# Physics Education Research and Teaching Strategies

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Because of globalisation, Information and Communication Technology (ICT) and knowledge advancement, the whole educational framework has changed. Learners now have access to information from the internet whenever and wherever required. It is evident that learning in 21st century is different in terms of skill and perceptions. The urgent question is what type of new pedagogy is required to better enhance learning? Pedagogy— a term derived from the Greek term 'PAID' (meaning child) and 'AGOGOS' (meaning learning). So pedagogy means the art and science of teaching children. In colleges and other institutions of higher learning, the learners are adults and thus mature and experienced. The adult learning is different from the traditional pedagogical approach. There is an emerging theory of adult learning, Andragogy — the word again derived from the Greek word 'ANDRA' (meaning man). Andragogy is therefore the art and science of helping and teaching adults. A further aspect of teaching related to pedagogy is called Cybergogy — principles and practice of teaching through the internet. The call of our time is to test the effectiveness of teaching strategies to enhance learning. In this direction physics education research is contributing and has brought many changes in physics teaching.

The emerging Physics Education Research (PER) is an interdisciplinary field which uses teaching approach of education for enhancing the learning of physics. It has potential to yield significant benefits for students, teachers and society by training the skilled science professional in this direction.

## Physics Education Research

Physics Education Research (PER) has become recognised as a legitimate research subfield of physics and recently emerged as a new field of research and physicists have begun to treat the teaching and learning of physics as a research problem similar to any applied science. It is based on the learning theory with the aim of introducing well defined learning outcomes or objectives for approving methodology of teaching and learning assessment. Today education is treated as topic worthy of scientific study. PER is a scientific approach to innovation in teaching-learning and involves—

- systematic observation made of students thinking and interpretation of concepts and then data collection; and
- in-depth probing and analysis of student's thinking by theories or models constructed to interpret the observation.

Based upon these theories and models, teaching instructional strategies are developed, implemented and finally assessed.

The main focus of PER is to find the gap between what is taught and what is learnt and looking for research based strategies to bridge that gap [Mc Dermott, 1991]. In other words PER is trying to identify students' misconceptions of core concept of physics, both before and after the completion of a traditional course of physics. There are a number of studies focusing on the pre-conceptions of student in physics [Trowbridge, 1980]. Physicists have found in their research that students even after completing their physics courses were unsuccessful at the answering question on mechanics (a most elementary sub field of physics), known as Force Concept Inventory FCI, (Hestenes,1992].

Traditional lectures (teacher-focused, with passive students) still reign as the instructional strategy of choice in many science courses (Hurtado et al. 2012). The continued prevalence of this approach is surprising given the dramatic gains achieved by research-based instructional strategies: improved conceptual understanding, increased retention in enrolment, and reduction of well-documented minority gaps (e.g., gender, ethnic). These improvements are becoming increasingly important as we face a shortfall of skilled workers in science related disciplines.

### Instructional Design

The sequence of teaching acts that a teacher plans, organises and carries out to create learning environment for the students is called instructional design. It is concerned with the structuring of the contents to create a suitable learning environment, selection of teaching strategies and assessments of performance level of students. Instructional designs are classified into objective based, skill based, competency based, model based and learning style based.

(i) **Objective based:** For formulating objective based instructional design, understanding of clear concept of instructional objectives in terms of learner behaviour is the pre-requisite. Bloom has classified objectives in to three categories: **Cognitive domain** (Thinking process), **Affective domain** (Feeling), **Psychomotor domain** (Practical/doing).

(ii) **Skill based:** A teacher performs many activities in the classroom which are interrelated; observable, measurable and controlled, thereby help in attaining the instructional objectives.

(iii) **Competency based:** Here the focus is on acquisition of specific competencies by students. Depending upon the need and capabilities of the learner, he is allowed to attain competencies at his own rate and space.

## Assessments

- Blooms taxonomy is useful in designing questions, lessons, and tasks for students.
- Higher level thinking allows a student's memory to be used effectively.

| Competency | Skills Demonstrated |
|---|---|
| Knowledge | Recognising and recalling facts; remembering; observation and recall of information; listing; locating; naming |
| Comprehension | Explaining ideas, understanding information; grasp meaning; making sense of what you have learnt, interpret fact, compare, contrast |
| Application | Using and applying the knowledge; use methods, concepts and theories in new situations use information; problem solving using required skill or knowledge. |
| Analysis | Breaking down information into components or parts; identification of components; recognition of hidden meaning. organisation of parts. |
| Evaluating | Justify, judging the value of information or idea; compare and discriminate between ideas; verify value of evidences. |
| Creating/synthesis | Predict, draw conclusion; design; formulate; generalise from given facts; relate knowledge from several areas; create. develop, integrate |
| *To assess specific levels of student mastery of course content needs taxonomy for describing those levels. Bloom's taxonomy is one such framework to improve testing precision by categorising cognitive functioning into distinct levels.* | |

## Teaching Strategies

For transacting information and knowledge to students in large groups strategies like lecture, seminar, symposium, panel discussion, workshop, etc., are adopted In small groups group discussion, simulation, brainstorming, case discussions, assignments etc., are useful. In individualised teaching tutorials, mastery learning, programmed instruction, etc., are effective. In PER, following Research Based Instructional or Teaching Strategies are used to enhance learning.

(a) **Peer Instructions or Interactive learning:** In this strategy, traditional lecture is stopped after seven to ten minutes and then a multiple choice question is posed to students. Small group discussion of conceptual questions is interspersed with lectures, thereby increasing engagement and providing formative feedback on student thinking. Students first answer questions individually with classroom response system, then discuss with their neighbours. Peer Instruction is an easy way to add interactivity to a traditional lecture course without making large changes. It can get our students engaged and interactive, and help students to learn and respond to what our students are thinking, both of which can lead to improved student learning. Peer Instruction is a band-aid on a traditional lecture course structure, which is not ideal for student learning.

(b) **Just–in–Time Teaching (JiTT):** Students answer questions online before class, promoting preparation for class and encouraging them to come to class with a "need to know."

(c) **Open Source Physics:** Open source code libraries, tools, and compiled simulations for physics, computation, and computer modeling. Includes

curriculum resources that engage students and enable them to discover new ways to understand, describe, explain and predict physical phenomena.

In addition to the above strategies, PER has workshop physics, tutorial in introductory physics, interactive lecture demonstrations (ILD), cooperative Group Problem Solving and Activity-based problem tutorials. Henderson and Dancy (2009) have provided a detailed list of research based instructional strategies.

## Conclusions

- The teaching and learning of physics is incomplete and inadequate, unless students have significant conceptual understanding and experience in practical. Physics Teachers can adopt research based teaching strategies and provide the greatest possible learning experiences for their students.
- PER has demonstrated surprising facts about student learning in Physics: Students retain very little from traditional lectures. Ideas propagated by the teacher "Chalk and Talk" are not understood by students in a same manner. Students believe physics as a collection of facts and equations/ formulas to be memorised. Indeed, they are unable to understand the concept of physics in a real world.
- In recent decades, as education researchers and cognitive psychologists have published research about how people learn, Interpersonal learning, personalised learning, collaborative learning. Physicists and researchers have now become more interested in using research based pedagogy/Andragogy to improve student learning in introductory physics.
- A new pedagogical/Andragogical (Research Based Instructional/ Teaching Strategy) with specific features that would meet the new century expectations is needed. Because the students and learner have access to information through Information and Communication Technology (ICT).

# References

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