Frontiers of Fundamental Physics 14

List of speakers in conference

Physics Education

Updated on January 8, 2015

Cécile **Barbachoux** (ESPE) **July, 15, 14h30 – 15h00, Room 407, Physics Education**

Dynamics of pedagogical innovations: roots and developments. Cases of study in Physics and Mathematic

In general, education, R&D and working life cooperation should form a solid and interactive whole that is able to respond to dynamic and ever-changing expectations. Embedding pedagogical knowledge in innovation activities may offer a long-desired theoretical basis for developing knowledge-based competitiveness in the cooperation between working life and education. Here, the cornerstones of innovation pedagogy are interdisciplinary operations, R&D, curricula and internationalisation in addition to entrepreneurship and service activities.

The key elements here are innovative learning and teaching methods, which can be interlinked with the surrounding working life and innovations by physical products, services and processes. Acting together in an interrelated, interactive and innovative environment, these elements operate within the circle of continuous improvement. In such settings, learning and teaching methods are developed more expediently, working life operations and competitiveness are enhanced and new innovations are created.

The overall aim of innovation pedagogy is to contribute to the development of student's innovation competencies.

Innovation competencies refer to knowledge, skills and attitudes needed for the innovation activities to be successful.

Frédéric **Bouquet** (UPS) **July, 15, 15h30 – 16h00, Room 407, Physics Education**

Reimagining the teaching of physics in university

In France, the teaching of physics at a university level generally follows the classical pattern lecture / tutorials / students' labs. Within this framework, we developed in our university new teaching units based on a project approach, following a "learning by doing" philosophy; a one semester unit focusing on outreach project (such as street art as a way to engage a public, a board game to discover astrophysics, and so on), and a week-long students's lab using the Arduino technology and letting the students choose and building their experimental setup. The outreach unit has been running for two years; the latter unit will be tested next year. We will present and discuss these units and how they are perceived by the students, who are not used to this approach. We will also present new ways to talk about physics that can be used outside the university to engage a larger public, developed in collaboration with designers, graphic and web professionals (see www.physicsreimagined.com).

Damir **Buskulic** (UdS / LAPP) **July, 16, 17h30 – 18h00, Room 407, Physics Education**

No magic wand for teaching physics

Is it possible to improve our teaching without becoming experts in didactics ? At the physics group of the Université de Savoie, we experimented a few techniques and options, with the help of experts in pedagogy. Among others, we will describe the use of the online teaching platform WIMS [1] that allows random exercises, has a large choice of interaction methods and a formal engine; the use of videos of physics courses to be viewed online; experiments in tutorial classes; the use of audience response devices (clickers), in connection to active learning. We are also experimenting some efficiency measuring tools (concept inventories) [2]. Finally, we will start in the near future experimenting a flipped classroom.

References

[1] One of the WIMS servers : http://wims.unice.fr

[2] D. Hestenes, M. Wells, G. Swackhamer, Force Concept Inventory, The Physics Teacher, Vol. 30, March 1992, 141-158

Ricardo **Coelho** (FCUL) **July, 17, 16h00 – 16h30, Room 407, Physics Education**

History and Philosophy of Science Can Improve Problem-Solving

There has been much research on students' misunderstandings of force. Some physicists have pointed out, however, that we do not know what force is. The most common definition of force in textbooks - force is the cause of acceleration - has been criticized for more than two centuries (d'Alembert, Carnot, Kirchhoff, Mach, Hertz, Poincaré, among others). By means of the simple Atwood machine problem it will be shown that the concept of force as cause of acceleration can be misleading [1,2,3]. It can be shown, however, that this concept of force is a logical consequence of the law of inertia. This law, in turn, cannot be tested experimentally (Planck, Schaefer, French, Nolting, among others). To avoid a statement of which we cannot be sure, the present paper proposes to understand the law through its function in the theory. In this case, we do not have to say how a free body moves, but rather that the rectilinear and uniform motion is the motion of reference in Newtonian mechanics. This enables us to overcome that difficulty with the concept of force.

References

[1] Poggendorff, J. C. (1853). Abänderung der Fallmaschine. Monatsberichte der Königlichen Akademie der Wissenschaften zu Berlin (pp. 627–629).
[2] Graneau, P., Graneau, N. (2006). In the grip of the distant universe: The science of inertia. New Jersey: World Scientific.
[3] Coelho, R.L. (2013) Could HPS Improve Problem-Solving?. Science & Education 22, 1043-1068. https://www.springerlink.com/content/l246453353g12818/fulltext.pdf

Benjamin **Couturier** (CERN) **July, 18, 15h00 – 15h30, Room 407, Physics Education**

LHCb outreach activities (on behalf of the LHCb Collaboration)

The LHCb experiment is a general purpose spectrometer in the forward region optimized for precision studies of beauty and charm hadron properties. The volumes of data produced by the LHC make it possible to perform such precision measurements with only a fraction of the total LHCb dataset, making it an ideal playground for developing new types of masterclass exercises.

We present here LHCb's first foray into the masterclass programme, in which students are taught how to make a 1% precision measurement of the D0 meson lifetime. The students learn to separate D0 mesons from the background in LHCb's vertex detector and build up a signal mass peak, before learning about how to use background sidebands to extract the signal properties in other variables of interest. They then perform a fit to measure the D0 lifetime, and discover that the result is biased by charm produced in the decays of B hadrons, which has an artificially long lifetime compared to charm produced directly in the proton-proton collision. Finally, the students learn how to separate these two kinds of charm based on the D0 mesons distance of closest approach to the primary interaction and obtain a precise measurement in agreement with the world average. We present the software framework developed for this exercise, give a demonstration of the exercise, and discuss plans for the future.

Damien **Givry** (AMU) **July, 18, 16h00 – 16h30, Room 407, Physics Education**

Schema or not schema? that could be the question of teacher

This research focuses on written language and systems of signs to study the learning of scientific concepts [1]. It proposes to show that students (Grade 10 [aged 15]) mobilize ideas about gas in different ways in regard to the semiotic registers (text or diagram) proposed during an assessment. Our study adopts a socio-constructivist approach of learning and develops a theoretical framework, articulating elements from the didactic of physics with semiotics concepts of Duval [2]. We give a test with questions (using simultaneously text and diagram) to approximately 90 students just after a teaching sequence on gas. We categorize with the software Sphinx students' answers and diagram. This analysis has excellent intra-analyst reliability of our coding with the best level of reproducibility (Cohen's Kappa test) and all our results are statistically significant (test of Khi2). Our results show that: (I) situations affect the mobilization of students' ideas in regard to the semiotics registers involved in the assessment, (II) the semiotics registers have an effect on the mobilization of students' ideas according to the facets of knowledge. Students are much more efficient in the register of: (a) schema to use facets about *particles contained in gas* and it homogeneous distribution and (b) text to mobilize their ideas about the *action of gas*, (III) the semiotic registers used in the tasks of the teaching sequence on gas could possibly be related to the mobilization of students' ideas in the semiotics registers involved during the assessment. The implications of this work in teaching and research in didactic of physic are important. It allows to have a better consideration of the semiotic register to assess students' knowledge.

References

[1] J. L., Lemke, Multiplying Meaning: Visual and Verbal Semiotics in Scientific Text, In J. R. Martin & R. Veel (Éd.), Reading Science, Routledge : London (1998)
[2] R, Duval . Sémiosis et pensée humaine: registres sémiotiques et apprentissages intellectuels. Peter Lang : Neuchatel (Suisse) (1995)

Paula **Heron** (Univ. Washington) **July, 15, 16h00 – 16h30, Room 407, Physics Education**

Designing and evaluating new approaches to instruction

Results from research indicate that many students emerge from traditional undergraduate science courses without having developed a functional understanding of important basic concepts. These findings have motivated changes in undergraduate courses in the sciences, mathematics, and engineering. Many newer strategies are described as "interactive" in that students are expected to engage in discussions with each other, and with professors during class time. Many strategies also involve paying attention to the ideas and beliefs that students have upon entering the classroom, ideas and beliefs that have they developed during previous formal instruction, and through their everyday experience with the natural world. Evaluating the effectiveness of these strategies requires a careful assessment of the goals of instruction and attention to a number of variables, many of which cannot be controlled. Examples will be used to illustrate the process of designing and evaluating instructional approaches and materials. The context will be physics but analogies can be made to other disciplines.

Marisa **Michelini** (UniUD) **July, 16, 15h30 – 16h00, Room 407, Physics Education**

Teaching modern physics in secondary school

The physics of the last century is now included in all EU curricula and in the last 10 years appear in all secondary textbooks, even if in not organic way. Although there are very different position as concern its introduction: conceptual knots in classical physics are quoted to argue the exclusion of modern physics in secondary school. Discussions are on goals, rationale, contents, instruments and methods, target students. The different proposals are relative to different goals: the culture of citizens, popularization, guidance, education. As concern what is considered useful to treat are considered: fundament, technologies and applications. Methods are: story telling of the main results, argumentation of crucial problems, integrated or as a complementary part in the curriculum. Modern physics in secondary school is a challenge which involves the possibility to transfer to the future generations a culture in which physics is an integrated part, not a marginal one involves curriculum innovation, teacher education and physics education research in a way that allows the students to manage them in moments of organized analysis, in everyday life, in social decisions. This innovation of curriculum outlines the request for new formative modalities, requires a school in which modern physics is presented as a cultural object that the teacher offers to the students not so much for them to be reproduced, but most of all, for them to be used in a creative way to face the interpretative problems as a competence in many contexts. For this scope it is necessary to undertake a revision of the contents and methods in school activities. Disciplinary knowledge should NOT be seen as static and definite, but in a progressive and continuous evolution, without split the product from its process, with a tight correlation between the many dimensions of knowledge. Disciplines have to become "maps": conceptual ones for understanding and organizational ones for a guidance in the interpretation of experience. In this perspective modern physics is an integrated content in curricula. Our research focus is the building of formal thinking on 3 directions: 1) Learning processes and role of reasoning in operative hands-on and minds-on to interpret phenomena; 2) object - models as tools to bridge common sense to physics ideas and ICT contribution focusing on real time labs and modelling; 3) building theoretical way of thinking: a path inspired of Dirac approach to quantum mechanics. From our research in physics education some different proposals for the modern physics are: 1) The physics in modern research analysis technics: Resistivity and Hall Effect, Rutherford Backscattering Spectroscopy, Time Resolved Resistivity; 2) Explorative approach to superconductivity (a coherent paths), 3) Discussion of some crucial / transversal concepts both in classical physics and modern physics: state, measure, cross section, 4) Foundation of theoretical thinking: quantum mechanics.

Elie **Milgrom** (UCL) **July, 15, 15h00 – 15h30, Room 407, Physics Education**

Less teaching yields better learning

What is the state of teaching in higher education? Can we provide evidence of the efficacy of our teaching practices? Are we really satisfied with the results we achieve? Do we actually contribute to develop creativity, initiative, autonomy, risk assessment and taking, collaboration, and do we actually prepare our student to solve complex, often multidisciplinary problems in innovative ways? Can we do better with our limited resources? Is our investment in teaching sufficiently acknowledged and valued? Are the QS rankings more or less relevant than the Shanghai ones, those of the Times, or those of Leiden?

We frequently hear such questions uttered by disillusioned and demotivated academics. We are, all of us, well aware of the expectations and needs of society, but we often feel that we cannot respond satisfactorily. It is tempting to blame our students ("who aren't any more like they used to be"), the shortcomings of secondary education, the pressures of competitive research, or even simply "the system", i.e. the others. Shouldn't we ask ourselves what we, as academics, could (or should) do to remedy the sorry state of affairs we so often deplore?

Solutions do exist! But we need to question our habits, our opinions, our intuitions, our traditions, our certainties. Also, if we are to change our teaching practices, we must do so based not on fads or on personal biases, but on validated results of well-run scientific experiments.

The talk will provide the author's answers to the following questions:

— What is efficacy in higher education?
— Is higher education efficacious?
— Why should we try to achieve better efficacy in higher education?
— How can we achieve better efficacy in higher education?
— Which conditions should be met in order to achieve better efficacy in higher education?

Olivier **Morizot** (AMU) **July, 18, 15h30 – 16h00, Room 407, Physics Education**

Collaborating with Historians of Sciences for a deep and complex rewriting of Physics courses.

"Balzac used to say that bachelors replace feelings with habits. Likewise, professors replace discoveries with lessons. Against this intellectual indolence that progressively deprives us of our sense of spiritual novelties, the teaching of discoveries along the history of sciences happens to be a great help. In order to teach students own to invent, it is good to give them the feeling that they could have discovered." [1]

University courses in Physics, such as we led them over years, do not work out anymore. Starting from this observation, we propose a reaction consisting in the rewriting and enrichment of their content [2,3]. As an example, we will present the structure of a course of basic geometrical optics. This course, focused on the essential part of the usual formal contents, gives priority to discovery, self-investment and reflection. And this is made possible by a structural interaction between the classic formalism of physics and fundamental questions arising from history of sciences.

This work is based on the collaborative work held by physicist O. Morizot (PIIM, AMU) and historian of mathematics Ph. Abgrall (CEPERC, CNRS/AMU).

References

[1] G. Bachelard, *The formation of the scientific mind*, (1938).
[2] P. Mahaffy, *Moving Chemistry Education into 3D: A Tetrahedral Metaphor for Understanding Chemistry. Union Carbide Award for Chemical Education*, J. Chem. Educ. (2006), 83, 49.
[3] O. Morizot, E. Audureau, J.-Y. Briend, G. Hagel and F. Boulc'h, *Two applications of the concept of human element in chemistry teaching; for a thorough understanding of chemical concepts*, submitted to J. Chem. Educ.(2014).

Valérie **Munier** (UM2) **July, 17, 14h30 – 15h00, Room 407, Physics Education**

Learning physics : from the nature and origins of difficulties to an evolution of teaching

There is a general agreement that undergraduate physics education presents a global challenge leading to many pedagogical innovations designed to enhance student's understanding of physical concepts. In France, current orientations focus on the development of inquiry based approaches with a model inherited from reforms in primary and secondary science education. Such an approach is promoted for its interactive nature placing students in a research-based environment. It is based on the view that designing the learning process should take into account the knowledge previously acquired by students ensuring that students fully understand the concepts involved and can apply their understanding to new situations. The purpose of that communication is to present long established results in physics education research and stress their impact on teaching practices. Using examples of scientific concepts known for presenting an obstacle to understanding, the communication aims at demonstrating that recurring ideas can be found amongst undergraduate students. These ideas might present a limited validity according to the scientific concepts. They are persistent and can be found amongst younger pupils, graduates, or teachers. They usually present a logic in a historical and cultural context. Many research studies indicate that the information presented through traditional science instruction is often incompatible with student's knowledge and beliefs and consequently, students persist on holding their alternative ideas of physics concepts. This lead to advocate a deeper understanding of the process of learning and teaching physics and conditions to its efficiency through close collaborations between physics academics and physics education research academics.

Daniel **Rouan** (LESIA) **July, 16, 14h30 – 15h00, Room 407, Physics Education**

Soon 20 years of "La Main à La Pâte", an international model for inquiry-based science education in elementary school

I'll present the status and the achievements of *La Main à La Pâte*, an international model for inquiry-based science education in elementary schools developed in France since 1995, under the impulse of Nobel prize Georges Charpak and Académie des Sciences. The pedagogical approach is based on study of objects of the real world, with science as an inquiry. Emphasis is put on: Questioning, Autonomy, Experimenting, Collective construction of knowledge. An important aspect of our action is the developmentof international partnerships, with for instance websites in six languages. I'll also present the new program *Maisons pour la science* started in France to insure the professional development of teachers in science.

Alexander **Rudolph** (Cal Poly Pomona) **July, 16, 15h00 – 15h30, Room 407, Physics Education**

Introduction of interactive learning into French university physics classrooms

We report on a project to introduce interactive learning strategies (ILS) to physics classes at the Université Pierre et Marie Curie (UPMC), one of the leading science universities in France. In Spring 2012, instructors in two large introductory classes, first-year, second-semester mechanics, and second-year introductory E&M, enrolling approximately 500 and 250 students respectively, introduced ILS into some, but not all of the sections of each class. Pre- and post-instruction assessments (FCI and CSEM respectively) were given, along with a series of demographics questions. Since not all lecture or recitation sections in these classes used ILS, we were able to compare the results of the FCI and CSEM between interactive and non-interactive classes taught simultaneously with the same curriculum. We also analyzed final exam results, as well as the results of student and instructor attitude surveys between classes.

Our results show that ILS are effective at improving student learning by all measures used: research-validated concept inventories and final exam scores, on both conceptual and traditional problem-solving questions. Multiple Linear Regression analysis reveals that interactivity in the classroom is a significant predictor of student learning, showing a similar or stronger relationship with student learning than such ascribed characteristics as parents' education, and achieved characteristics such as GPA and hours studied per week. Analysis of student and instructors attitudes shows that both groups believe that ILS improve student learning in the physics classroom, and increases student engagement and motivation. All of the instructors who used ILS in this study plan to continue its use.

This work is based on our paper which was published recently in Physical Review Special Topics - Physics Education Research; it was an editor's suggestion when it came out: http://journals.aps.org/prstper/issues/10/1

Chang-Mo **Ryu** (POSTECH) **July, 16, 17h00 – 17h30, Room 407, Physics Education**

Design and build physics lab course for general physics program in college

A new type of general physics experimental lab in a college, learning physics principles via designing and building a device has been attempted at POSTECH in Korea, Since 2010. Traditional general physics experiment course, which is almost standardized all over the world, is based on the concept to confirm and verify in the real world the principles taught in the class. The design and build physics lab (DBL) normally provided in the second semester emphasizes students to learn and realize themselves how physics principles operate in a real product by working on a project as a team, in agreement with the sprit of the STEAM educational system. In this paper, our experience on this new teaching approach in Korea in the past few years will be presented.

Alberto **Stefanel** (UNIUD) **July, 17, 17h00 – 17h30, Room 407, Physics Education**

Upper secondary students face optic diffraction using simple experiments and on-line measurements

The phenomenon of optical diffraction is crucial in order to recognize the wave behavior of light [1]. It limits the resolving power of optical instruments, including the human eye. Therefore it is of fundamental importance not only for practical applications, for example as in microscopy, but also in ability of our eye to distinguish two objects, as well as in our perception of one colors next to another, aspect exploited for example by Pointillists painters.[2]

The exploration of the optical diffraction in didactic laboratory with on-line sensors offers a unique opportunity to high school students to have experience of this important phenomenological context. Activities of computer modeling allow to pass from phenomenology to its interpretation. [3-5]

A research-based path was developed for upper secondary school approaching the optical diffraction through the experimental exploration of the diffraction pattern produced by a laser beam incident on a single slit. Students first analyze the diffraction pattern qualitatively, recognizing the global properties, then measuring with on-line sensors the light intensity vs position, constructing empirical relations between order and position of minimum, order and position of maximum, position and intensity of maximum. A computer modeling, based on Huygens' principle, is used to fit experimental data, showing the empirical relations, characterizing the experimental distribution and that obtained with the model. [3, 6]

Experiments in school was performed with 85 students, using IBL tutorial worksheets e pre-test, post-test. Positive learning paths of students emerged concerning the role of diffraction in everyday situations, activated by the qualitative analysis of the global properties of the diffraction pattern. The characteristic properties of the diffraction pattern, explored with on-line sensors, combined with the modeling activities aided students to move from a geometric point of view, based on rectilinear rays, to a physical one, based on an interference / intensity analysis.

References

[1] L. C. Pereira, J. A. Ferreira, H. A. Lopes eds., Light and Information, Girep book, Univ. do Minho, Braga. (1993).

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[6] M. Michelini, A. Stefanel, L. Santi, Teacher training strategies on physical optics: experimenting the proposal on diffraction, in Quality Development in the Teacher Education and Training, Michelini M ed., selected papers in Girep book s, Forum, Udine [ISBN: 88-8420-225-6], (2004), pg.568-576.

Guillaume **Trap** (Palais de la découverte) **July, 17, 15h30 – 16h00, Room 407, Physics Education**

Frontiers of popular physics demonstrations

Notwithstanding the proliferation of virtual tools of scientific communication, the use of real experiments presented live by science explainers remains extremely precious. Beyond obvious pedagogical and epistemological benefits, a demonstration is also source of ethical and esthetical reflections [1]. We will discuss some aspects and practical modes of the implementation of experimental popular fundamental physics shows (as performed in science museums in particular) according to the nature of the targeted public and the phenomena popularized.

References

[1] Trap, G. (2011). Le spectacle de la nature. In A. Giordan, J.-L. Martinand & R.-E. Eastes (Eds.), *L'idée de nature dans la médiation et l'éducation scientifiques, Actes des 31es Journées internationales de l'éducation scientifique*, (12 pages).

Laurence **Viennot** (SPC & LDAR) **July, 18, 14h30 – 15h00, Room 407, Physics Education**

From a subtractive to multiplicative approach, two concept-driven interactive pathways on the selective absorption of light

This talk will be devoted to a type of teaching strategy - concept-driven intellectual pathways , aiming at developing conceptual understanding and critical faculty in students. The examples will bear on interaction between light and matter at university level (absorption of light by pigments, liquids, the atmosphere) and will illustrate how formal simplicity main be compatible with some exigent approach linking a search for conceptual coherence and a critical analysis.

Jean-Marc **Virey** (CPT) **July, 17, 17h30 – 18h00, Room 407, Physics Education**

Experimentation of a new pedagogical method in 1st year's teachings of physics

The teaching of physics for first year post-bac students is confronted to increasing difficulties since several years. This problem is reinforced this year in France due to a new reform of the secondary educational system. We have experienced a new pedagogical method in the cursus "préparation aux écoles d'ingénieurs polytech", which is the first year of the Polytech engineer school of the Aix Marseille University.

The pedagogical method is a mixing between "problem based learning" and "peer instruction". The results of the method are very encouraging.

The outline of this talk is the following :

– listing of problems encountered by students and teachers
– presentation of the new pedagogical method
– results of the first year's experimentation

Nadine **Witkowski** (UPMC) **July, 16, 16h00 – 16h30, Room 407, Physics Education**

Horizons in Physics Education: a network to improve the attraction of physics

The academic network HOPE - Horizons of Physics Education - has been launched for three years from October 2013 with the support of the Life Long Learning Programme of the European Union. The 71 full partners are from 31 LLP-eligible countries of the Europea; they comprise 65 academic partners and 6 non-academic partners including the European Physical Society. The consortium is further enriched by 20 associated partners including the Institute of Physics, the American Physical Society or GIREP.

With an overall aim of enhancing the impact of physics within Europe and its visibility in society, the network will research and share good practice within four themes: the factors influencing young people to choose to study physics; physics graduates' competences that enable them to contribute to the new needs of the European economy and society; the effectiveness and attractiveness of physics teaching in Europe's university physics departments and their competitiveness in the global student market; strategies for increasing the supply of well-trained physics school teachers and for developing links between university physics departments and the teaching of physics in schools.