www.ijpce.org
ISSN: 2589-8876

EDITORIAL

The Valuable Contribution of "The International Handbook of Physics Education Research" (IHPER) to Physics Education Research and Physics Education: Reflecting on the Field

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Abstract
The International Handbook of Physics Education Research (IHPER) is a collection of up-to-date review papers that highlight the state of the art of physics education research (PER). The IHPER was published in April 2023 and consists of three volumes, namely, Learning Physics (Taşar & Heron, 2023a), Teaching Physics (Taşar & Heron, 2023b), and Special Topics in PER (Taşar & Heron, 2023c). By taking this opportunity, in this editorial, I am reflecting on the past, present, and the future of PER.

Keywords
innovation, research, physics education research, PER, IHPER

◆ Received 14 May 2024 ◆ Accepted 31 May 2024

The origin of contemporary research in the field of physics education and other scientific disciplines dates back to the '50s and '60s as it is widely accepted. In the context of the Cold War and the launching of Sputnik a wave of curriculum reforms began in the USA and spread gradually across several Western European countries. For the first time innovative teaching materials were compiled in well-designed educational packages, including textbooks, experiments, tests, worksheets, teachers guides and AV items. Authors had mainly scientific background aiming at the improvement of teaching and learning of scientific knowledge. The focus was on deep understanding of conceptual knowledge, yet approaches promoting experimentation and active involvement of students in learning activities were also adopted against the dominant teaching methods based on passive learning of scientific content. Notably, some great pedagogues, like Dewey, have opted in favor of such didactical approaches for a long time ago. In the beginning, innovative curricula were addressing secondary school students but soon they started focusing on primary school ones.

The need for design, support, and evaluation of the effectiveness of these curricula and response to social and educational demands led to the gradual establishment of research groups in Physics and Educational Departments devoted to discipline-based research targeted on revealing students' scientific understandings. During the same period theoretical developments in psychology, cognitive science, and epistemology, like constructivism, and the nature of scientific changes took place influencing research and practice in physics education. Students were seen as active creators of their knowledge instead of passive consumers of information engaging in the learning process, focusing not only on understanding concepts but cultivating scientific thinking and ability to experiment.

Studies on the evaluation of several innovative curricula have indicated limited results compared to the expectations set, due to several reasons. One influential factor was that that, at least in physics, such curricula were difficult for most students who went through them. In practice, these curricula were appropriate for preparing future science and engineering careers, not for the general population. Another reason was that students were conceived as young scientists, while discovery learning that was the dominant pedagogical approach was rooted on a positivistic conceptualization of science. A third reason was research finding concerning the persistence of students' alternative ideas even after years of education and their implications for instruction. This was a critical issue, thus motivating more researchers to use physics as a context for thorough examination of students' and teachers' cognitive processes and learning strategies, resulting in considerable momentum in physics education research (PER) worldwide.

In the process of gradually developing the new field of physics/science educational research and differentiating it from the teaching of physics/science, researchers involved were mainly associated to scientific or education departments. Contribution of researchers was either discipline-based, focusing on upper levels of education and publishing in journals, such as Physics Education and American Journal of Physics or physics/science education based, focusing on all levels of education and publishing in journal such as Science Education and European/ International Journal of Science Education. In this context new scientific groups or organizations were developed in terms of discipline-based research in Physics, like GIREP along with other disciplines, for example ERIDROP in Biology. Furthermore, groups regarding educational research across scientific disciplines have continued to develop, such as the old-established US based NARST or the relatively newly formed European/International Science Education Research Association, ESERA. Similar trends have also appeared in conferences and seminars.

https://doi.org/10.51724/ijpce.v15i1.372

Education research in the scientific fields, cognitive studies, epistemological studies to name but a few were inspired using a wide spectrum of methodological approaches. Soon it became apparent that there was no strong worldwide consensus about a body of knowledge, which is reasonable since this field is/was a newcomer. As a response the first handbooks were published, namely the Handbook of Research on Science Teaching and Learning in 1995, followed by the First and the Second International Handbook of Science Education in 1998 and 2012 respectively. These valuable books have provided a real breakthrough in the interdisciplinary field of Science Education Research, bringing together studies and researchers from various fields and cultures.

However, it was not feasible for such general Handbooks to include reviews covering comprehensively specific, discipline-oriented research. Focused research in the specific scientific disciplines, including physics, was and still is imperative and draws the interest of researchers. Several secondary education curricula around the world are discipline oriented. Besides, advanced studies in tertiary education benefit from research-based instructional strategies. Furthermore, disseminating research results for articulating evidence-based practices benefit from discipline and topic-oriented, in-depth studies. This is an open issue which brings about certain actions and discussions among researchers.

Over the years PER has been growing, spreading out and eloquently advancing. It is in this context that "The International Handbook of Physics Education Research" (IHPER) makes a valuable contribution to PER and physics education in general. The wealth of studies, presented in three volumes, the richness of available results and the variety of contexts, cultures and methodologies applied constitute a body of knowledge beyond the grasp of an individual researcher and requires some compilation and classification that may reveal its breadth and depth. This is a challenge that IHPER faces and responding to in an authoritative way includes a collection of up-to-date review papers that highlight the state of the art of PER. IHPER provides a comprehensive picture of past achievements in the field, contemporary open issues, and emerging matters for the future to secondary and higher education, without excluding any reference to primary level. Certain selective remarks on the content and focuses of the three volumes follow.

The first volume of IHPER focuses on learners (students) and how they learn both conceptual knowledge, the practices and nature of physics. It includes a comprehensive presentation of specific review studies focusing on classical topics, like optics, mechanics, energy, thermal physics, electricity and magnetism, sound and waves, and fluids along with chapters on more modern topics, like relativistic mechanics, particle and quantum physic. Incorporating chapters on the affective domain denotes the role of this rather less investigated crucial factor affecting students' learning. Besides, there are review papers concerning the epistemological aspects of learning and teaching that reflect the recent growing interest of researchers regarding students' and teachers' epistemological understandings. Aspects of the dynamic and complex nature of teaching learning processes are thoroughly presented and discussed in several papers in this volume.

The second volume focuses on the other crucial aspect of educational endeavor, that of teaching physics. Here is emphasized the prominent role of many aspects of digital technology and its integration in physics education, covering about one third of the whole volume. Comparison with the space available for the then known as educational technology in previous handbooks indicates the crucial role of such technology in affecting and potentially radically changing physics teaching and learning. Concerning teachers, it is obvious that there are considerable changes in the scope of the review studies since they refer to education instead of training. Besides, the studies focus on all levels of education in physics providing valuable insights in rather less investigated areas like preschool teachers and graduate staff.

Physics education is not and should not be confined to teaching and learning. It is a human endeavor with a long-standing history, enacted and progressing within cultural contexts and sensitive to societal trends and tensions. Such a broad perspective of PER is taken and illustrated in the third volume. Thus, research on aspects of gender and equity, the nature and history of physics/science and their dialogue with physics teaching, and scientific literacy are reviewed among several other innovative themes like visualization with digital tools in mathematics, and teaching learning sequences in physics.

This outstanding compilation of review papers in IHPER represents major strands of PER, their evolution and change during recent years. The emerging picture out of the IHPER chapters reflects disciplinary and intradisciplinary approaches, the breadth, depth, and considerable internationalization of PER. Moreover, in several chapters the two working research traditions, namely those originating from physics discipline and those from physics/science education seem to merge. Within this context, physicists, science educators, cognitive scientists, sociologists, and computer scientists have been collaborating and conducting research that has produced and corroborated valuable data about students' knowledge, reasoning and learning in physics. Furthermore, researchers have worked based either on established powerful theoretical frameworks or developing new ones that have guided their investigations.

Such developments are also shown at the methodological level. It is demonstrated through the IHPER reviews that, beyond almost exclusive use of quantitative pre-post designs in early studies, the research methods used are enriched to include qualitative methods which provide valuable in-depth information on students' thinking and learning. Certainly, quantitative, and mixed methods are used depending on the objectives and designs of the investigations. Enrichment of research designs, advancement of research methods, enlargement of educational and cultural

contexts has led to considerable progress in the field of PER, which is reflected thought of the three volumes of IHPER.

PER aims at improving physics education. However, it is widely accepted that it is neither straightforward nor simple to disseminate research results in educational practice. PER is no exception. Despite the progress in this matter and increasing trust in the practical significance of research results, there are difficulties in communication among researchers and other contributing parties in physics education, such as policy makers and teachers, partly due to political and economic factors, classroom constraints, lack of information and exchanges among these sectors.

In conclusion, the succinct compilation of research of IHPER facilitates the quest and use of identification of relevant issues for individual and research groups. In this sense IHPER makes up for an attractive and intellectually stimulating reading not only for experienced researchers but for postgraduate students, physics teachers and university staff. Physics education and physics as a discipline will benefit from deep knowledge of students' learning and the implementation of evidence-based teaching.

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