rather than enjoying laboratory experiments, my friends and I were intimidated by the potentiometer and spectrometer. And to add to our misery, we never knew how to trouble-shoot, nor did we get the 'expected' results. We soon learnt that all one had to do was 'massage' the results so that the professor would 'sign' the lab report. These experiences date back thirty years, and I sincerely hope the situation has improved since then.

Though it may be argued that my concerns (or perhaps, lamentations) are based on a few isolated instances of personal experience, it would only be wishful thinking if we were to brush them aside. Let me hasten to add that I am not trying to lay the blame on those involved in the business of instruction, but it would not be honest if we thought all is well. We are all part of a system, and we are very much a part of the problem. The solution, naturally, has to come from within the system. In recent times, I have heard that improvements have occurred in some colleges and institutions, but widespread scaling of such efforts is essential to reach more schools and colleges. With progressive organizations like the APT, I can already see a silver lining in the cloud.

One area which needs to be seriously addressed is academic freedom, or should I say the lack of it, for teachers. One of my former students - now a professor at one of the IITs in India - expressed concerns about the excessive course load, leaving little room for meaningful discussions between students and teachers in the classroom. I suspect this is not an isolated situation. Many researchers who have experienced education abroad and returned to India are enthusiastic about contributing to the education system but often encounter rigid constraints. Universities must offer educators greater flexibility to modify content and embrace alternative teaching and assessment methods.

Though it may be argued that centralized systems have the advantage of ensuring uniformity in standards across a country as large as ours, they can stifle innovation due to their lack of flexibility. I firmly believe that there is some room for a middle-of–the-road approach which not only ensures a fair degree of uniformity, but also encourages teachers to experiment depending on what, and whom, they need to teach. It is time for a constructive debate among the various stakeholders to look at local issues and problems - of which our country is never short - and strategize for both the short and long terms. Though there do exist several institutions which are in charge of ringing in improvements, what is perhaps missing is a national vision. It is time to take serious efforts to raise the standards of teaching. Fortunately, the methods of PER have been implemented successfully in many universities worldwide, and we may not have to start from scratch.

3. My experiences as a teacher

I consider myself fortunate to have crossed paths with Prof. Ananthan early in my life. It is only natural that my teaching approach has been heavily influenced by his methods. Along my journey, I have also adopted and, I must admit, quite shamelessly borrowed strategies from various other educators.

My initial teaching role was as a Physics and Math teacher at Padma Seshadri Bala Bhavan Senior Secondary School in Chennai, where I dedicated six years of my career until 2004. Subsequently, I spent seven years at the American International School in Chennai, where I not only taught physics and math but also middle school chemistry and biology. Both schools placed a strong emphasis on professional development, affording me the opportunity to attend numerous workshops in India and abroad. These workshops proved more enlightening than my obligatory two-year Bachelor's Degree in Education (B.Ed) . They brought a breath of fresh air that was sadly absent in the B.Ed. course.

One particular workshop, organized by the Australian National University in 2000, inspired me to start designing"hands-on" experiments using easily accessible materials. One of my early explorations was into the physics of toys, an idea suggested by a colleague who happened to be an English teacher. What began as a hobby ultimately led me to set up a physics laboratory. My current teaching approach predominantly follows what could be termed a"demonstration-based lecture." In my view, physics is inherently an experimental science, and I am not particularly fond of 'virtual experiments' conducted solely on computers (why?). I believe teachers should be encouraged, and if necessary, trained, to construct their own apparatus using readily available materials. The internet is galore with several textbooks and videos which teachers must make use of to design their own contraptions. In his 1881 annual report as Superintendent of the Public Schools of Boston, Mr. Seaver states: "A true scientific spirit enables one to achieve much with minimal tools; however, if one's efforts are merely routine, even the finest equipment will yield limited results."

It is sad, but true, that many students perceive physics as a 'mere cram subject'. Teachers must investigate the factors contributing to this perception, which is, unfortunately, not a favorable one for one of the fundamental natural sciences. Mr. Seaver, in another part of his report, exclaims with concern: "How many of our textbooks begin, not with the suggestion of concrete illustrations, but with abstract definitions, and still more abstract 'first principles', - blind guides to the blind teacher, and sources of perplexity to teachers who are not blind." Similar concerns were voiced by Alfed P. Gage in his 1888 book, 'Elements of Physics': "Why should the pupil so frequently, to his great discouragement, be called upon to break through a wall of such difficulties before coming in contact with Nature?"

To ensure that our teachers are adequately prepared, we can explore at least three potential avenues:

(1) It may not be too difficult to rely on the successful strategies practiced by experienced teachers. Though one may argue that this approach is mostly 'anecdotal' and relies solely on the intuition of the educators, it has a strong operational value. My own teaching philosophy has been largely based on what I learnt from my teacher, (late) Prof. Ananthan, and I believe most teachers would have their own source of inspiration. In this context, the article 'The plural of anecdote is data' by Dan Stangler would lend itself for a healthy debate among the readers.

(2) Educators may be encouraged to access the existing literature on PER, and experiment with some of the methods which are known to be successful. PER looks beyond anecdotes. PER, one could say, is powered by another equally provocative statement, which is again worth a debate: 'Research is not the plural of anecdote'.

(3) We should organize conferences specifically focused on PER. I have personally benefitted immensely from participating in professional development workshops throughout my career. Even now, I regularly attend workshops offered here at Purdue University, and each experience offers new perspectives, even on familiar topics. Attending workshops is a refreshing experience, and I urge readers to proactively search for such opportunities. Way back in December 2014, it was a random search on the internet that led me to the APT workshop series. To be honest, I doubted whether APT would consider my request to join the workshops since I was not affiliated with any university. However, Prof. Harikrishnan's prompt email marked the beginning of my association with APT.

"Made weak by time and fate, but strong in will
To strive, to seek, to find, and not to yield."
- From 'Ulysses', Alfred Lord Tennyson.

4. Teaching Physics is like teaching a language.

Several years ago, just out of plain curiosity and a desire to try something different, I enrolled in an introductory French course in an institute in Chennai. Right from day one, I noticed that the instructor's approach was strikingly different from that of other language teachers I had encountered in the past. As a policy, she would speak only in French even when the students posed their questions in English. There was no translation whatsoever. Initially, as you may expect, I was a bit concerned about how one may survive the course. "Shouldn't she be teaching the script, and then the grammar?", I wondered. Well, she did neither. Much to my delightful surprise, within a couple of days, I observed that we were all compelled to converse in French. We would, of course, fumble and mumble but never would there be even the slightest hint of reproach from anyone. In fact, we were encouraged to experiment with the language right from the word go. We had so much fun laughing at, and learning from, our 'mistakes'. I was surprised that we were putting the language to use even by the second week. This was a stark contrast to my college experience, where even after two years of 'learning' Sanskrit, I could barely speak a few sentences. In my view, the issue lies in traditional language teaching's undue and possibly unnecessary emphasis on teaching grammar, at least in the initial stages.

Let us consider how most of us may have acquired our mother tongue. Did our mothers teach us grammar? Did anyone correct you as you made the 'mistakes'? It all happened organically, and the mystery of how grammar fell into place is indeed a subject worthy of research. As may be evident to most of us, most people are highly fluent in their mother tongues even if some, like me, do not even know the script. Modern approach to language teaching is 'operational' and 'functional'. It is not to say teaching grammar is not to be attempted; just that it can wait. I believe there are valuable lessons here for physics teachers. Aren't our textbooks loaded with quite daunting and abstract material for a beginner? Imagine yourself in a foreign language class. How would you feel? Don't you think your students may feel the same in your class? I get the feeling that we physics teachers are teaching 'grammar' to our students, possibly to an excessive degree. Can physics learning be made more operational, functional, and organic? Can we find better and more interesting ways to help our students figure things out for themselves?

Of course, there will be skeptics who would argue that following an operational approach would be time consuming and impractical. However, I believe it would be a disservice to science and to human learning if we continue to merely force-feed content to our students without affording them the time or the opportunity to play with the material and derive their understanding. This approach contradicts the spirit of 'constructivism', which is advocated by social scientists and educationists. How can our students truly grasp the subject if they are not able to make sense of it? As physics educators, we may need to pause and ponder for a moment about what the symbols and equations which we may 'scribble' on the board may mean to the learners on the other side. Teaching physics shares similarities with teaching a language. Unfortunately, this realization dawned upon me only after several years into my career as an educator. Fortunately, these days I am more respectful to the fact that my students are primarily language learners. While I was a teacher at the American International School, the academic coordinator, who had been in several international schools before, nearly rocked us off our chairs during a staff meeting with this question: "Would you like to sit in your own class?"

5. So, what is PER?

I personally believe it may be a challenging task to come up with a precise definition. It would certainly be worth your time if you can discuss it over coffee with your friends and colleagues. Dr. Beicher in his essay on PER states, "Physics Education research is not just curriculum development or instructional design." He adds, "PER is focused inquiry into what happens as students struggle to grasp and use the concepts of physics." At this point one may interject to point out that these are self-evident to any observant and conscientious teacher, and question if studying these aspects can be termed as 'science research'. If you share this perspective, you may certainly not be alone. Prof. Richtmeyer, in his thought provoking and delightfully lyrical essay 'Physics is Physics', claims "Teaching, I say, is an art and not a science." Well, that was in 1933. Fast forward to the year 2000, in her Oersted Medal lecture, Prof. Lillian McDermott, renowned for introducing Physics Education Research at the university level in the US, highlighted a significant shift in thought. She stated: "Results from our research support the premise that teaching can be considered a science." I would strongly urge the readers to take a detailed read of the articles in reference and arrive at a definition that may suit their style and taste. The bottom-line is that, like any research, PER is about asking deep questions. Only that the questions are aimed at gaining insights into students' thinking and understanding. In the process, it helps us reevaluate our own teaching approaches, and work towards improving learner experience.

At this point one may think that PER is all about pouring one's attention into the exam scores of students and brush it aside as 'data digging'. It is far from being merely 'a game of statistics' as a friend of mine once called it, in a lighter vein though. Of course, there is much data to be considered. We teach real people, and there is no way we can ignore 'hard' data. There will, naturally, be statistics. What may not be immediately apparent, especially to newcomers or outsiders, is the scientific rigor that underpins PER. I would be exaggerating if I stated I am fully aware of, or in possession of, all the science-based methods that are employed in PER. But I do get the 'feeling' that my training in physics and mathematics, coupled with my long years in teaching are instrumental in my progress in this field. My first few steps in PER are still largely based on 'intuition' (for want of a better word), which may be good but not sufficiently rigorous enough. I hope to make my studies in PER more scientific as I tread along.

6. Teaching methods - some avenues for research:

In countries like the USA, as well as many others, the following teaching strategies are commonly employed. Even if your department may formally not be into PER, there is a lot you may be able to do right away.

Lecture: This is probably the most prevalent mode of instruction and is certainly of high value. I gained immensely from Prof. Ananthan's weekly discussions and Dr. S.V. M. Satyanarayana's lecture series. Their subject expertise, eagerness to share their knowledge, empathy for the learners, and the ability to 'pitch it right' are a few reasons why I enjoyed their lectures. Given the budgetary constraints most schools face, lecturing will mostly remain the fundamental teaching method. Though the current trend of online education has certainly placed a strong challenge to the physical classroom, online teaching is still largely lecture-based. Despite the criticism - which is supported by considerable research - that this method does little to develop critical thinking among the learners, this method is highly cost effective. In my view, the lecture method can work well if the class size is 'small' and if the teacher can ensure active interaction of most, if not all, the learners. Rather than dismissing lecture-based teaching, I think we should invest our time in exploring ways to breathe life back into lectures. Lecturing may be an old method, but is still a fertile ground for PER.

Recitation: Though less common in India, recitation sessions are typical in the USA. Graduate teaching assistants, often PhD students like me, usually lead the recitation sessions. The groups are smaller in size, and the instructor discusses various aspects of a set of problems, often encouraging group discussions. There is usually a reasonable amount of time for the students to discuss the problems among themselves, thereby facilitating peer learning. In my department, we have started using the Jupyter Notebook (which is almost like a Word document within which you can write and run Python codes) for recitation problems. I encourage APT teachers, and others, to explore using similar web-based interactive computing platforms.

Demonstration-based lecture: In the decade or so, I have been largely experimenting this approach, and it is what may be called a middle-of-the-road approach. I am of the view that students need to convince themselves that what they may read in textbooks really works in practice. Demonstrations motivate students and help the instructor draw their attention. In my experience, I have been able to cover topics in greater depth in lesser time. However, the drawback is that the students will mostly be passive observers, except those who may be asked to try the demonstration with the teacher's guidance. Also, there is the question of time and money the teacher may have to invest. I have enjoyed doing both in the setting up of my personal laboratory, but not many may be inclined to do the same. Furthermore, it may be far too difficult to set up a demonstration for every topic in the syllabus. With a reasonable budget, this area may be another candidate for PER.

Laboratory experiments: Most schools usually have a laboratory room or two assigned for students to engage in actual hands-on work. Instruction manuals, while helpful for large classes, may lead to a 'cookbook' approach with little genuine learning, and there is little fun and barely any learning in going through the motions. During my university days, some of my professors would insist on us getting the 'correct' result which we would mostly never get. We discovered that we could get away if we 'massaged' the results. Unfortunately, such practices would ultimately undermine the integrity of science. Though the laboratory provides the maximum learning opportunity for students, it is generally a drain on the budget. There is a maintenance cost as well. My teacher, Prof. Ananthan, had an exceptionally deep understanding of laboratory apparatus, and he would spend several hours discussing the design of apparatus. He could dismantle several apparatuses, and reassemble them with ease. So, a resourceful hands-on teacher can elevate the laboratory from being treated as a mere storehouse of gadgets to a vibrant and happening place.

Here at Purdue University, we have embraced Engineering-Design based labs as a part of our research efforts. In this context, students create their lab reports using Jupyter Notebooks (which is freely available). Students proce what we call as the 'Computational Physics Essay,' a clever fusion of text, data, images, computation, and coding. Importantly, it demands only minimal programming skills and is relatively straightforward to implement.

Considering the increasing importance of coding skills in today's industry and job market, this approach aligns well with contemporary expectations. Numerous web-based tools are available to aid educators in incorporating computer programming into physics classrooms, offering a valuable means to contextualize learning. An additional advantage is that these tools are engaging and enjoyable for both students and teachers alike.

7. Why PER must be conducted by physics departments

There is evidence that PER has had a positive impact on the teaching of physics at both the school and the university levels. Many universities already engage in outreach programs, which involve running summer camps for the professional development of teachers. When incoming students are well-prepared, universities benefit; and when graduates possess strong content knowledge, it benefits the industry. Physics departments at the universities can serve as a vital link between schools and industry. Moreover, universities often have the necessary resources that regular schools may lack, further highlighting their role in advancing PER.

Formal research, aided by anecdotal evidence, has shown that the lecture-based teaching approach, though widely adopted, is not always effective in engaging students. However, financial constraints often make it impractical for departments to entirely abandon lecture-based teaching. There is room for improvement within this approach by tailoring it to local contexts to enhance the overall learning experience. If physicists equip themselves with techniques from the well-established field of educational research, it would become easier to introduce meaningful changes. Content knowledge is critical, and it may not always be the case that researchers in the education department have a formal background in physics. Physicists can bridge this gap by adopting and applying educational research techniques effectively, leveraging their subject expertise to enhance physics education.

8. Methods in PER

(1) Quantitative research, as the name implies, relies heavily on numeric and categorical data, among others. It involves an extensive application of statistical concepts. As an example, am applying the chi-square test in one of my current projects.
Though there may be tendency to brush this approach aside as mere 'number crunching', the fact is that the information gathered by analyzing the data can inform educational policies at both institutional and national levels. Typical studies include student achievement in exams, faculty performance, correlation between student demographics and performance, surveys on student perceptions and behavior etc. The success of this method rests, as in any research, on choosing the right data and applying the appropriate statistical tools. Fortunately, the emergence of Data Science as a distinct field offers valuable tools to enhance the precision and depth of our research efforts.

(2) Qualitative research draws upon non-numeric data. Sample sizes tend to be smaller than those in quantitative research, but the data collected provides a nuanced and comprehensive understanding of the subject. Common methods include interviews of individuals or focus groups, study of audio and video transcripts, portfolios and biographies. My current research is almost entirely based on qualitative analysis. The reader may explore some of my recent publications to get a sense of my research.

(3) Mixed methods involve a mix of both quantitative and qualitative methods.

9. My current research

Having been a physics teacher for a long time, my long-standing belief has been that 'what cannot be quantified cannot be science'. However, my years in teaching have also taught me a humbling lesson – the complexity of human learning cannot be fully comprehended solely through numerical data. This realization led me to explore a path that diverged from my established belief system.

During my first ever meeting with my advisor, while discussing our mutual interests, I expressed my eagerness to investigate student learning while placing numerical data aside. My advisor, as is his nature, gave me a free hand and encouraged me to pursue what I was passionate about. This marked the beginning of my venture into applying qualitative methods in the field of physics education. Neither did I know the depth of this field, nor its scope. It was an 'in the moment' decision.

In our subsequent meeting, my advisor mentioned that I might need to do some 'coding' for my research. I, in all my innocence (actually, ignorance), assumed this meant computer programming and confessed my lack of expertise in that area. My advisor politely clarified that 'coding' in our context had nothing to do with computer programming. That was two years ago. Now, I have a graduate certificate in qualitative research from Purdue University and all my publications so far have largely employed qualitative methods. My learning curve has been steep, thanks to the unwavering support of my advisor and Ph.D. committee members who have been generous in sharing their knowledge, in addition to providing me guidance and enouragement.

The conference paper I recently submitted involved the study of audio-recordings capturing conversations within student-groups. These students were tasked with exchanging ideas about a problem related to the influence of air drag on a projectile as part of their weekly laboratory activity. My responsibilities included transcribing the audio into text and analyzing the same to understand the 'Ways of Thinking' displayed by the students. Additionally, I explored how students substantiated their statements with evidence. I plan to extend this study to facilitate students' engagement in 'Evidence-Based Reasoning'.

In the last few semesters, I have solidified my understanding of educational research methods by enrolling in courses with a focus on qualitative and quantitative methods in educational research, in addition to courses in statistics. I have begun using coding in Python and R for my data analysis. It is worth noting that my work is largely Data Science. In this context, it is important to be aware of several ethical issues data access, storage and usage. To address this, I have completed certification in courses such as 'Responsible Conduct of Research (RCR) Training - Faculty, Postdoctoral and Graduate Students' and 'Human Research - Group 2. Social Behavioral Research Investigators and Key Personnel', offered through the Collaborative Institutional Training Initiative (CITI Program).

American universities are well known for their diverse and unconventional course offerings. As a graduate student, I have the privilege of enrolling in courses from almost any department in the university. About a year ago, one particularly fascinating course I had enrolled in was 'Gender and Culture in Science Education'. I strongly urge the readers to explore such topics. I encourage our APT teachers to contemplate facilitating group discussions on such crucial topics within their classrooms. Given the increasing presence of women in the workforce, it is imperative that we understand the myriad challenges women may face when pursuing or contemplating careers in science. A physics classroom provides an ideal platform for engaging in meaningful discussions about these important issues.

10. The road ahead

This is an opportune moment—and it is never too late—to reflect on the evolution of pedagogical initiatives over the past few decades. What reforms, if any, have been attempted in the past? Have the goals of such reforms been met? If not, what may be the way forward? In India, most students are introduced to physics around grade six, providing a fertile ground for school teachers to engage in Physics Education Research (PER). The government could incentivize teachers pursuing research in PER and encourage the implementation of well-researched practices. Proper documentation of these efforts is crucial for further study and improvement. We should also explore and adapt successful ideas from other countries, particularly in the Western world, where significant progress has been made in PER over the past few decades.

Given the substantial number of higher education institutes already in existence, and many more in the pipeline, it is imperative to allocate ample funding to Physics Education Research. The goal should be to upskill educators who will shape the next-generation workforce.

This educational initiative of APT may well be remembered as a watershed moment in our country's history. I earnestly hope more organizations take it from here and elevate PER to a widespread 'movement'. Equally important is that these initiatives be followed up with 'ground-level' changes, which can be studied, measured, and scaled up.

Years ago, during one of our road trips, Prof. Ananthan drew my attention to a memorable billboard slogan which read:

"Do it now; today will become yesterday."

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