Making the results of research in Physics Education available to teacher educators

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Introduction

In the years 1997-1998, under the chair of Paul Black, the ICPE Commission undertook the publication of a book to make available the results of Physics Education Research (PER) worldwide to all those involved in pre- and in-service teacher education.
The title of the book, "Connecting Research in Physics Education with Teacher Education"[1], explicitly declares the aims. In the words of Paul Black, the book should signal "the beginning of a longer term and continuing project of linking together researchers in Physics Education with those who train Physics teachers". The book, which is freely downloadable from the web, has been widely read and hopefully has had an impact on teacher education programs in many countries.

In 2006, the continuation of the ICPE-books project was discussed amongst the members of the International Commission on Physics Education (ICPE, Commission 14 of International Union of Physics and Applied Physics) and it was decided to produce a second ICPE book with the same title as the first.
The reasons behind this decision were related, in first instance, to the ten-year lapse of time between the publication of the two books. During these years both PER and Physics Education (PE) have evolved and spread worldwide. Many new research results have been obtained on learning and teaching processes, while data collected by international projects such as TIMMS[2] and Pisa[3] have raised serious questions about the efficacy of physics teaching. Moreover, the issue of communicating to students the organization and methodology of scientific knowledge (the so-called "image of science") has been identified as an important factor for raising the interest and motivation to learn Physics, as the ROSE Project has shown[4]. And one should not forget either the advances in ICT- based tools or the contributions Educational Technologies are making to teaching strategies and learning environments.
The plausible audience for the second ICPE book has been identified as teacher educators, PER and PE communities, physicists, policy makers and so on, in other words all those involved or interested in PE. The overall goal is to gather significant experiences and viewpoints from different areas around the world that are expressed in plain language, in order also to encourage the implementation of innovative class practices and the starting of PER initiatives.

The starting points for planning the continuation of the project were the rationale and contents of the first book . These largely concerned four main themes:

- *Perspectives on Physics* - Physics as a structured body of knowledge, Physics seen from the viewpoint of a professional researcher and the history of physics as seen by physicists and historians.
- *Student knowledge and learning* - research results about common and robust learning difficulties in Mechanics, thermodynamics and Electricity; students' understanding of methods of scientific inquiry; and strategies for facilitating learning through conceptual change.

[1] http://www.physics.ohio-state.edu/~jossem/ICPE/TOC.html
[2] http://timss.bc.edu/index.html#
[3] http://www.pisa.oecd.org/pages/0,2987,en_32252351_32235731_1_1_1_1_1,00.html
[4] http://www.ils.uio.no/english/rose/

- *Teachers' attitudes and practices* - the relations between teachers' views on teaching and learning, beliefs, convictions, epistemological postures and the effectiveness of teaching activities and class practice.
- *Curriculum development, assessment and teaching situations* - aspects of the complex interaction amongst knowledge, student learning and teachers' methods and practices; learning sequences on the Particle Model and Electricity; and problems related to assessment and evaluation processes.

Reflections about these themes, the communication of new research results, the image of science, the diversity of teachers' education practices in different countries, increasing attention to the impact of PER on PE: all of these contributed to the rationale behind the continuation of the ICPE-books project. It was decided to continue the discussion of epistemological and historical aspects, to present aspects of teaching strategies and learning environments, to look both at laboratory work and at the development of ICT-based approaches/tools and distance learning processes.

The challenge of planning and organising this second book has not been a minor one. It seemed appropriate to call for contributions from areas where PER is more consolidated and emblematic PE experiences are acknowledged. The need for some kind of balance between different areas of the world has also been taken into account. In order to limit the size of this freely downloadable book, the contributions are not an exhaustive collections of viewpoints.

Continuing the tradition started with the first book, some of the contributions have been commented on. The goal is to provide different ways of looking at the same content.

1. Organization of the book

Since the main target of this book are people involved in teacher education, it seemed useful to sketch a kind of reader profile. Plausibly, this would be of a person who has an interest in education but does not have either the resources or the time to be updated about PER results and PE emblematic best practices. S/he may be a physicist who has some competence and interest in epistemological and historical aspects; a teacher educator who may see the main problem in teacher training programs as that of updating the knowledge acquired in university courses; a teacher who is at home with traditional syllabi contents delivered in traditional mode, i.e. via lectures characterised by low interaction with students; or a policy maker who is seeking to "feel the pulse" of the PE and PER communities.

Another goal of this book is to provide some suggestions and hints to those just beginning a career in PE and PER. Some misconceptions about what PE and PER actually are appear not only in educational practice but also in workshops, conferences, and teacher education interventions. The first misconception could be summarised as *any activity addressing physics topics is Physics Education*, the second as *any activity addressing Physics Education is Physics Education Research.* As is the case of naïve ideas/reasoning of students (and sometimes teachers) about disciplinary contents, these misconceptions can create considerable confusion. Both need to be carefully addressed if the quality of PE and PER is to be improved.. As with any educational process, teachers and operators need specific competences and skills which, if lacking, can impede or hinder meaningful and effective impacts. Knowledge of specific methodologies, literature, procedures and tools is required in PER, as in any other research field. The mere experience of teaching some areas of physics does not provide or guarantee this type of expertise.

It thus seemed important to direct the book's focus towards epistemological and historical aspects and to some teaching strategies and learning environments, with the partial aim of presenting some of the main features of PER.

The book is organized in four parts:
Section A "About Physics", where the aim is to convey a sense of the organization of scientific knowledge, its language and the relation between science and technology. Three essays focus on specific aspects: J. Ogborn discusses similarities and differences between scientific and common-sense knowledge; M. Pietrocola addresses the role and use of mathematical language in physics; D. Gil Perez et al. reflect about the relation between science and technology and the need, in science teaching, to embrace technological aspects.

The three essays in Section B "About learning" report new research results about conceptual understanding, the development of skills/values, and the role of international competitions in learning. L. Viennot addresses the issue of what we have learned about conceptual understanding beyond simplistic ideas; V. Talisayon points out the importance of fostering the development of specific skills and values; G. Tibell discusses the contributions of international competitions to teachers' and students' education.

Section C "About teaching" presents three essays dealing with the issue of the skills needed in didactical communication, the use of the history of physics as a teaching tool, and the problems of disciplinary knowledge from a pedagogical viewpoint. A. M. Pessoa addresses communication skills, I. Galili the role and use of history, and D. Grayson focuses on Pedagogical Content Knowledge.

Section D "Technologies for learning and teaching" concerns experimental activities proposed in the classroom, the role of distance education and the use of ICT-based approaches. R. Lambourne addresses the distance learning approach, P. A. Haterly comments about virtual laboratory practices, R. K. Thornton discusses some educational experiences based on ICT tools, E. Sassi and M. Vicentini present some facets of didactical lab-work.

The above contributions are the result of a kind of negotiation between the authors and the editors. We acknowledge the goodwill of the authors who, in some cases, have agreed to make repeated modifications to their papers.

2. Links between the Sections

The common core of all Sections is, of course, Physics. This core is looked at from different viewpoints: the epistemological one in Section A, that of learning problems in Section B, that of teaching methods and skills in Section C, that of technological tools and support for teaching in Section D. Links and intersections exist among these Sections, their boundaries are not sharp.

Epistemological aspects are related to class practice, interpretation of the role of experimental activities at school and discussion about the history of physics. This last aspect is addressed by M. Pietrocola as far as the language of physics is concerned and by I. Galili in terms of its role as a teaching tool.

The learning problems discussed by L. Viennot have links with the communications skills addressed by A. M. Pessoa and the relations between scientific and common-sense knowledge reflected upon by J. Ogborn.

The distance learning approach has been spreading rapidly of late and attracting considerable attention and resources. This is discussed by R. Lambourne and is related to untraditional ways of teaching and learning such as the international competitions described by G. Tibell.

The aims and strategies of experimental activities addressed by E. Sassi and M. Vicentini are linked with the ICT- based approaches and experiences discussed by R. K. Thornton and the Interactive Screen Experiments presented by P. A. Hatherly.

Another type of link comes from the points where all contributions address, implicitly or explicitly, as V. Talysaion does, the values of Physics. The values of science and physics are seldom addressed in current PE. Usually some attention is paid to the general public's negative perceptions of physics, which are often generated by events where science applications have generated tragic or at least negative consequences. It is therefore appropriate to call the attention of teachers, educators and students to values linked to: public sharing of methods, results and tools; peer review and judgment; openness to critics; the quest for completeness; appreciation of collaborative, co-operative work; intellectual honesty; pure, blue-skies research that is independent of possible applications. In current technology-driven societies, excessive emphasis is sometimes placed on the value of *applied* rather than *basic* research. Teachers should help students to perceive the beauty of the exploration, representation and modelling that science makes of the natural world, independent of what concrete and applications might result from research.

3. Links with the first ICPE book

Education is a complex field where different dimensions and aspects intersect in many ways: from knowledge of the discipline taught and its epistemological status, to the problems and difficulties encountered by students in learning and by teachers in teaching, to the skills demanded of teachers for successful communication, to the strategies and tools that can improve and support didactical practice.
Some facets of these aspects are presented in the first ICPE book. Both physics knowledge and teaching-learning problems are discussed through exploration of: the variety of ways in which physics knowledge is taken into account in a didactical perspective; the problems related to students' understanding of some physics topics; teachers' views on the knowledge they are to communicate to students; the interplay between these views and teaching practices.
Physics knowledge in a didactical perspective is again the main topic of this second ICPE book. It contains reflections on: the organization of scientific knowledge compared with common-sense ideas and reasoning; relations between physics and mathematics and between science and technology; experimental activities and ICT-based approaches in teaching and learning; contributions that the history of physics makes to teaching ; the impact of communication skills; innovative ways of teaching and learning.

4. Perspectives

Looking at the future, we can set the problems of PE in the framework of E. Morin's suggestions about the "savoirs" needed for a sustainable future[5]. Specifically, Morin points out the importance of communicating knowledge that positions partial and local knowledge in the global, basic, urgent, complex problems of today. This means that a way of knowing, usually fragmented in various disciplines, should be replaced by a way of knowing that is capable of setting the context, enhancing complexity, explicating the importance of understanding its character of unity.

[5] Edgar Morin Les sept savoirs nécessaires à l'éducation du futur. Organisation des Nations Unies pour l'éducation, la science et la culture. © UNESCO 1999 http://www.agora21.org/unesco/7savoirs/
Edgar Morin (2000). Les sept savoirs de l'éducation nécessaires à l'éducation du futur. Paris : Seuil

The PE and PER communities are reflecting on these themes in the light of different concerns expressed by various sources about diverse issues: policy makers who point to the importance of a reasonable and widespread science education for all citizens in a knowledge society; the gaps between students' interests and science (physics) taught at school; the results of international and long term projects such as TIMMS and PISA regarding the effectiveness of science education; the ROSE study about students' interest in science and scientific carriers and the global perception of the image of science; fears about the declining enrolment of students in physics courses, which in some countries has caused the closing of physics departments; the surveys and results of the EUPEN network and its follow-ups[6].
The answer to the question "which physics is to be taught and for whom?" should aim also to bridge the gap between students' interests, the structure of curricula and contents of syllabi. This does not mean that the traditional way of organizing disciplinary contents should be completely abandoned, but rather that PE and PER communities should think of innovative and motivating ways of choosing and presenting the physics to be taught, including in context-driven curricula.

A point for reflection and action is collaboration between physics educators and physicists. The present level of collaboration is better now than about ten years ago, but it is still affected by problems on either side. One of the aims of this book is to help foster relations amongst the three communities: physicists, PE and PER. There are still a number of steps to be taken in order to reach a synergic and complete collaboration among all these actors and to attain mutual, satisfactory recognition.
We hope this book will help.

To be completed with acknowledgments

[6] http://www.eupen.ugent.be/wg/wg3.php