Teaching proposals for improving students' understanding using physics education research

Symposium organized by GTG-Physics Education Research at University (PERU)

Chairperson: Jenaro GUISASOLA
Donostia Physics Education Research Group and Applied Physics Department, University of the Basque Country (UPV/EHU), Spain

Participants: Italo Testa (University Federico II, Italy); Ricardo Karam (University of Compenhagem, Denmark); Jose Guiterrez-Berraondo (IMH Institute, Spain) and Ramon E. Lopez (University of Texas, USA)

Introduction to the Symposium

At the center of any educational research is the goal of 'improving' students' learning [1,2]. The Physics Education Research (PER) has developed around the fact that this goal of improvement is possible. Therefore, PER has gone beyond the identification of difficulties in student learning and the deficiencies of traditional teaching. The research has developed didactic materials and strategies that have been repeatedly tested, evaluated and redesigned. However, the difficulties to carry out research in physics teaching whose objective is to improve the practice of their teaching should not be underestimated. We agree with Lijsen and Klaassen [3] when they argue that the design of learning sequences requires a complex process of applying the general principles of didactics to the specific contexts of teaching the subjects of the curriculum.

Nowadays. there are some shortcomings, even in the most recent approaches, and some questions without answers, as in all rigorous investigations of any discipline. In the IV Symposium GTG-PERU, we will present research based on the proposals, which try to overcome the gap between the results of PER and the classroom practice. The purpose of this symposium is to present to teachers and researches recent research results and to discuss their ideas , work in progress and experiences.

We draw different lines of teaching approaches. First, we present two studies in the area of Quantum mechanic. I. Testa will present an empirical study about undergraduate students learning of quantum mechanic (QM) when they exposed to different teaching conditions, from introductory to upper-level university course. He and colleagues developed a questionnaire with 25 open items that addressed topics such as wave function properties, Heisenberg's uncertainty principle and measurement in QM, atomic description of matter. In tis contribution will be presented some examples using Rasch data analysis and results of students' achievement in the different ways of teaching. Secondly, R. Karam presents a study about the justification of complex number in teaching quantum mechanic (QM). Making such justifications explicit in teaching should encourage students to focus on the structural role of mathematics in physics. In this study, we will look for explicit justifications for the use of complex numbers in quantum mechanics textbooks, especially when these mathematical structures are presented for the first time. Karam shows a preliminary analysis of the selected textbooks where it is noticed that explicit justifications are scarce. It is usually assumed, implicitly, that there is no problem in using complex numbers and defining complex valued quantities, which essentially cannot be separated into (pure) real and imaginary

parts. He will discuss some types of justification that textbooks use to introduce complex numbers as mathematical tools in QM.

The third presentation by J. Gutierrez-Berraondo will be about the analysis of the learning effectiveness of a teaching-learning sequence (TLS) on the generalized principle of work and energy in mechanic at first year of engineering degree. It presents results on the feasibility of a design and implementation of TLS following a research-based design methodology. Examples of evaluation issues and their results will be shown. Finally, R.E. Lopez will present a study that analyzes the advantages and disadvantages of taking the theoretical bases and pedagogical strategies generated by research at an educational level (introductory physics courses) and applying it to create an appropriate learning environment for higher and postgraduate physics courses. It shows that careful consideration is required of the problems faced by students at each educational level. In the presentation, Lopez will discuss several examples of the application of research-based techniques to classroom instruction in upper division and graduate physics courses, how the specifics of the student audience have resulted in modifications of the pedagogical approach, and the student response to these instructional strategies.

In this Symposium we present empirical and theoretical evidences that research-based teaching approach can contribute to improving the process of creating appropriate environment of teaching and learning. Physics Education Research plays a crucial role to contribute to the knowledge base in a way that can guide the translation of results of research to classrooms practice and, to identify approaches to make science and engineering education effective and inclusive.

References

[1] Report to the European Commission on Improving the quality of teaching and learning in Europe's higher education institutions. (2013) . ISBN 978-92-79-30360-9. http://ec.europa.eu/dgs/education_culture/repository/education/library/reports/modernisation_en.pdf

[2] Singer, S. R., Nielsen, N. R., & Schweingruber, H. A. (2012). Discipline-based education research. Washington, DC: The National Academies.

[3] Lijnse, P. and Klaassen, K., (2004). Didactical structures as an outcome of research on teaching-learning sequences? *International Journal of Science Education,* 26(5), 537-554.