

Some Views about Research in Physics Education

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Abstract

The field of Physics Education Research (PER), now about 40 years old, is developing rapidly. It is increasingly recognised by physicists in other research fields, even though better interaction is still needed. For about 50 years, physics education has been undergoing reform in many countries, most recently as part of an effort to improve basic science education for the purposes of economic growth and effective citizenship. In the last few years the decrease in the number of students who choose to study physics has also been receiving attention. PER can help address these problems. Given the intrinsic complexity of PER, there are many different viewpoints regarding its methods, models and tools, as well as its areas of applicability. This paper comments briefly on some of those viewpoints, on some urgent demands currently being made on PER, and on some possible future trends in the field.

Introduction

Physics Education Research (PER) is an applied research field focusing on all aspects of Physics Education (PE): processes, methods, models, strategies, tools, materials, etc. PER does not address problems of general education; it aims at achieving specific results in specific contexts, the ultimate goal being to foster the construction of physics knowledge based on research into what physics (methods, models, topics) is to be taught and to whom. Now about 40 years old, PER is developing rapidly. A 2002 inquiry by the European Physics Society [1] indicates that PER groups are present in about twenty of the 22 participating countries, both in physics and education departments. Nowadays, a web search reveals about one hundred groups in the EU and USA (about fifty each) and about a dozen throughout the rest of the world. This scenario gives an idea of the growth, even though many groups are not listed on the web.

Even though methods and tools may sometimes differ, PER activity centres on two closely related foci: the acquisition of knowledge about learning/teaching, i.e. study of the phenomenology of PE and cognitive modelling; the educational design of curricula, teaching strategies, learning environments, tools, materials. The interaction between these two foci is crucial. The results of empirical studies on learning/teaching physics are used to produce research-based resources for teacher and student education, and also to envisage components of theoretical frameworks; an educational design has to rely on a reasonably sound knowledge of the entities and processes one wants to act upon. Fortunately there is no single solution for transferring PER results in the design of proposals; choices depend on knowledge and experience. PER lines have changed with time: this is borne out when examining two data sources, the IPN bibliography “Students’ and Teachers’ Conceptions and Science Education” [2] and the themes of major international conferences¹, and comparing the decade from the mid 70s to the mid 80s with that from the mid 90s to 2004/5. The STCSE database covers the “leading English and German journals in the field of science education, books, conferences and other bibliographies”.

¹ As those organised by IUPAP International Union of Pure and Applied Physics, ICPE Commission on Physics Education (established in 1960), GIREP Groupe Internationale de Recherche sur l’Enseignement de la Physique, International Research Group on Physics Teaching (in 1966); ESERA European Science Education Research Association (in 1995); EPS Physics Education Division (in 2000).

Its language focus means that it does not cover all PER production, as many practitioners write in their own national language, a natural way to communicate with the local PE community and impact on school practice. The number of publications on “Students’ Conceptions“ is about three hundred in both decades: this line still receives considerable attention, as in early PER times. Many empirical studies have identified common and teaching-resistant difficulties in learning physics. The line “Instruction taking Students’ Conceptions into account” has grown from about 80 to about 600 publications. The studies on students’ learning difficulties almost always end up in instruction proposals; sharing knowledge of students’ ideas/reasoning strategies does not imply agreement on teaching strategies and learning environments, so the same data can produce very different proposals according to the cognitive model adopted. The works about “Lab work, Multimedia, Modelling” have increased (reaching 70, 70 and 20 respectively): this trend is probably related to the new approaches/activities made possible by ICT-led innovations. The “Teachers’ Conceptions” theme has been much more commonly addressed in the last decade (increasing from only a few to about 70 works), while the works on “Curriculum” are about the same in number for both decades.

In the decade 1975-85 the main international conferences discussed themes such as probability and statistics in physics teaching, the role of lab work, teaching/learning of mechanics and so forth. Recently, the themes addressed tend to become wider in scope: this is borne out by conferences such as: EPEC-1, What Physics Should We Teach? (ICPE, Durban 2004); World View on Physics Education in 2005: Focusing on Change (ICPE New Delhi)²; Contribution of Research to Enhancing Students’ Interest in Learning Science (ESERA, Barcelona 2005)³; Informal Learning and Public Understanding of Physics (GIREP International Seminar, Ljubljana 2005). These titles link to the main recommendations of the institutions involved in PER.

Major PER areas

Many research lines are present within PER. The awareness of the need to address these themes is impacting on school practice, even though this is a slow process. Figure 1 shows two ways of looking at PER lines.

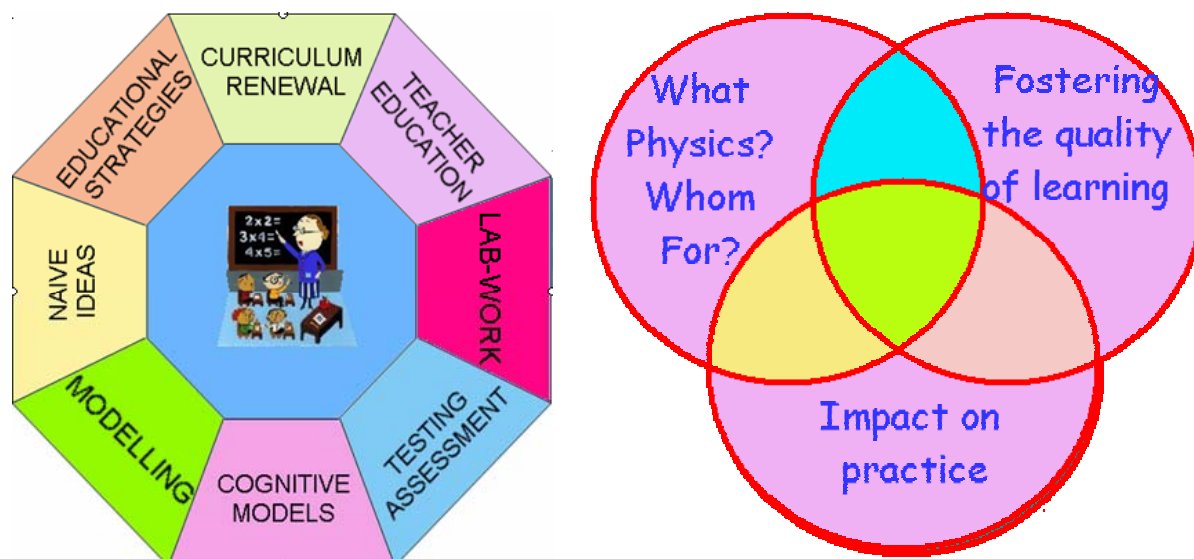


Fig. 1. a) PER lines: this is a 3D representation seen from above. Each facet seen here has a corresponding facet in the unseen lower half that contains the fine structure of the upper facet. Research lines about informal and e-learning are not shown; b) PER lines grouped according to the main challenges currently facing PER.

² Very many contributions by India and Asia PER groups have been presented, indicating strong development of PER activities in those countries

³ Papers about Physics and Chemistry Education research have been the majority of the presented contributions.

The Naïve Ideas facet in Fig. 1a deals with the most commonly studied naïve knowledge patterns [2, 3] such as those related to Motion-Force-Energy-Equilibrium, Heat-Temperature, Electric Current, Light, Waves, Atoms/Molecules, Properties of Matter, Quantum behaviour, etc. These patterns are interpreted variously as coherent, stable, and resistant-to-change structures that appear in many contexts, but also as fragmented, labile, easy-to-change structures [4]. When students learn, inevitable transformations occur, always and everywhere; they depend much on the idiosyncratic naïve knowledge net. Maybe the most well known PER result is that students' understanding of what is taught is mainly determined by their ideas and reasoning strategies. The teacher's optimization of accessibility is helpful but does not guarantee that learning happens. Fig.1b groups the PER lines according to major challenges; the three areas are intrinsically overlapped. The first area is "What Physics and whom for?". With the population involved in secondary and tertiary education increasing worldwide, a major challenge is how to foster the construction of physics (scientific) knowledge for informed and confident citizens. A central research theme is curriculum innovation/dynamics, given the increasing "globalization" of knowledge. Since the 50s, new physics curricula have been proposed; there are now many research-based resources available to help curricular design and implementation (cfr. Jon Ogborn, this Conference).

The area "Fostering the Quality of Physics Learning" is linked to the unsatisfactory situation of PE, as shown by the PISA and TIMSS projects [5,6]. These results have provoked deep concerns, even though the significant differences in the education systems and curricula of the studied countries suggest caution is needed in interpretation. The claims of experienced teachers and PER results do show that current education is not effective in providing many key features of sound physics knowledge. There is a wide gap between what is taught and what students learn. Current teaching generally centres on "talking the topic", usually covering topics up to the early twentieth century and ignoring most of the science technology developments that are interesting for students. Teaching is usually ineffective in building a coherent conceptual framework, in building connections between students' commonsense knowledge of complex phenomena and their disciplinary models, and does not help overcome many conceptual difficulties. A study of the attractiveness of science education at school [7] shows that physics is amongst the least interesting disciplines, being perceived as boring, difficult, and not related to important every day issues⁴. Most students in the 12-18 age range are interested in issues about Earth/Universe, ICT, life and living systems, genetic manipulation, energy, pollution, climate, arms systems, etc. Current PE does not pay much attention to strategies/activities addressing the decrease in students' interest in scientific topics and the image of science, and insufficient effort is being put into communicating the strength/limits of scientific evidence. Physics-related communication in school is problematic not only because of the great difference with respect to (multimedia) communication in the world at large, but mainly because of insufficient awareness of the differences between the teacher's and students' schemata of knowledge. The code of the teacher's message is based on *his/her* knowledge representations, while the student decoding is based on *their* knowledge representations, so transformations and misunderstanding are inevitable. Furthermore, the role of the emotional sphere is almost completely ignored in typical school physics communication. Bridging all these gaps means acting on the complex dynamics involving at least three components: the school system; the educational authorities; interaction between PE and PER. Changing the current situation is therefore a long process, specially in the framework of current rapid changes in social contexts and demands. Society and science-technology are undergoing dramatic changes, and as a consequence so are the demands being made. Knowledge is being increasingly recognised as a crucial resource: in the EU the move

⁴ A survey in German high school quoted by M. Euler at the 2004 GIREP Conference indicates the typical physicist close to a common stereotype: male, shy, unattractive, lonesome worker, not socially engaged.

towards a “Knowledge-based Society” demands scientific literacy for the informed citizen. On the other hand, the number of students studying physics at school and university is decreasing. The UK situation is emblematic (D. Raine, this Conference): the number of universities offering a physics degree there is also decreasing and several physics departments have been closed. There is consensus on increasing the number of outreach initiatives to improve public understanding of physics, e.g. the very many events within the World Year of Physics 2005. But changing the learning environment inside universities is a very complex process requiring both deep critical analysis of well established beliefs/patterns and the capacity to address questions like “What physics?, Whom for?, Which approaches/tools?” The main research lines within the “Fostering the quality of physics learning” area concern: how to innovate teaching strategies through research-based design/experimentation; cognitive models; contributions by ICT/ET (Educational Technology)-led approaches; multi-dimensionality of learning. The third area, “Impact on practice”, involves improving PE and reducing the gap between PER results/proposals and current practices; the transfer/adaptation of results is a problem in any applied research. The main themes are: teacher education; procedures and tools for testing and assessing students; diffusion/support of didactic innovation with special focus on analysis of the transformations teachers make to the innovative rationale [8-10]; structure, content and maintenance of research-based resources to support students and teachers, etc.

For the sake of brevity we will comment on only a few lines of the PER areas here. One issue is the meaning of a theory and the role played by cognitive models. Up to now, our community does not share an agreed model about how students learn, nor do we have common expectations about a theoretical framework. There are strong reasons why these two foundations are difficult to build: the lack of acknowledged comprehensive theories about human cognition, organization and representation of knowledge, or about education; the different level of importance given to the role of a framework about students’ construction of knowledge and its dynamics; the degree of effort demanded for conducting empirical studies that were launched in the early days of PER and still absorb many resources. What actually *is* fairly commonly shared is a learning model inspired by moderate constructivism and its empirical validation. This focuses on individual knowledge construction and organization, in the framework of one’s own experiences; amongst all the inputs coming from the natural and socio-cultural environments, the learner selects those perceived as significant according to her/his previous knowledge schemata and integrates them into the personal, dynamic and multi-dimensional knowledge net. Many inevitable transformations occur in this process.

The research line dealing with ICT/ET-led innovation deserves particular attention. Contributions in this field are many, including the educational use of data acquisition systems, professional general purpose software, visualization tools, simulation and modelling environments, virtual laboratories, web based archives, collections of problems, questions, images, e-learning (in its multiple meaning), etc.... Three technology-based research lines: Lab work, Modelling and Visualization are schematized in Fig. 2.

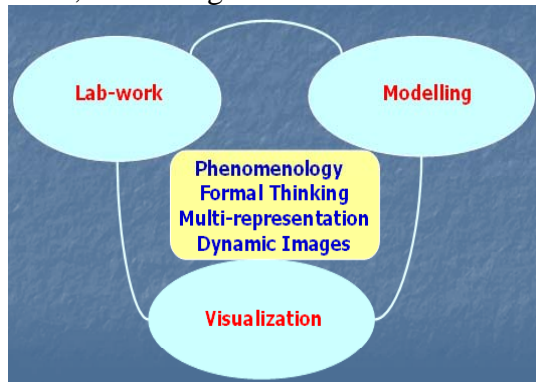


Fig 2: Three technology-based PER lines

Their synergic interaction facilitates the addressing of important aspects of PE such as: exploration of phenomena, made much easier by on-line sensor based experiments; becoming familiar with multi-representations of the same data and being capable of choosing/using the most appropriate representation for the problem to be solved; the role played by models in representing phenomena, in constructing formal thinking and in relation with a theory; the role of dynamic images in clarifying key features of dynamic processes.

Lab work and Modelling are two “old” research lines that have been addressed for some considerable time. In the nineties computer-based lab systems began to be used in many schools⁵. Several names are used for these: Data Logging, Computer-based Lab Systems, MBL, On-line Lab, etc. We prefer to use RTEI (Real Time Experiments and Images) to explicitly refer to the role of images of graphs. Our group has been conducting research in this area for many years, focusing on teacher education and on proposals for class activities [11-13]. RTEI is a suitable approach whenever emphasis on lab work is crucial. Amongst the main didactic advantages to be gained are: on-line graphical representation of data, which fosters the linking of observations and abstract representations; implementation of the PEC cycle (Prediction – Experiment – Comparison) to help students explain their ideas/reasoning in their own words; global versus local viewpoint, to look at and compare trend features with local variations in the time evolution of a variable; variation approaches (what if ... is changed?) to distinguish between major and minor effects; multiple representations of the same data to enhance students’ competences in correlating variables; etc. Our research has focused on investigating how RTEI approaches can: favour the integration of knowledge (scientific, naïve); help in addressing contents that are otherwise difficult to tackle; help change the lab work rationale from step-by-step guidance to motivating exploration of complex phenomena familiar to students and well known in terms of commonsense knowledge; make possible (and easy) a “From Real to Ideal” rationale through paths starting from real phenomena, searching for regularities and rules, building models of the studied system and finally abstracting to the ideal case behaviour and physics law. Fig. 3 shows an example activity that addresses the Galilean composition of velocity, which inspires to this rationale.

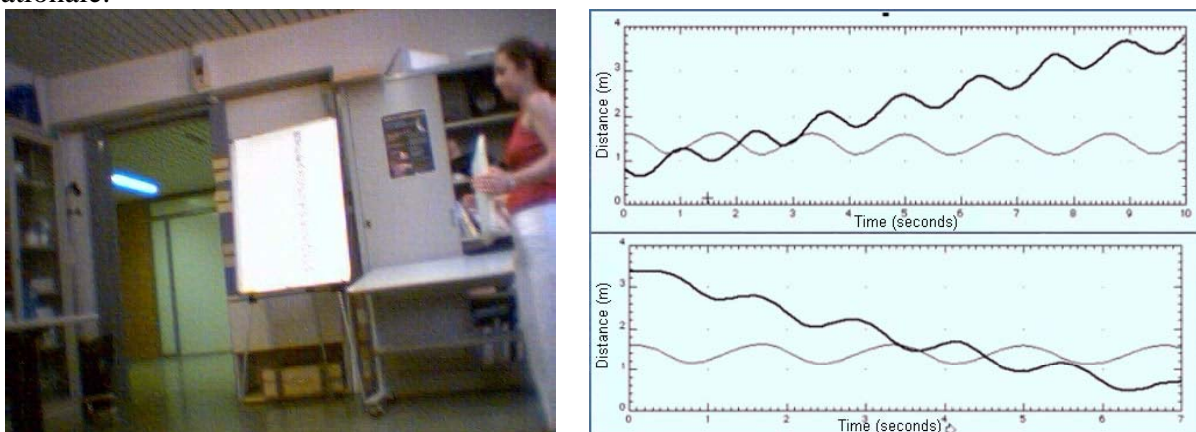


Fig 3: a) a person walks regularly toward/away from a motion detector while moving a plate she is holding back and forth; b) resulting $s(t)$ graphs of the combined motions. The thin line is the $s(t)$ of the plate when the person is still.

The kinaesthetic knowledge about the motion of a plate held in the hands and moved back and forth is the basis of the activity. This motion is combined with a regular walk toward or away from a motion sensor and, if the student is seated, with the motion of the chair moved in phase or in counter-phase by another student. The knowledge coming from perception and everyday life is linked with abstract kinematics representation of motion, namely position, velocity and acceleration vs. time graphs. From graph analysis it is easy to infer rules such as “V of plate when student walks = V of plate when student is still + o – V of walking student” and “V of plate when chair moves in phase (counter phase) = V of plate when chair is still + o – V of chair”. These rules lead the way to the one-dimensional Galilean law of velocity composition, which is later extended to 3D. This approach helps to elicit difficulties about the meaning of

⁵ Several user friendly systems are commercially available: *Data Logger*, *Science Workshop*, *Coachlab*, *V-Scope*, etc.; some include video analysis tools.

negative velocity, the role of conventions vs. invariants in motion, the extrapolation from real, “dirty” phenomena to ideal/abstract cases, etc. So, a topic usually learned through memorization comes to life; students are motivated, share their experiences and exploit peer learning.

Another important PER line is modelling, the understanding of the role and meaning of models being one of the cornerstones of physics knowledge. Ideas about models held by many students (and some teachers too) are often confused and ambiguous. Difficulties are encountered in: distinguishing the real phenomenon from the mathematical, formal model of its main features; being sufficiently aware that a model is an artefact of the human mind (whose construction is also fed by observations and experiments) and not a natural object “hidden somewhere”; distinguishing model from theory and being aware that a theory can frame many models [14, 15]. Metaphorically speaking, models are like clasps between, on the one hand, the worlds of physics phenomena and their descriptions in terms of empirical rules/laws and, on the other, the world of theory, a system of principles, definitions, theorems, etc. justifying processes and phenomena [16]. Simulation and modelling environments have been proposed by PER since the early 80s; the theme continues to be a crucial one⁶. Programming-based approaches have been proposed to the building of models, the language being the equations. By contrast, visual language is proposed by modelling environments based on the manipulation of virtual “objects”⁷.

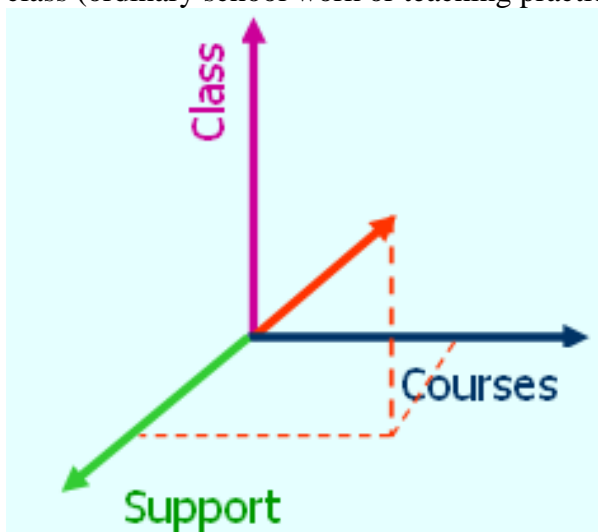
PER has focused on several didactic facets of modelling, aiming to help students: learn that the same mathematical model can describe various phenomena, according to the meaning of the variables; become aware of the power and limits of a model for description/prediction; understand through experimentation that using/interpreting proposed models is different from building a model starting from ideas/hints about the aspects or nature of the phenomena to be modelled; learn that different models can be framed by the same theory. As with the role of the PEC cycle in lab work, the HPE cycle (generation of Hypotheses, Prediction of trends and Exploration of the model) is proposed as a powerful tool for a cognitive fruition of a modelling activity. The distinction between simulation and modelling is not a clear-cut one: students (and teachers) often think of them as synonymous, forgetting that generally in a simulation the computer program is withheld from the user while in a modelling environment the user actually “writes” the program, in terms of equations or through manipulation of virtual objects. Simulations are rather popular in PE: unfortunately they are sometime often used to replace lab work, especially by teachers largely unfamiliar with experiments. This approach may entail disadvantages or even lead to a cognitive trap: in a simulation whatever happens has been foreseen by the software, while in lab work the unforeseen can offer powerful opportunities for encountering unknown zones (which may be investigated further or deliberately and consciously sidestepped), for establishing links, for deepening the topic, etc. The ideal is to combine modelling and simulation activities with lab work; the competencies that can be acquired through these means are different and complementary. At school, fitting experimental data is often one of the first modelling activities; in the case of the RTEI approach, given the very many data that can be collected and represented on on-line graphs, the synergy between lab work and modelling can be easily aimed at.

One of the PER areas with major impact on the school system is Teacher Education (TE). There is some socio-cultural bias in thinking about a «good teacher»; many members of the PE community believe that subject matter knowledge is a sufficient condition to teach well, that teaching cannot reach the status of a science, being essentially an art, therefore innate capabilities

⁶ A pioneer work is Cellular Modelling System by J. Ogborn. The 2006 GIREP Conference title is Modelling in Physics and Physics Education

⁷ Spreadsheet and general purpose software as Mathematica and Mathcad are also used. Several modelling environment are available (ex. StarLogo, CoMet-MODUS, Stella, Modellus, Interactive Physics, etc...). A friendly manipulation of variables/parameters and choice of grade of complexity of the model, is a common feature

are needed and not very much can be learned. Being gifted in relating to people is surely helpful, as well as being emphatic and capable of fostering interactive and constructive group dynamics. Nevertheless many aspects of the science of teaching can be studied and learned so as to acquire professional competencies. On top of a sound disciplinary knowledge, competencies are needed in: students' learning difficulties and research-based approaches to elicit and overcome them; advantages and problems of learning environments and didactic materials/tools; optimal accessibility of tasks, etc. Critical analysis of research results about teachers' conceptions of learning/teaching processes can help increase awareness of one's own naïve and practical epistemologies and their consequences on interactions with students. In implementing a research-based teacher education program, the ideas, actions and requests of the teachers bring crucial contributions to the viewpoints practiced in PER through a cross-fertilization that brings mutual advantages. TE may be described as a process with two main dimensions (fig. 4), one representing all situations where pre- and in-service teachers are taught (courses/workshops, in presence or at distance, etc.) and perceive themselves as learners; one representing their work in class (ordinary school work or teaching practice).



In current TE, the “courses” dimension is given higher priority than the “class” dimension and is usually focused on: remediation of possible “grey zones” in disciplinary knowledge; updating of physics to be taught; analysis of naïve knowledge schemata and use of tools to elicit them; experiential approach to research-based “best practices”; etc. Practicing the “class” dimension makes it possible to discuss how teachers: interact with students; put their practical epistemologies into action; use tools and materials; communicate (contents and registers); question, test and assess the students; etc.

Fig 4: A schemata of Teacher Education process

When a teacher implements innovations in ordinary class practice, inevitably transformations occur, according not only to the boundary conditions of the local context but also to the teacher's beliefs about teaching/learning, her/his knowledge and experience, goals and attitudes. Awareness of typical transformations, both resonant and dissonant with the innovation rationale, is helped by critical analysis of “stories” of fellow teachers who implemented the same proposals [9]. In this analysis, special attention should be paid to those critical details [10] or fine structure of the innovation rationale that, when well interiorised/managed by the teacher, can really support learning. The “courses” and “class” dimensions are equally relevant and should be practised with about the same intensity; the acquirable competencies are diverse and are all necessary to be an effective physics teacher. In pre-service teacher education the “class” dimension is easier because of the teaching practice; for in-service teachers it is more complex, but technology-based resources and communication can help greatly, especially for cooperative situated interaction via structured virtual communities. Such communities are also powerful means to implement the “support”, dimension so crucial to helping teachers in self-education and day-by-day work at school.

TE can be viewed as a process starting from “knowledge of physics” and reaching “knowledge of physics to teach” (Fig. 5). The latter is very similar to PCK (Pedagogical Content Knowledge) [17,18], increasingly addressed by current research.

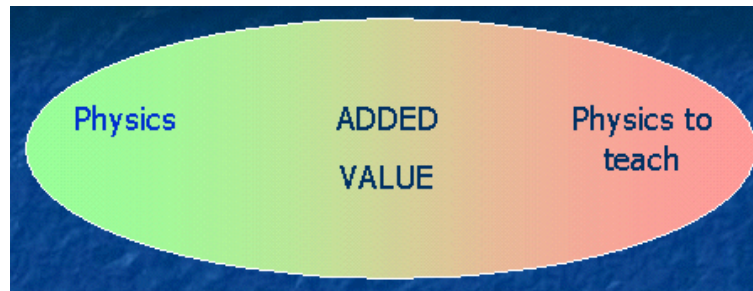


Fig 5: Transition from “Physics” to “Physics to teach”

Building PCK not only means integrating disciplinary and pedagogical knowledge, it also needs much added value. A non-exhaustive list of its components includes competencies in: exploiting students’ knowledge in planning/managing class work; tuning activities/tasks to diverse cognitive styles; evaluating and choosing resources available for teaching; valuing students’ ideas about the world; dealing with the transformations that always occur in all areas of learning; tuning to the communication registers of students; exploiting ICT/ET; etc. Different facets of PCK should be possessed by an effective physics teacher, e.g. PCK-in-planning (an intervention); PCK-in-action (in reacting to students with very rapid decisions); PCK-in-reflection (when reflecting about what happened) [19]. Direct experience⁸ with the same learning environments proposed to their students (approach, setting, materials, etc.) helps to learn experientially “the physics to teach”. Crucial features of the construction of PCK are a synergic mix of methodologies and contents addressed at the same time (to decrease the risk of ineffective meta-discourse about methods), explicit “teaching” about competencies and focus on the added value.

PER future trends and challenges

PER is a rather young field and different perspectives are natural components of its progress. There is general consensus on transforming the current PE, as far as teaching strategies, learning environments, approaches, contents, etc. are concerned. Research along these lines will continue and expand together with that on ways to engage students’ interest in physics and, more widely, in science. This trend has a broad justification: intrinsic educational value, demands from rapidly changing social contexts, new professional opportunities for physicists, the need for a sense of social responsibility about science-based decisions, etc. A better equilibrium is to be hoped for between the emphasis on empirical research into students’ ideas/reasoning and the suggestions that might come from theoretical frameworks and/or cognitive models, taking into due consideration the multi-dimensionality of learning/teaching and avoiding the possible traps of “the global incantation to grand theories” [20]. An important research line concerns the innovative contributions from educationally correct use of ICT/ET and TEL (Technology Enhanced Learning). An open, constructive discussion about how much the physics research paradigms are transferable in PER is needed. Occasions like this conference provide good opportunities for discussing these issues. The future trends are mixed with some *needs* to be addressed urgently. Interaction with the physics research community needs improvement, the current acceptance is insufficient. PER should be more convincing in providing evidence of results and in claiming their practical usefulness. Many physicists should change their belief that “teaching is but an art”. A better integrated international PER community is needed: the 2003 Varenna Summer School made visible the significant differences between the EU and US viewpoints. Appropriate, stable funding and better career prospects are needed to support PER development. In the EU a greater effort is needed for effective sharing/dissemination of the rich patrimony of results and research-based materials published in national languages. These are major challenges, as is that of establishing an effective relationship with education policy makers. Furthermore the PER community has to interact closely with both the physics and the pedagogy

⁸ Direct experience may mean, in the case of ICT/ET-led innovations, to have some experience of personal use of basic ICT tools; this may still be a problem in some countries.

communities; this implies competencies in Physics, Cognitive Sciences, Pedagogy, Epistemology, Communication, ICT- ET, Linguistics, Semiology, etc. This situation does not mean that a PER person is a “Jack of all trades and master of none”: the solution is coherent teamwork where different (sometime conflicting) viewpoints are experienced as advantages rather than obstacles, and the supporters of each perspective learn to negotiate constructively.

A vision of PE/PER



Fig 6: transition from the “School of Teaching” to a “Laboratory of Knowledge”

My vision deals with the transformation from “the School of Teaching”, where activities are largely teacher narrations, to “a Laboratory of Knowledge (LoK)”, a learning environment that inspires to the characteristics/atmosphere of a Renaissance master painter’s workroom (Fig. 6). The centre of LoK is the learner building knowledge through an idiosyncratic process of integration into her dynamic knowledge net, of the inputs from the natural and socio-cultural environment, according to a moderate socio-constructivist learning model. The character of the process is emphasised, the process is valued as much as the goal. A crucial feature is collaborative and situated construction of knowledge: learning is almost always undermined by isolation and enhanced by co-operation. ICT/ET have produced many changes in how physics is communicated: web-based learning materials are increasingly being used; distance and face-to-face learning should be usefully blended in LoK.

Physicists have a long tradition of collaborative work; not by chance the web was born at CERN. LoK places great value on striking a balance between knowledge based substantially on abstraction (a strong feature of the School of Teaching) and knowledge “of doing”, which students usually manage to do better. In a continuum between Abstract Knowledge and Knowledge “of doing”, any student needs to find/choose an appropriate access point. The characteristics of LoK foster this process through variety in activities, peer learning, playful learning of topics resonant with personal interests, working according to one’s own attitudes and capabilities, being supported by a group identity. Another crucial balance is between the cognitive and emotional spheres; if the latter “work well”, learning is favoured as the neurosciences indicate and experienced teachers know. Emotional aspects are deeply related to motivation and social interactions. LoK aims at fostering both the capability to listen to others’ opinions, a skill needed to co-operate effectively, and respect for differences, seen as a source of richness rather than of fear. Gaining realisation, through experience, that the same topic can be seen from multiple/different viewpoints is crucial. Co-operative work helps to develop a sense of responsibility toward the group, the realisation that one’s task affects the success of others.



Fig 7: Dante and the Three Kingdoms by Domenico di Michelino. Museo dell'Opera del Duomo, Florence

Globally, the LoK rationale can be summarised by two keywords central to the thought of Dante Alighieri: “Intelletto” and “Amore”, the former representing the cognitive spheres, the latter the emotional ones. In Dante’s vision (Fig. 7) personal growth is a balanced enfoldment of Intelletto and Amore. I strongly believe that education as a whole, PE and PER should be characterised by such an enfoldment.

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