ICPE-EPEC 2013

The International Conference on Physics Education

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Book of Abstracts

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- The International Commission on Physics Education (ICPE) –
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- The European Physical Society Physics Education Division (EPS PED)
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Table of Contents

Welcome to Prague

Dear participants of the ICPE-EPEC 2013 conference!

We are really glad that so many experts from all over the world agreed to come to Prague to exchange experience in various areas concerning physics education. This *Book of Abstracts* shows that we can look forward to each day of the conference. In total there will be 8 keynote lectures, 175 oral presentations, 15 workshops and 120 posters – this promises to provide a lot of inspiration and is sure to initiate many interesting discussions.

Abstracts of more than three hundred contributions represent a lot of pages. We decided to save paper (and your arms that otherwise would have to carry a heavy printed book) and to publish this *Book of Abstracts* in an electronic form. We hope that – "in a changing world of new technologies" – you will find this solution natural and reasonable.

All abstracts submitted to the conference were reviewed by two independent reviewers. We would like to thank very much all those who kindly agreed to review the abstracts; we really appreciate their help.

Also, we would like to thank both IUPAP and EPS as well as the other sponsors mentioned below for their support. Last but not least, many thanks to all of you who submitted your abstracts, created your lectures, presentations and posters, and prepared your workshops. It is you, the participants, who are the most important element of the conference – and we hope you will enjoy both its scientific and social program. We wish you an informative and memorable week in Prague!

Leoš Dvořák

The conference is organized by:

The conference is sponsored by:

Schedule at a glance

Monday 5. 8.	
9:00-9:30	Opening
9:30-10:30	Keynote 1 Eugenia Etkina
10:30-11:00	*Coffee break*
11:00-12:00	Keynote 2 Rupert Leitner
12:00-12:30	EPS ceremony
12:30-14:00	*Lunch*
14:00-15:20	Session 1
15:20-15:30	*short break*
15:30-16:50	Session 2
16:50-17:10	*Coffee break*
17:10-18:30	Session 3
20:00-21:30	Workshop night 1

	Tuesday 6. 8.	**Wednesday** 7. 8.	**Thursday** 8. 8.
8:30-9:30	Keynote 3 Leopold Mathelitsch	Keynote 5 Pratibha Jolly	Keynote 7 Kyoko Ishii
9:30-10:00	*Coffee break*	*Coffee break*	*Coffee break*
10:00-11:00	Keynote 4 Irena Dvořáková	Keynote 6 Josip Sliško	Keynote 8 Douglas Caldwell
11:00-12:00	Poster session 1	Poster session 2	Poster session 3
12:00-13:30	*Lunch*	*Lunch*	*Lunch*
13:30-14:50	Session 4	Sightseeing tours	Session 7
14:50-15:00	*short break*		*short break*
15:00-16:20	Session 5		Session 8
16:20-16:40	*Coffee break*		*Coffee break*
16:40-18:00	Session 6		Session 9
		Free evening	Conference dinner (19:00-23:00)
20:00-21:30	Workshop night 2		

Friday 9. 8.	
8:30-9:50	Session 10
9:50-10:10	*Coffee break*
10:10-11:30	Session 11
11:40-12:00	Closing ceremony
12:00-13:30	*Lunch*

Note 1: Registration will take place on Sunday 4. 8. at 17:00-20:00 (together with Welcome coffee) and on Monday 5. 8. since 8:30.
Note 2: A short ICPE ceremony will follow Keynote 4 (Tuesday, 11:00).
Note 3: Oral presentations will last 20 minutes including discussion (15´+5´). There will be four oral presentations in each session.
Note 4: Periods when posters will be dispayed:

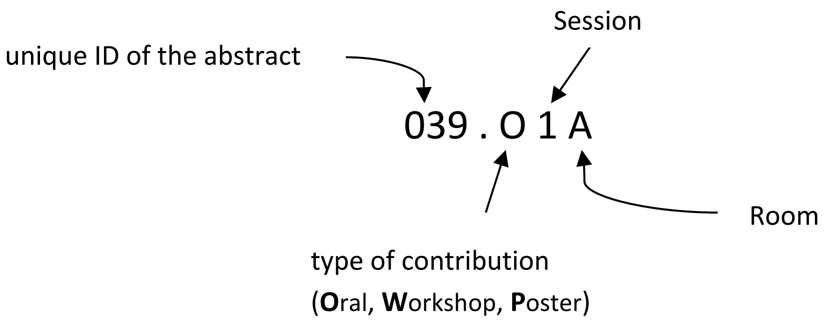
Posters for Poster Session 1: Monday - Tuesday 13:00
Posters for Poster Session 2: Tuesday 13:30 - Wednesday evening
Posters for Poster Session 3: Thursday morning - Friday

How to find information in this book

In the following pages you will find abstracts of keynote lectures, then of oral presentations and workshops (in chronological order), and finally of posters.

Each abstract has its own code – see the figure below on this page. Keynote lectures are denoted just by K1 to K8. All other codes start with a number equal to the abstract ID in the EasyChair system into which all abstracts were submitted. Then, after the full stop, a letter distinguishes types of contributions: O for oral presentations, W for workshops, P for posters. Then the number of a session follows: 1 to 3 for the three poster sessions, 1 to 11 for the oral and workshop sessions. (See the 'Schedule at a glance' above for further information.) There are also two "workshop night" sessions coded WN1 to WN2. For oral presentation and workshops, the code ends with a letter indicating the room. Examples:

321.O11F	denotes an oral presentation that takes place in Session 11 in Room F. (in the 'Schedule at a glance' you can find that it will start on Friday at 10:10; number 321 is just a unique ID of the abstract).
099.W6D	denotes a workshop in Session 6 (Tuesday from 16:40) in Room D
066.P1	denotes a poster in Poster session 1.



The codes are used both above the title of each abstract and in the Author index at the end of this book. Because this *Book of Abstracts* is in the form of a PDF document you can easily find the abstract you want using its code. Of course, you can also let your PDF reader find the author's name, a keyword, part of the title or any other information.

Keynote lectures

K1

Using physics to help students develop scientific habits of mind

Eugenia Etkina
Rutgers University, USA

Interactive engagement curricula are successful in helping students develop conceptual understanding of physics principles and solve problems. However, another benefit of actively engaging students in the construction of their physics knowledge is providing them with an opportunity to engage in habitual “thinking like physicists”. Some examples of such thinking are: drawing a sketch before solving any physics problem, subjecting normative statements to experimental testing, evaluating assumptions, or treating each experimental results as an interval. We can help students develop these “habits of mind” if we purposefully and systematically engage them in the processes that mirror the processes in which physicists engage when they construct and apply knowledge. For such engagement to occur, we need to deeply re-conceptualize the role of experiments in physics instruction and their interaction with the theory. However, most importantly, we need to rethink the role of the instructor in the classroom.

K2

Recent discoveries in Particle Physics and physics teaching

Rupert Leitner
Charles University in Prague, Czech Republic

In 2012 major discoveries in particle Physics were announced, the most important being the discovery of the Higgs-like boson with CERN LHC experiments ATLAS and CMS, as well as very important measurement of the third yet unknown mixing angle in neutrino oscillations experiments Daya Bay and RENO. Main experimental aspects of these discoveries will be explained using the knowledge of basic Physics.

K3

Physics and Sport

Leopold Mathelitsc
University of Graz, Austria

The combination of sport and physics allows for an extreme interpretation of active learning: students perform athletic activities, they measure physical parameters of their own movements, and analyze the resulting data. Since human motions are very complex, simplifications are necessary in order to interpret and understand the data. This includes active modelling and leads finally to a mathematical formulation. But new technologies can also play a crucial role in this process. Video cameras and in particular high speed cameras are now available on the market in such high quality and low price that school labs can afford to buy and handy them to the students for use. Also software for analyzing movements on videos can be applied by the students, since some of them exhibit a very comfortable handling, for example by providing an automatic tracker. Various examples of different sports activities, from physics lectures in school gyms to world-record events, should give an impression of the variety of possibilities that are inherent in connecting (school) physics and sport in an active way.

K4

Active learning in the Heureka Project – teachers in the role of students

Irena Dvorakova
Charles University in Prague, Czech Republic

Active work is a basic component of learning and teaching in our long-term Heureka project – both at school with pupils and in teacher training. Teachers in our seminars work the same way as pupils or students at school – they solve the same problems, do the same experiments and sometimes they even make the same mistakes. We offer them long-term and systematic training – the cycle of seminars for new participants takes ten weekends during the course of two years. So all participants have the possibility and also time to change their approach to teaching physics.

The character of our seminars is rather informal. Teachers join Heureka on a voluntary basis and for this they have no formal advantages or benefits at their schools. Also seminars are free of charge; they are organized during weekends, and teachers stay (and sleep) in classrooms. In spite of these conditions, already the 6th cycle of seminars for new participants has started in the autumn of 2012. From all the teachers that have attended Heureka so far, there are about 150 teachers that remain active and in contact with us. They have the possibility to meet both at different seminars organized for them and at an annual conference “The Heureka Workshops”. Usually more than 100 participants and guests from abroad take part on this conference.

We are convinced that our experience could be interesting and inspiring for other people working in physics education in different countries.

K5

A Collaborative Initiative for Strengthening Undergraduate Physics Education and Promoting Active Learning in the Developing World

Pratibha Jolly
University of Delhi, India

Project Physware emanates from globally shared concerns on the lack of high-quality education in physics with detrimental consequences on scientific research and socio-economic progress. A significant milestone in international cooperation, *Physware* aims to provide a sustainable collaborative model for capacity building of physics educators through a series of *Educate the Educator* workshops for those in the developing countries. The workshops are carefully designed to promote activity based pedagogic methods proven to be effective through rigorous educational research. They propagate curriculum and resource materials that are easily adapted to the needs of any region. While the emphasis is on using low-cost equipment and appropriate technologies that are locally accessible, participants are also introduced to ways of integrating emerging computer-based technologies for physics teaching, contemporary research, and applications of relevance to the work place. They explore ways of teaching fundamental new physics within the context of contemporary pedagogy that is both, hands-on and minds-on. After the success of a pilot workshop held at Trieste in 2009, the *Physware* series was launched in 2012 from the University of Delhi. Both workshops brought together a vibrant and eclectic group of participants who contributed actively to creation of innovative resource materials. It is hoped that many participants will emerge as regional leaders. Feedback shows that going beyond the constraints of its workshop format, *Physware* has the potential to emerge as a professionally networked community of practice.

*The *Physware* workshops have so far been conceptualized and co-directed by the author along with Priscilla Laws, Elena Sassi and Dean Zollman.

K6

Active physics learning: Making possible students' cognitive grow, positive emotions and amazing creativity

Josip Slisko
Benemérita Universidad Autónoma de Puebla, Mexico

It is well known that carefully designed sequences of active physics learning support students' comprehension of physical concepts and laws. If only this were its effect, active learning should replace lecture-based teaching and passive students' learning at all educational levels. Fortunately, the impact of active learning experiences in students is much broader. In my talk I would share research-based and anecdotal evidence about effects of active physics learning on students' cognitive level, emotions and creativity. A few students' demonstrations of weightlessness in free fall will be shown, too.

K7

Active learning in teacher training

Kyoko Ishii
Tamagawa University, Japan

Active learning is an innovation of teaching and learning and strongly connected to teacher education reform. A teacher's role in a knowledge based society is being shifted from a knowledge teller to a facilitator.

The practice of active learning in teacher training in the University of Fukui in Japan will be introduced. The faculty provides active learning for prospective teachers to engage themselves in scientific inquiry collaboratively. Students training to be teachers apply "Physics by Inquiry" (McDermott and the Physics Education Group at the University of Washington) during their undergraduate course. The students discuss and develop physical concepts.

We are also encouraging in-service teachers to innovate the lesson through "lesson study" and collaborative reflection. Professional development is a continuous, lifelong process for teachers because they are reflective practitioners. A teacher who is reflective tries to pay attention to the minds of the students and to figure out what the students think. In Japan, teachers try to improve "pedagogical content knowledge (PCK)" through "lesson study". They develop active learning programs to encourage their students to acquire knowledge through participating and experiencing.

K8

The Kepler Mission: Finding and Understanding Exoplanets using Undergraduate Physics

Douglas Caldwell
NASA-SETI, USA

We are living in a new golden age of discovery where the goal is not new continents, but entire planets around other stars, or "exoplanets." Since their first discovery in the 1990s, nearly 1000 confirmed exoplanets have been found along with thousands of other planet candidates. Within the next few years we will know whether planets like the Earth are common or rare in our galaxy and the students in school today won't remember a time when the existence of other solar systems was even in question. This tidal wave of discoveries, which has captured the public imagination, was made possible by advances in instruments and computing power, but the physics and math behind the search for and characterization of exoplanets is broad-based and largely covered in introductory undergraduate-level courses. I will discuss some of the physics tools used in various exoplanet detection techniques, emphasizing those used to understand and interpret data from NASA's Kepler Mission. By drawing examples from current exoplanet research, we can motivate students and let them know that what they are learning allows them to understand and contribute to cutting-edge research that is reshaping our understanding of our place in the universe.

Oral presentations and workshops

Monday

5. 8. 2013

»»Session 1A, 14:00-15:20««

004.O1A

Application of situated learning in the formation process of concepts of scientific physical limit transition models in the university students

Vladimir Ivchenko
Kherson State Maritime Academy, Ukraine

After the pioneering work of Hestenes the interest to the model approach in physical education is steadily increasing. Generally in the process of training it is customary to distinguish scientific models (aimed at the development of hypotheses, theories, and verification thereof) and educational models (the models constructed for solving educational tasks, models-algorithm for carrying out educational activities, and visual (material and virtual) models). One of the most widespread types of scientific idealizations in the university physics course is the limit transition abstractions – the models of objects that are constructed by way of limit transitions for selected number of their characteristics to their maximum or minimum values (for example: point mass, rigid body, ideal gas, black body, etc.).

Our long teaching experience has shown that the concepts of such ideal models are poorly perceived by students due to the high level of abstraction thereof. We have acknowledged that it is necessary to consider application thereof in various possible cases, i.e. to apply the situational approach, for deeper understanding.

Our research involved the forming of criteria for selection of real physical situations for the analysis of such models. We have concluded that these criteria are:

1. the purpose of theoretical description (qualitative criterion): which real objects can (or can not) be described within the framework of the analyzed model;

2. the accuracy of theoretical description (quantitative criterion): Whether it is possible to neglect the modeling errors in the quantitative description, i.e. errors arising as a consequence of neglecting several factors considered to be insignificant in the construction of the model.

For example, considering the point particle model it is necessary to use kinematic and dynamic approach. For illustration of the first criterion within the kinematic approach we propose to consider the following situations with the students: 1) whether it is possible to consider the Earth as a point particle while calculating the characteristics of the Earth's orbit and explaining the sunrise and sunset phenomena; 2) whether we can consider the bus of a certain size moving rectilinearly and passing large and small distances as a point particle. Within the dynamic approach the situation concerning misconception about the ideal gas as a set of non-interacting point particles may be very demonstrative.

To illustrate the second criterion within the kinematic approach one may estimate the error in identifying the moment of finish border crossing by a hundred-meter sprinter when the running time is measured by means of the manual stopwatch and the electronic stopwatch. The dynamic approach assumes separation of body properties into inert and gravitational ones in this case. It is convenient to consider the deviation of the inert body properties from point mass by the example of the relative error calculation in determining the oscillation period which error arises when replacing the physical pendulum of some form with mathematical pendulum of the same mass. A similar task can be suggested when analyzing the deviation of the gravitational properties from the point mass of quite common objects in the Universe, such as binary stars.

In summary, we can conclude that for successful implementation of situational approach in the formation process of concepts about scientific physical limit transition models it is necessary to:

– use deductive method – from introducing concept of model to specific physical situations in which it can (or can not) be applied;

– in the selection of these situations one should take into account two criteria for their theoretical description;

– these situations should have real life context.

Keywords: University education, limit transition physical model, situated learning

Topics: Learning

039.O1A

Student Engagement in a Collaborative Group-Learning Environment

Gerald Feldman, Larry Medsker and Raluca Teodorescu
George Washington University, United States

Studies of undergraduate science education show that students must be actively engaged in the learning process for it to be effective. Passive lecturing ("teaching by telling") is known to be insufficient for developing critical thinking skills. In the "studio physics" methodology, students work together in small groups and the instructor serves as a facilitator or "coach" instead of a lecturer – the laboratory component is integrated into the classroom, leading to a seamless progression of activities, including group problem-solving exercises, lab experiments and short demonstrations. An extension of the "studio physics" approach called SCALE-UP (Student-Centered Active Learning Environment for Undergraduate Programs) was adapted for larger classes – students sit at round tables (3 teams of 3 students each) for classroom activities, and the instructor circulates to keep students on track, answer questions and promote useful discussions. By merging the collaborative approach with the integration of various pedagogical activities, a dynamic collective learning environment is created which fully engages students.

We have implemented the SCALE-UP approach at George Washington University for all of our introductory physics classes. We have redesigned a classroom with 9 round tables, accommodating a total of 81 students. Each group of 3 students shares a laptop computer and a portable white board to facilitate their work together. The classroom walls have large white boards on which students can display their work, several large LCD screens for image projection, and nearby storage space for lab equipment. We instituted SCALE-UP in 2008, and we now have 5 years of experience with this method. The class has 3 sessions per week – 2 hrs on Monday/Wednesday and 1 hr on Friday (which includes a short weekly quiz). Groups are arranged by the instructor, and guidelines are outlined in a "group contract" that is prepared by each group. In class, students work collaboratively on conceptual questions and numerical problems ("ponderables"), in addition to short hands-on activities and longer lab experiments ("tangibles") using real-time data acquisition. Lecture is reduced to a minimum, so class preparation is quite important for students. To help students gauge their own understanding and to motivate their preparation, online "Warmups" are assigned and completed before each class. Student engagement is high in the SCALE-UP environment, and students gain a greater facility with the physics material in this collaborative mode compared to a conventional lecture format.

We have made a concerted effort to evaluate the effectiveness of this active-learning pedagogical approach. We have acquired data using in-class exams and various conceptual assessments (for both mechanics and electricity/magnetism), as well as information about student attitudes. We will describe the SCALE-UP pedagogy, summarize the particular features of our implementation, and present our data analysis results which indicate higher student gains in performance and improved student attitudes about their learning, and about science in general.

Keywords: Collaborative learning, active-learning environment, SCALE-UP, studio physics, student engagement, group problem solving

Topics: Learning, Teaching

098.O1A

Improving students' understanding of abstract concepts using cognitive conflict

Charles Bonello
University of Malta, Malta

Students find theorizing about abstract concepts in science a very challenging task. The challenge is derived from the fact that when learning about these concepts they tend to develop a conceptual understanding that is to a certain extent 'personalized'. Students' personalized understanding, often referred to as students' alternative frameworks [Driver, 1989] proves to be even more problematic if the student cohort considered is student teachers. The process of supporting students' improved understanding of such concepts can be enhanced through the use of 'cognitive conflict' during a teaching intervention [Adey, 2002].

In this teaching intervention, students are presented with a number of practical demonstrations and True-False [T-F] statements that have embedded in them sources of cognitive conflict. The classroom talk that results from these two classroom activities is meant to trigger cognitive conflict in the students and encourage them to problematise the concept under study. The intended outcome of this process is that the students would rethink their conceptual understanding of the subject area.

The findings of this study suggest that embedded sources of conflict do tend to provide a useful source of cognitive conflict but not necessarily of improved understanding. Furthermore, they can also prove to be a source of negative affective reactions for students. The overall outcome of this

study is that when such strategies are used, students need to be closely followed and supported so that the whole learning experience would not prove to be counter-productive.

References:

Driver, R. (1989): Students'conceptions and the learning of science, International Journal of Science Education, 11:5,481-490

Adey, P. and Shayer, M. (2002): Really raising standards: Cognitive intervention and academic achievement

Keywords: Cognitive conflict, improved understanding, affective reactions

Topics: Learning, Teachers, Teaching

200.O1A

Designing curricular reform from students' experiences as a way to reduce dropout rates in Physics undergraduate courses.

Paulo Lima Junior[1], Fernanda Ostermann[1] and Flavia Rezende[2]
[1]*UFRGS, Brazil*
[2]*UFRJ, Brazil*

High dropout rates strike most Physics undergraduate courses worldwide. Despite student's dropout being, in part, related to social and individual issues that lie beyond institutional control, high dropout rates might also indicate students' bad experience in the course (such as harassment, lack of support and bad teaching strategies). In this abstract, we briefly report the core results of a doctoral thesis dedicated to (1) identify reasons for dropout in undergraduate Physics' courses; (2) design curricular reform from students' experiences as a way to reduce dropout rates. This investigation took place at the Institute of Physics from a large public research-based Brazilian institution. After carefully reviewing international literature on dropout phenomena, we realized a three-leveled sociological analysis of (1) structural, (2) individual and (3) institutional factors related to dropout. This three-leveled analysis is theoretically subscribed to Pierre Bourdieu's sociological approach and led us to identify various reasons producing students' dropout - some of these reasons fall under institutional jurisdiction, while others do not. In the structural analysis, we found that working class and elite students are equally susceptible to dropout. However, working class students are much more likely to fail Physics' tests. In this sense, structural analysis supports that, although everyone is equally likely to leave the course, elite students are more likely to dropout toward more prestigious careers while working class students are more likely to abandon the course due to school failure. In the individual analysis, through in-depth interviews, we identified material conditions, skills and dispositions that are responsible for the dropout of five former Physics' students. These interviews demonstrate that some students do not only come into Physics undergraduate course with critical lack of skills in science subject matters, but they also demonstrate different dispositions toward dedicating to high educational achievements. This disposition toward high performance have played a critical role in students' retention and, eventually, is not acquired from family background.

Together, structural and individual analyses provide us with important information on how dropout rates do not depend only on institutional matters. However, it is precisely through critically analyzing institutional actions that one may identify actual ways of controlling dropout rates. Hence, institutional analysis was realized from interviewing a representative sample of students currently enrolled in the undergraduate course. Interviews were focused on students' institutional experiences. It resulted from the content analysis performed that the Institute of Physics, due to its own institutional arrangements, can not be considered capable of providing all students equal opportunities to learn for two reasons: (1) this institution accepts students from very different backgrounds, binding everyone to the same standards of high achievement without providing the necessary support; (2) it cultivates autodidactism as an educational principle, creating a hostile atmosphere to most students and legitimizing that some professors, for convenience, be careless to their most basic educational obligations. As the literature holds, providing all students with the same opportunities is a critical issue in controlling dropout rates. Hence, based on research findings, we designed a curriculum reform that puts the best professors in contact with the most needed students and strives to actually provide everyone with the same opportunities.

Keywords: University education, curriculum, dropout, sociology of education

Topics: Curriculum

Session 1B, 14:00-15:20

015.O1B

The Predict - Observe - Explain technique as a tool for students' understanding of electric circuits

Joan Borg Marks
University of Malta, Junior College, Malta

The use of multimedia in teaching physics offers a pedagogy which helps to motivate students' learning of the topics concerned. At the same time, even if the trend in modern teaching methods is to use multimedia, teachers must not ignore simple but effective teaching techniques which focus on putting the responsibility of learning on the student.

This paper looks at the learning of the topic of electric circuits by 17-year-old students covering an advanced level course in physics in Malta. The course consisted of traditional lecture sessions, tutorial sessions to help students tackle numerical problems and laboratory sessions where students carried out simple experiments on their own by following instructions provided on worksheets.

Electric circuits are taught in schools both at primary and secondary level. In spite of this, many researchers in education have reported problems related to the understanding of circuits, even after instruction has taken place. The ideas presented during the teaching process are described as 'abstract' by students and the so-called 'simple circuit' is seen as anything but simple. This paper reports the results of part of a pilot study dealing with the learning of key concepts in electric circuits. The main study was being carried out with the aim of establishing by how far traditional instruction helps in the understanding of the basic ideas related to electric circuits, with a focus on the understanding of potential difference in simple parallel circuits. At the end of the course the teacher, acting as a researcher, conducted interviews with one third of the student sample using the Predict-Observe-Explain technique, as students worked with the electric circuit made available to them. The aim was to see if this technique could offer a learning strategy helping students' understanding to become more meaningful. The study indicated that all students interviewed made a visible effort to understand and try to correctly explain how the circuit presented to them works. Moreover, about one third of these students managed to bridge the gap between their unscientific intuitions and the scientific view.

The use of new technologies was not specifically promoted by this course of study yet the Predict-Observe-Explain technique helped students shift their thinking towards the scientific view. The implication is that whether multimedia is used or not during teaching, choosing a teaching strategy which helps to arouse students' curiosity by creating cognitive conflicts to make students think, leads the way to a powerful and a qualitatively enriched teaching and learning experience.

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Keywords: Electric circuits, The Predict-Observe-Explain technique, thinking to learn

Topics: Learning, Teaching

081.O1B

Investigation of teachers' concept confusion related to electric and magnetic fields and the potential of a sequence of activities to address it

Miriam Lemmer[1], Ilsa Basson[2], Jeanne Kriek[2] and Aletta Zietsman-Thomas[3]
[1]*North-West University, Potchefstroom, South Africa*
[2]*University of South Africa, South Africa*
[3]*University of Witwatersrand, South Africa*

Basic concepts and interactions of electric and magnetic fields are usually introduced as separate topics in the school curriculum. Without explicit comparison of these phenomena, confusion of concepts and effects may be expected. Concept confusion related to these fields has been reported by physics education researchers on different levels of education and even amongst practitioners such as technicians and electrical engineers. Alternative models of magnetism, for example, "magnetism as electricity" and "magnetism as electric polarization" were found. Some students ascribe both magnetic and electric fields to charges, whether stationary or in motion. Concepts such as electric potential and potential energy, electric and magnetic dipoles and polarization and induction are often used incorrectly or interchangeably.

The paper reports on a study that was done with 21 South African secondary school teachers to

- investigate the occurrence of conceptual confusion regarding electric and magnetic fields

- select and sequence remedial activities based on conceptual refinement and context variation
- analyse the teachers' responses to the sequence of activities aimed to enhance conceptual discernment of electric and magnetic fields and interactions.

The teachers' conceptual confusion was identified with the aid of a conceptual questionnaire based on research results of the CSEM and other studies. In addition, their sketches of electric and magnetic fields and electric polarization were analysed.

The results showed different aspects of concept confusion amongst the group of teachers which were then addressed in a knowledge-upgrading workshop. The designed sequence of activities focussed on similarities, differences and relations between electric and magnetic fields, concepts, models and interactions. The activities were selected and arranged in order to attain conceptual refinement of experiential knowledge towards a scientific explanatory framework. In the activities variation in concept and context was applied with the aid of experiments and computer simulations. The teachers' responses during the workshop indicated the potential of the activities to foster conceptual understanding of electricity and magnetism through discernment of critical aspects of basic concepts and interactions.

Keywords: Concept confusion, electric and magnetic fields, conceptual refinement, variation

Topics: Learning, Teachers, Teaching

121.O1B

Magnetic vector potential in secondary school: a teachers' path

Marco Giliberti[1], Sara Barbieri[2] and Michela Cavinato[1]
[1]Physics Department University of Milan, Italy
[2]University of Palermo, Italy

The magnetic vector potential is traditionally presented only at university level and is widely considered as a pure mathematical tool to calculate the magnetic and the electric fields, i.e. a device without any (or at least with very poor) physical meaning. Even if in recent literature, many papers can be found that, on the contrary, clarify the physical meaning of the vector potential, at the best of our knowledge a clear and complete educational path on it is still missing. Our experience and some pilot experimentations with high school students and teachers, however, have driven us to seriously consider the opportunity to introduce the magnetic vector potential also at high school. In fact, in our opinion, the use of vector potential is a way both to better understand some fundamental aspects of classical electromagnetism and to open a door for a direct way of introducing important aspects of modern physics (i.e. the notion of the photon and the London equation of superconductivity).

In this talk we'll discuss the motivations that led us to develop an educational path for the introduction of magnetic vector potential in upper secondary school, some considerations in order to clarify general aspects of its physical meaning with examples, and the framework of our course on

magnetic vector potential for pre-service teachers training at the Milano TFA (Formative Active Training).

Keywords: Secondary education: upper, teachers training, magnetic vector potential, electromagnetism

Topics: Teachers, Teaching

127.O1B

Prospective primary teachers address electromagnetic phenomena

Marisa Michelini and Stefano Vercellati
Research Unit in Physics Education, University of Udine, Italy

Teachers education for Perspective Primary Teachers (PPT) need to develop competences both on contents (CK) and pedagogical aspects (PK) in an interlaced way; PCK (Shullman 1987, Anderson, 2008). If the study of the contents in the pedagogical and subject areas is not placed in the context of an in deep discussion of the learning knots and the core nuclei of the subject in the framework of the development of a learning path designed for a particular age group of students , it is not enough for the foundation of the referents implied in the planning of an active learning classroom coherent paths (Michelini 2004).

In the particular case of electromagnetism, it is not an teach subject in CK formation for PPT in Italy. Even if for today pupils, magnetic phenomena became part of everyday life. Playing with magnetic toys and using everyday objects, pupils observe magnetic interactions and develop their own mental spontaneous models (Gilbert et al, 1998) arriving in classroom with more relevant practical experiences on the subject than their teachers. Improve teachers experiences in a critical way allows them to understand the roots of the naïve pupils interpretative models that, being related to conceptual elements and reasoning on problematic situations that pupils faced in those spontaneous explorations (Viennot, 2006), are often characterized by a local vision of the phenomena for which the teachers had to select and address with pupils specific activity that will allow to pupils the best experimental framework of investigation.

A significant contribution in the foundation of conceptual nuclei and the identification of the milestones and the stumbling blocks of the subject is offered by activity based on an experiential model centered on the personal involvement of PPT in carrying out the same learning experience of pupils in an Inquired Based Learning path (Michelini & Vercellati, 2012).

The 120 PPT participating to the Laboratory have their own worksheet and were asked to use worksheets as planned for pupils during the Experiencial part of Interactive Lecture Demonstration (ILD) of the path presentation and discussion. At the end of this activity they individuate the conceptual nuclei and the learning knots and to compare and discuss individual choices done, working in small group to develop a proposal of learning path described by means of a conceptual map and a list of questions and actions aimed to be adopted in class with pupils.

Data coming from individual and collective analysis of nuclei and learning knots, exploitation and reinforcement of knots and nuclei, development of a procedural prospective as list of related steps of problematic activities descript in terms of conceptual maps are analyzed and discussed.

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Keywords: University education, perspective primary teachers, magnetism and electromagnetism

Topics: Teachers

Session 1C, 14:00-15:20

038.O1C

Web database of solved problems encourages students' active learning in physics

Zdeňka Koupilová, Dana Mandíková and Marie Snětinová
Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

To solve physics problems is a key ability which students should reach during their physics education. This competency is developed usually on the higher levels of education while the lower ones prefer the conceptual understanding of physics phenomena. There is usually lack of time to solve enough problems during lessons especially for students with worse previous education or mathematical skills. And moreover, there are hardly any suitable materials for home study of these students. For this reason we have developed a collection of fully solved problems. The structure of problems' solutions is specially designed to substitute tutor's help during lesson and encourage students to solve at least some parts of a problem independently. The development of the database started in 2004. Nowadays it contains more than 750 tasks in Czech, 90 tasks in Polish and 50 tasks in English. The database is available at the website http://www.physicstasks.eu/.

In the contribution we will present intention with which we have developed the database, used technology, structure of the problem solution, and experience with using it in introductory university courses and in high school physics course. We are continuously monitoring how the database is used and users' opinions on the collection; we will mention the results too.

Keywords: University education and secondary education: upper, web-based learning, solved problems, structured help, physics

Topics: ICT

049.O1C

E-Learning in Physical Science through Sport: Learning Objects and their Dissemination

Robert Lambourne
The Open University, United Kingdom

E-Learning in Physical Science through Sport, the ELPSS project, was part of the first generation project strand of the UK's National Teaching Fellowship Scheme. The main aim of the project was to design, produce and disseminate a range of reusable learning objects (RLOs) that would encourage and enhance the teaching of various aspects of physical science using examples and contexts drawn from the field of sport, and particularly from the various Olympic sports. A supporting aim was the

production of dissemination materials that would inform academics of the existence of these (non-commercial) RLOs and explain how they could be down-loaded from digital repositories and incorporated into a range of courses at a variety of levels. This talk will briefly introduce the ELPSS RLOs and discuss the principles that guided their design; the main emphasis, however, will be on the dissemination of information about the project, the special efforts that entails, and the challenge of bringing about changes in pedagogic culture in an established area such as physical science.

Keywords: University education, Secondary education: upper, reusable learning objects, sport, basic physical science, dissemination

Topics: ICT

110.O1C

Development of a Pre-service Course on Integration of ICT into Inquiry Based Science Education

Trinh Ba Tran[1], Ed van Den Berg[2], Ton Ellermeijer[3] and Jos Beishuizen[2]
[1]*VU University Amsterdam, Viet Nam*
[2]*VU University Amsterdam, Netherlands*
[3]*Foundation CMA, Amsterdam, Netherlands*

In order to be able to integrate ICT tools in Inquiry Based Science Education (IBSE), teachers need much time and support for mastering ICT tools; learning the basis of IBSE; and getting experience in applying these tools into students' scientific investigation. Following a design research approach, our project aims to develop a training course for both pre-service and in-service secondary science teachers on the use of ICT tools integrated into IBSE lessons. The challenges in both groups are the lack of time and the heterogeneous background of teachers.

This report focuses on two case studies of an ICT-IBSE course for pre-service science teachers from universities in the Netherlands. The course offers flexible learning contents with supporting materials through a blended environment via the Moodle platform. Pre-service teachers are introduced to the Coach learning environment which integrates all ICT constructive tools such as data logging, video measurement, and modeling. The course consists of 3 sessions of each 3 hours, spread over 5 - 7 weeks, and major tasks in between the meetings. A participant first learns basic concepts, skills, and possibilities of the ICT tools in science teaching (broadly at conceptual level), then chooses a particular tool (data logging, video measurement, or modeling) to practice advanced skills mostly on their own with supporting materials such as Coach basic, tutorial, subject activities and instructional videos. With that tool, next, he/she has to prepare an IBSE lesson, try it out in class, and evaluate the integration of the tool into the IBSE classroom activities.

During the case studies, we use instruments such as questionnaires, observations, documents, and interviews to collect data on the participant's learning process and outcomes. Data analysis will help to answer the following research questions:

1. To what extent is the course implemented as intended? What are the obstacles in its implementation?
2. To what extent does the course have the effects as expected? What are the reasons for not realized effects?

Evaluation of faithful implementation and effectiveness of the course will provide evidence to revise the course design, which will be subsequently elaborated into the next course setting to be tested again in next case studies.

In the presentation, we will present the design principles in detail, the courses themselves, assessment questions, and the findings of two case studies.

Keywords: University education, post-graduate teacher education, ICT, IBSE, design research

Topics: ICT, Teachers, Teaching

268.O1C

Simulated Interactive Research Experiments (SIRE) - A novel ICT tool for active learning in the domain of quantum research

Mathias Tomandl, Christiane Maria Losert-Valiente Kroon, Martin Hopf and Markus Arndt
University of Vienna, Austria

We report on the development of a new technology-enhanced learning tool for modern physics – the Simulated Interactive Research Experiment (SIRE):

The SIRE is a highly complex interactive simulation of a real existing experiment of fundamental research with authentic photo-realistic visualization as a tool for active learning for physics of the 21st century.

Many university curricula of physics provide courses concerning modern science only in higher semesters. Insight into current open research questions is mostly given with diagrams, sketches and formulas, but hardly based on active or inquiry based learning.

Even though a few lab courses allow working on real-world research experiments, the time is usually too short and the experiments are too expensive to be used as a didactical resource. They only allow preliminary insights into the scientific discipline.

SIREs aim at balancing these deficits: Based on interactive screen experiments [1] and interactive simulations [2-4], SIREs are highly complex representations of modern real-world research experiments.

We present a first prototype which focuses on a representation of the Kapitza-Dirac-Talbot-Lau-Interferometer [5, 6], a unique experiment for fundamental research in molecular quantum optics, which implements with massive matter what could otherwise only be studied with light in a student lab [7].

SIREs open a wide space for curiosity driven learning – they allow the students to manipulate all relevant parameters in the experimental setup and to control phenomena that can usually only observed by scientists with intense lab training. SIREs are easily repeatable and students can use this learning tool as long as they need to understand the underlying concepts. Additional resources allow learning of various topics (e.g. mechanics, optics, thermodynamics, quantum physics) in the context of a modern research experiment. In order to provide an authentic look and feel of the experimental situation the KDTLI-SIRE is enhanced with photo-realistic graphical representations and scientifically correct simulations of the experimental results, including measurement artifacts and experimental limitations. The modes of interaction with the SIREs will be limited to those that are possible in the lab. The learning experience with a SIRE will be closer to reality than with any other learning object for modern science before. That way SIRE aims at avoiding misconceptions caused by artificial visualizations and give an insight in the nature of modern science.

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Keywords: University education, technology enhanced learning, quantum physics, interactive simulations, active learning

Topics: Experiments, ICT

Session 1D, 14:00-15:20

202.O1D

Physics on a Shoestring: A Soap Film Motor

Jeremy Pfeffer
Hebrew University of Jerusalem, Israel

Two articles describing the experiment I wish to demonstrate have appeared in Physics Education and can be viewed on line at

http://iopscience.iop.org/0031-9120/37/1:

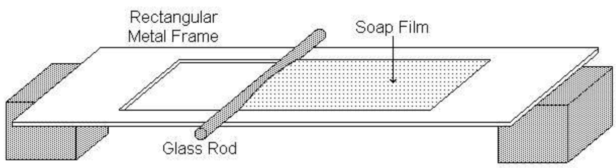
1. Physics on a Shoestring: A soap film motor; 2002 Phys. Educ. 37 77

2. Let's Investigate: How fast can a soap film roll a glass rod? 2002 Phys. Educ. 37 78

The study of the “sensible forces” that act at “insensible distances” within fluids is sadly neglected in many contemporary physics courses. Surface Tension does not even appear as an entry in the indices of many widely used textbooks. Notwithstanding, the interpretation of these important phenomena in terms of the underlying cohesive and adhesive forces is an instructive topic and provides a basis for the study of many physical principles. Furthermore, the role these effects play in living systems, such as in lung function, is central to an understanding of their workings.

The simple apparatus I have devised directly demonstrates the ability of a liquid surface (a soap film) to perform useful work as it contracts. In a quantitative extension of the experiment, the free surface energy of the soap film can be estimated by measuring the kinetic energy made available from the work done by the film as it contracts.

The apparatus which comprises a rigid sheet metal frame (approx. 30cm × 10 cm) that stands on two small blocks, glass rods of length 15-20 cm and radius 0.1-0.3 cm and a soap solution that forms lasting films, is cheap, safe and fun to use.



Keywords: Surface tension, surface free energy, adhesive and cohesive forces, soap films, Laplace-Young equation

Topics: Experiments, Informal Physics Teaching & Learning

211.O1D

The drinking bird engine

Andrea Gróf
Karinthy Frigyes Gimnázium, Hungary

Everyone likes to play. The drinking bird is a popular toy, often used in the classroom to grab the attention of students. (The head and belly of the bird are two glass bulbs connected by a long thin neck in which a volatile liquid periodically rises and falls, making the bird tip over and "drink" from a glass, thereby keeping its head wet.)

From an educational perspective, the bird is worth more than just being fascinated by it and stating qualitatively that it is powered by evaporation. Students are easily motivated to carry out measurements and draw quantitative conclusions. This provides an opportunity to synthesize knowledge from various chapters of mechanics and thermal physics: work, energy and power, communicating vessels, states of matter and changes of state, heat engines and their efficiency, etc.

In addition, the investigation of the bird's operation and dry-bulb and wet-bulb temperatures also leads to a deeper understanding of the idea of relative air humidity, a term familiar from weather reports but only superficially touched on in class.

The working of the bird has been discussed in literature, including quantitative considerations. This presentation shows a possible approach at high-school level: it gives an account of how data are collected in a series of simple and low-cost measurements, and how data are processed to determine the power and efficiency of the drinking bird toy as a heat engine. The results raise questions on the factors influencing the power, and the answer obtained from data analysis demonstrates the increase of efficiency with temperature difference: a fact that only appears in text books in the context of idealized engines.

Keywords: Toy as heat engine, simple measurements, data analysis, synthesis of knowledge, relative air humidity

Topics: Experiments, Learning

218.O1D

A novel experiment in birefringence using single-mode optical fibre

Ivan Ruddock
University of Strathclyde, United Kingdom

The study of polarised light and birefringence in crystals has long been a feature of university level optics classes and laboratories. A thorough understanding of such themes is an essential prerequisite for postgraduate research in lasers, nonlinear optics and optoelectronics; for example, efficient second harmonic generation depends on the incident laser beam and the generated frequency-doubled beam propagating with the same phase velocity within the doubling crystal, a situation only achievable when the beams are orthogonally polarised.

Experiments in birefringence normally involve the identification of a uniaxial crystal's birefringent axes and then the measurement of the retardation (phase difference) between them by one or more methods. To modernise the topic and to demonstrate its continuing importance in physics, the University of Strathclyde's version uses birefringent single-mode optical fibre as an alternative to the crystal.

Step-index fibre has a small abrupt difference in refractive index between the core and the surrounding cladding. Light striking the core-cladding boundary at an angle greater than the critical angle experiences total internal reflection and is confined to the core in the form of modes as in a waveguide. Single-mode operation, essential for reducing dispersion in high capacity communication systems, is obtained by decreasing the core's diameter until only the lowest order mode propagates. For the single-mode fibre used in this experiment, the core diameter is 3.5 microns.

The lowest order mode may be launched and transmitted in a perfectly cylindrical fibre with its polarisation in any direction. However, due to manufacturing tolerances and mechanical strain, the longitudinally integrated refractive index signature is not azimuthally uniform and thus propagation characteristics analogous to those of a uniaxial crystal are exhibited. Consequently, there are orthogonal fast and slow axes along which incident plane polarised light is resolved, with the state of polarisation at the exit depending on the two components' relative amplitudes and the accumulated phase difference between them. Specialised single-mode fibres with high or low birefringence are available for specific applications in lasers and sensing.

In this paper, the birefringence experiment as performed by students is described and typical results presented to show its relevance in a modern physics degree. The tasks covered are (a) identification of the polarisation axes in a uniaxial crystal plate and a short length of single-mode optical fibre, and (b) measurement of retardation using a Babinet-Soleil compensator and by analysing the emergent elliptically polarised light with a photodiode-polariser combination. Apart from demonstrating birefringent components and measurements in a novel way, it is also a challenging exercise in laboratory technique. Students can determine retardation by two independent methods and, since both have resolution limits and uncertainties, they must be able to reconcile their results. In addition, it trains students to work systematically as the components must be placed in the laser beam in a particular order and adjusted in a highly logical fashion such that their polarisation axes are parallel, orthogonal or at 45 degrees to each other.

Keywords: University education, laboratory experiment, optical fibre, optics, birefringence

Topics: Experiments

225.O1D

Chaos in High School

Tamas Meszena
ELTE, Hungary

We are faced with chaotic processes in many segments of our life: meteorology, environmental pollution, financial and economic processes, sociology, mechanics, electronics, biology, chemistry. The spreading of high-performance computers and the development of simulation methods made the examination of these processes easily available. Plain, periodic motions (pendulum, harmonic oscillatory motion, bouncing ball), as taught at secondary level, become chaotic even due minor changes.

If it is true that the most considerable achievements of twentieth century physics were the theory of relativity, quantum mechanics and chaos theory, then it is presumably time to think about, examine and test how and to what extent chaos can be presented to the students. In the presentation I would like to introduce the 10-12 lesson long facultative curriculum framework on chaos designed for students aged seventeen.

Keywords: Chaotic proces, simulation metod, nonlinear oscillator

Topics: Experiments

Session 1F – workshop, 14:00-15:20

005.W1F

Active learning in optics

David Sokoloff
University of Oregon, United States

Widespread physics education research has shown that most introductory physics students have difficulty learning essential optics concepts—even in the best of traditional courses, and that a well-designed active learning approach can remedy this. This workshop will provide direct experience with methods for promoting active involvement of students in the optics learning process. The focus will be on active learning, hands-on lab activities (1), and Interactive Lecture Demonstrations (ILDs) (2,3)—a learning strategy for large (and small) lectures, including the use of special Optics Magic Tricks. Sample ILD materials and instructions on how to do the tricks will be distributed. These materials have been used successfully by the author in his introductory college level physics course, and recently in a series of Active Learning Optics and Photonics (ALOP) (4) workshops in developing countries, sponsored by UNESCO, SPIE and ICTP. Research on the effectiveness of these approaches will be presented.

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Keywords: Active learning, optics, introductory physics, lecture demonstrations

Topics: Assessment & Evaluation, Curriculum, Experiments, Learning, Teaching

»»Session 2A, 15:30-16:50««

045.O2A

Innovations in physics´ teacher education – how to educate GEN Y teachers?

Renata Holubova
Palacky University, Czech Republic

The purpose of the pre-service teacher training at the university is to become competent teachers and skilled members of the society. We can see that one of the most important goal of education at our faculty is improving the quality of teaching. Our pre-service teachers must be prepared for the changing work at secondary at high schools. The aim of the paper is to discusse the outcomes of the project focused on the innovation of the professional teacher training. A new programme of the physics´ teacher study was started, new subjects and modules were prepared. It will be shown that all the innovations are based on learner-centered methods (active learning, PBL, interdisciplinary relations) and technology-based lessons to improve pre-service teachers´ skills and knowledge.

The paper is supported by the project OPVK CZ. 1.07/2.2.00/15.0310

Keywords: Teacher education programme, physics, gen Y teacher, innovation

Topics: Teachers, Teaching

047.O2A

Some lessons from a 3-year experiment of PBL in Physics in a French School of Engineering

Philippe Ageorges, Géraldine Poutot, Adriana Bacila and Bernard Blandin
CESI-LIEA, France

For the past three years, CESI School of Engineering (France) has experimented a Problem-based learning methodology (PBL) in the field of Physics. The main objectives of this experiment were to make physics more attractive for our students as well as to help them develop professional skills. The very first steps of this experiment were presented at the GIREP – ICPE – MPT conference in Reims (France) in 2010 (Blandin, 2010). The results of the first year of the experimentation, comparing learning outcomes achieved through PBL and through traditional course were presented during the World Conference on Physics Education in Istanbul (Turkey) in 2012 (Poutot & al., 2012). The proposed contribution, this year, will draw some lessons from this experiment which might be useful for all Physics teachers.

The implementation of the PBL methodology at Cesi School of Engineering had to face two major difficulties, which do not appear in the literature:

- The first one was related to the large number of students, the limited number of available teachers and the school economic constraints: do not spend more with PBL than what costs traditional teaching. How to set up a PBL session with 150 students, with 2 tutors and without increasing the number of teaching hours? In traditional teaching, one person can easily teach to 150 students sitting in a lecture theater. With the PBL approach, it is not so obvious to handle 12 groups of 12-13 students separately.

- The second difficulty was the students' negative reaction to the PBL methodology. Moving from a comfortable passive methodology to an active one has been destabilizing and more demanding for most of them. Making efforts and learning by themselves has raised major complaints from our students at the beginning!

The proposed contribution will explain how we solved these difficulties, while our demonstration that the same learning outcomes could be achieved through PBL and through traditional teaching lead the School to plan further developments of the PBL approach in other fields as well as developing multi-domain problems in physics and technology.

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POUTOT, G. BACILA, A. AGEORGES, P. BLANDIN, B. (2012) PBL in Mechanics: some results of a controlled experiment, in Proceedings of the World Conference in Physics Education, Istanbul, Turkey, July, 1st – 6th, 2012 (proceedings in preparation)

Keywords: University education, problem-based learning, large groups, students' resistance to PBL
Topics: Learning, Teaching

051.O2A

Using Class-room Communication System in Physics Laboratory

Ajay Wadhwa
SGTB Khalsa College, University of Delhi, Delhi, India

Class-room Communication System (CCS) refers to a combination of electronic hardware and its associated software that can be used to support communication in a classroom to make it more interactive and student-centric. Use of CCS in class-room lectures has been quite common in most institutions imparting science education. Like any science stream, physics is a subject where Laboratory activity is an integral component of the curricula. We intend to present a CCS-based laboratory activity to emphasize the utility of technology in promoting physics education. For a student of physics, a laboratory experience is different than a class-room lecture experience because during experimentation the student encounters nature as it 'really' exists and not in an idealized form as projected in a class-room lecture. We selected a simple experiment that involved the measurement of g by measuring the time-intervals between two initial successive bounces of avertically dropped ball on a floor from a given height. A class of about 50 under-graduate students of 4th semester were asked to perform the experiment which was integrated with the CCS device

(NETGEAR N150 router) in their physics lab. The students were divided into 25 groups with two students per group. Each group was assigned a computer terminal for doing analysis and to communicate through CCS with the instructor. Due to limited resources we could set up two experiment-terminals where the experiments were performed by the students and observations saved in a computer for further analysis on their respective computer terminals. The experiment was discussed in the class and each group was given a set of formulas related to the experiment. Based on the activity and results obtained by them the students were given a questionnaire to respond and communicate to the instructor in a specified time (about 30 minutes). The questionnaire contained questions that tested a student's knowledge about basic concepts like conservation of momentum and energy, elasticity of matter, damped oscillatory motion etc. The results obtained by different groups of students were compiled and then analyzed.

Experiment/Activity: A vertically dropped ball bouncing-off a rigid floor is a two-body system that is characterized by the value of coefficient of restitution (CoR) of the ball-surface combination. Using the laws of physics we can express the CoR in terms of physical quantities like g, initial height h and time-interval Δt between the first two successive bounces. For experiments we asked the students to choose from different types of sports balls-tennis, squash basket-ball etc. Using the standard values of CoR and by measuring the time-intervals, the value of g can be obtained. For measuring time-interval Δt we made use of Vernier audio sensors interfaced with the USB port of computer.

Keywords: Class-room communication system, physics laboratory, router, CoR, sensors, computer interface

Topics: Assessment & Evaluation, Curriculum, Experiments, ICT, Learning, Teaching

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080.O2A

An approach to the concept of Maxwell-Boltzmann distribution: a pedagogical path based on Guided Inquiry

Onofrio Rosario Battaglia, Claudio Fazio and Rosa Maria Sperandeo Mineo
University of Palermo, Italy

The understanding of the statistical distribution concept plays an important role in any undergraduate physics curriculum.

However, not many laboratory experiments related to this topic are actually available to support students in their comprehension of such a concept. As a consequence, a strictly theoretical approach is usually applied to the teaching of the Maxwell-Boltzmann distribution function and students often consider it a purely mathematical abstraction without any investigation about the meaning of such a representation.

Within the framework of an Inquiry Based learning approach, we designed a pedagogical path based on simple experiments and computer simulations. Both are used for involving students in learning the concept of distribution and its related properties by personally investigating relevant problems. Our paper describes how the preview path has been used in a workshop for undergraduate students by following an Inquiry Based approach stimulating learning processes like diagnosing problems, critiquing experiments, planning investigations and constructing models that describe and explain experimental data.

We will discuss preliminary results that show how our teaching/learning approach has been effective both to consolidate tough physics concepts and, at the same to clarify relevant aspects of the scientific investigation methods.

Keywords: Experiments, guided inquiry, Maxwell-Boltzmann distribution, undergraduate students

Topics: Experiments, ICT

Session 2B, 15:30-16:50

203.O2B

Content analysis and coding the Student's weekly reports in order to research their self-reflection epistemology and improvement their solving problem skills

Nasrin Taheri Asghari and Mojtaba Jahanifar
Ministry of education, Islamic Republic of Iran

As physics teachers, we expect students in our classes to gain an understanding of the true perception about nature of physics.In the other words, instead of accumulate a large collection of facts or knowledge separated from each other, they must be able to perceive a set of coherence concepts that drive from their careful observation at the real world. These different views about the nature of knowledge and learning are called "epistemological beliefs". Researches on students' epistemological beliefs and how they are developed show that these beliefs depend on the particular content domain about which students have believe that, or special background that student belongs to, And the specific context in which the beliefs are expressed and measured.

At this study we used student's weekly reports to observe and discovery epistemological beliefs. Epistemological beliefs are discovered in conceptions, contents and contexts of many physics phenomenon. Weekly reports were made by students themselves, they explained in their reports what they learned or how they learned and reflect their learning process or solution problem strategies. Weekly Reports were developed as an instructional tool and implemented elsewhere before being implemented at OSU [1]. Each week students in this study reflected on what and how they learned by writing Weekly Reports. Specifically, students were asked to answer four open-ended questions:

1. What did you learn in lab this week? How did you learn it?
2. What did you learn in lecture and recitation this week? How did you learn it?
3. What questions remained unclear?
4. If you were the professor, what questions would you ask to determine if your students understood the material?

Each week, more than half of the reports from each course section were randomly selected to be graded and given feedback. In this way, each students' reports were graded at least every two weeks, some even more frequently. Every report was given feedback in the first week. Teachers answered students' questions (from question 3), and provided comments on questions 1, 2, and 4. The comments to questions 1 and 2 encouraged the students to be precise, clear, and complete in describing what and how they learned, and prompted them to refer to the in-class observations, experiments, and reasoning processes that were intended to help them learn physics. Weekly reports process, coding and their analysis were conducted for 100 participants (students) that they study engineering science in free university in Iran in two semester. We began by reading the Weekly Reports of students. While reading, we took note of what the students wrote that had particular epistemological content. The "epistemological content" we initially had in mind included the dimensions and stages from prior research results. We looked for indications of beliefs about the structure and content of physics knowledge, the source of physics knowledge, and its connection to the world outside the classroom. We also had in mind the course's special instructional methods and goals, especially predicting and interpreting the results of experimental tests and then applying verified knowledge to solve new problems. After reading the reports of these students, it was clear that they described learning in a number of different ways. We found, however, that many of these ways of reflecting appeared several times in a student's reports and also in the reports of other students. We gave names to the most common kinds of indications, thus creating our initial coding scheme. In the end, fourteen of the codes we developed were chosen; these codes could be placed in one of three categories. Result show that the low gainers tended to describe their learning in terms of learning from authority or by practicing solving problems. The high gainers more frequently described learning by reasoning or by making personal connections to the concepts. The results of these studies show that epistemological beliefs are important factors affecting the conceptual learning of physics students. In addition, getting students to reflect meaningfully on their knowledge and learning is difficult, but it can be done with consistent feedback. More research into the epistemological beliefs of physics students in different contexts and from different populations can help us develop a more complete model of epistemological beliefs, and ultimately improve the conceptual and epistemological knowledge of all students.

Keywords: Epistemological beliefs, weekly reports, physics education, problem solution, meta cognition

Topics: Learning

219.O2B

Problem-solving in university-level Physics: What kinds of abilities are developed?

María Elena Truyol[1], Zulma Estela Gangoso[2] and Vicente Sanjose[3]

[1]Núcleo de Pesquisas em Inovação Curricular (NUPIC), Laboratório de Pesquisa em Ensino de Física (LAPEF), Faculdade de Educação, Universidade de São Paulo, Brazil

[2]Instituto de Física Enrique Gaviola, Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba, Argentina

[3]Departamento de Didáctica de las Ciencias Experimentales y Sociales, Universidad de Valencia, Spain

One of the main tasks of physicists is to build models of reality and to solve a wide range of problems. If these activities are central to professional development, as noted by the available profiles, they should be developed because they are not innate abilities. It is therefore assumed that the development of these abilities, at least to some degree, should occur during formal instruction. In this work we present the results of an experimental design that seeks to know some aspects of the modeling skill acquisition in problem-solving tasks, at university-level Physics.

Understanding problem-solving in physics as a modeling process, we analyze what happens to the representations constructed during the resolution process and how these representations are related to student performance, measured by traditional criteria for examinations score. The study was performed on a sample of 91 students of different levels of formal education in Physics.

The design of the task of written problem-solving and the analysis of data are based on the theoretical construct “Model for Comprehension for Problem Solving in Physics” and a proposal to classification of instructional physics problems statements. In previous works, these theoretical frameworks has allowed a description of the characteristics of the statements used in formal instruction, the design and validation a set of experimental statements with specific characteristics and the description of some features of the problem-solving processes generated by different types of problem statements. From this previous work follows the basic assumption that guides this research: there are differences in the statements of instructional physics problems that enable or inhibit the development of certain abilities involved in the problem-solving process, which are not innate.

Some of the results obtained indicate that students, although presenting very good performance in solving the problems traditionally used in instruction, have not developed the abilities necessary to solve, with efficiency, other problems in where it is necessary to model the situation presented. These results are independent of their level of formal instruction in physics. These results highlight the need to include working with other types of problem statements during instruction. To develop modeling abilities, these statements should be oriented towards making informed choices about what physical model should be used to solve it and why this is so.(*)

(*) This work was performed as part of the doctoral thesis of María Elena Truyol with the advisorship of Dra Gangoso and Dr. Sanjosé Lopez, at the Institute of Physics “Enrique Gaviola”, Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba, with the support of a doctoral fellowship from the National Council of Scientific and Technological Research (CONICET). Available on-line at: http://biblio.famaf.unc.edu.ar/cgi-bin/koha/opac-detail.pl?biblionumber=16677

Keywords: University education, problem-solving, comprehension, modeling abilities, performance

Topics: Assessment & Evaluation, Learning, Teaching

236.O2B

Evidence for the applicability of Dual Processing Theory in Physics problem solving

David Sands
University of Hull, United Kingdom

Dual Processing Theory (DPT) posits the existence of two separate systems in thinking: an automatic, intuitive system and a slower system, referred to here as the rational system. When confronted with a problem, many people answer intuitively, but often incorrectly: reasoning is a deliberate process and occurs only if it is recognised that the intuitive answer is lacking. However, it takes considerable cognitive resources [1].

Direct testing for the applicability of Dual Process Theory within a subject such as physics is very difficult: problems test specific knowledge and it is difficult to distinguish between an intuitive wrong answer and an inability to reason through the physics. Rather, the evidence for DPT in such circumstances is indirect. For example, it is well known in the physics education literature that naive conceptions exist, as do phenomenological primitives, commonly known as p-prims. These imply the existence of a non-scientific conceptual structure which is often invoked in simple explanations. However, they are also consistent with DPT: conceptions as deeply ingrained as these effectively become intuitive problem solving heuristics which can actively prevent rational thinking about a problem.

Of more direct interest in this paper is the evidence gathered from research based on the the Force Concept Inventory [2]. This well known multiple choice questionnaire tests for alternative conceptions in mechanics, but it does not normally provide any insight into the reasoning behind the choice of answer. The author has been collecting additional information on a couple of questions over the last two years and found evidence that students might well have sufficient information to answer a question correctly despite making a wrong choice. This is consistent with DPT in as much as belief, rather than reason, appears to be guiding the choice of answer. These findings are described and the educational implications of DPT in physics are explored.

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Keywords: Force concept inventory, misconceptions, problem solving, dual processing theory

Topics: Learning

251.O2B

Analyzing patterns in experts' approaches to solving experimental problems

Maja Poklinek[1], Gorazd Planinšič[1] and Eugenia Etkina[2]
[1]Faculty of Mathematics and Physics, University of Ljubljana, Slovenia
[2]Graduate School of Education, Rutgers University, United States

Physics education is gradually moving from the traditional method of lecturing to more interactive approaches. One such approach is ISLE, an Investigative Science Learning Environment (Etkina and Van Heuvelen, 2007), that engages students in learning physics through repeated cycles of observations, pattern recognition, invention of explanations, and testing these explanations in new experiments. The aim of ISLE is not only to help students obtain new knowledge, but also to help them learn to think like scientists.

In our research, we compared the flow of the ISLE cycle with the way practicing scientists solve experimental problems. We conducted case studies where several pairs of scientists, both physicists and researchers from other fields, were given a simple but a non-trivial experimental problem. Each case study consisted of filming two scientists while they were trying to explain a phenomenon in optics, which they had never seen before. We videotaped scientists in pairs, so we could follow their mental steps through communication between them. We then analyzed their conversations and mapped them to the ISLE steps. We created graphs that show the progression of steps over time and the transitions between them. We repeated the procedure with undergraduate physics students.

Preliminary findings suggest a close match between the proposed ISLE cycle and the way expert scientists approach problems. Logical transitions common to the ISLE cycle were much more frequent than other logical transitions. Of course, problem solving by scientists is more complex than the simplified progression of the ISLE cycle, but in general, we can say that the ISLE cycle is a good model of the scientists' thought process. Because none of the subjects interviewed had any previous exposure to ISLE, we can conclude that the ISLE cycle is a natural way of problem solving and is either innate in expert scientists or learned through years of experience.

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http://per-central.org/per_reviews/media/volume1/ISLE-2007.pdf

Keywords: Experts solving problem, ISLE cycle, problem solving timeline, experimental problem, logical transitions

Topics: Learning

Session 2C, 15:30-16:50

097.O2C

University students' ideas on physical meaning and role of wave function and state vector in quantum physics

Giacomo Zuccarini, Marisa Michelini and Alberto Stefanel
University of Udine, Italy

Difficulties students find in learning quantum mechanics are primarily due to counterintuitive nature of quantum concepts and to the new and highly mathematical structure in which they are shrouded. Research shows that students struggle to recognize the conceptual meaning of formalism, considering it instead as a mathematical machinery (Johnston et al, 1998), as well as they struggle to apply it in order to make qualitative inferences (Singh, 2008). In particular, the re-definition of the concept of state and the way in which physical information is encoded in its formal representations plays an important role in student difficulties (e.g. McKagan et al. 2008, Robertson & Kohnle, 2010). Nevertheless students reasoning patterns concerning the connection between quantum state and related formal entities still need to be explored in depth, as well as their possible links with those concerning basic features of quantum behavior and cultural points of view. For this purpose we planned an empirical research, based on a 21 item questionnaire and follow-up interviews, to be administered to a small group of university physics student. The questionnaire is made up of open questions and organized in two sections: (A) quantum behavior and the domain of applicability of quantum formalism; (B) wave function and state vector properties at a point in time, unitary time evolution of state, graphical representation of wave function. Semi-structured interviews with rogersian modality of answer collection have been scheduled on each item. The study explores students points of view on various levels: cultural, qualitative-conceptual, formal (vector-algebraic, wave function, Re{ψ} graphs, $|\psi|^2$ graphs). Here are reported the main results of answer analysis of each question posed. Particular attention is devoted to some indications emerging about student learning modalities on relevant concepts, e.g. the need to recognize the role of phase difference in WF and state vector in describing processes, and the need to recognize on different levels the non-stationary nature of linear combinations of energy eigenstates and position eigenstates.

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Keywords: University Education, quantum mechanics, conceptual understanding

Topics: Learning

271.O2C

What motivates high school teachers to join the Masterclasses Day - Hands on Particle Physics?

Francisco Serafim[1], Augusto Moisão[2], Cristina Pinho[3] and Florbela Rêgo[4]

[1]*LIP - Lab. Ins.Fisica Experimental de Partículas, Escola Secundária D. Manuel I, Portugal*

[2]*Escola Secundária D. Manuel I, Portugal*

[3]*Escola Secundaria Ferreira Dias, Portugal*

[4]*LIP - Lab. Ins.Fisica Experimental de Partículas, Escola Secundária de Vendas Novas, Portugal*

Over the last nine years, the Portuguese edition of the International Masterclasses Day - Hands on Particle Physics (http://ippog.web.cern.ch), has seen its number of applicants steadily rise, with teachers and students clearly showing an increasing interest. We have been involved in this program almost since the beginning. The recent discoveries made on CERN and widely covered by the news channels paired with CERN's outreach programs such as the "Portuguese Summer School in CERN" (P. Abreu et al, 2012), has contributed for the enthusiasm around Particle Physics. The living proof of this success is that Portugal is the country with more participants in the international program (M. C. Abreu et al, 2012).

The mechanics of this program promotes experimentation, interdisciplinary ventures and the mastering of information and communication technologies. These features are attractive for both teachers and students who see them as a very good and necessary complement to the classical high school academic programs (Allen, 2004). This is especially useful when we take into account that only a few concepts are taught at the start of the 10th grade (Bello et al., 2001) and at the 12th grade Physics (Cardoso et al., 2004).

The student's feedback, after the MasterClasses, enabled us to evaluate their opinion. The most common statements will be presented in this conference. The teachers consider that this academic training is very welcome. To sum up, the Masterclasses promote an update on knowledge as well as educational experiences. The complete details of this positive outcome will be quantified properly in our presentation.

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Keywords: Teaching, motivation, learning

Topics: Learning, Teaching

291.O2C

Variations in physics students' ways of depictions as the context of explaining changes from quantization to light quanta

Mengesha Ayene[1], Jeanne Kriek[2], Baylie Damitie[1] and Åke Ingerman[3]
[1]*Bahir Dar University, Ethioptia*
[2]*UNISA Institute for Science and Technology Education (ISTE), South Africa*
[3]*University of Gothenburg, Sweden*

While the wave particle duality is frequently the major topic students' encounter in quantum mechanics, the quantum model of light and photon remain elusive for many physics undergraduates. Students find it conceptually counterintuitive and difficult to understand. Nevertheless, compared to many areas of classical physics, students' understanding of quantum mechanics has received minimal attention in the physics education research. A phenomenographic study was carried out where the description categories which form the basis for students' depictions of quantization, the concept of photon and light quanta are constructed. Data for this study were obtained from a semi structured interview conducted with 35 physics students from two universities in Ethiopia (Bahir Dar and Wollo Universities). The phenomenographic analysis revealed that it is possible to construct three qualitatively different categories to characterize students' depictions of energy quantization, namely, energy in Blackbody Radiation (BBR) as a factor of "square of frequency"; Hybrid description of energy in BBR; and energy in BBR as "quanta" of energy size $E = hn$. It is also explored that students' depictions of the concept of photon and light quanta can be described with three different models of description categories, which are classical intuitive model description, mixed model description and quasi-quantum description models. With regard to learning quantum mechanics, these categories of description made clear three issues: (i) Students extended their naive and classical intuitive conceptions to quantum phenomena, (ii) Students used the language of physics non-discriminately and (iii) Students description were bounded by the mix-up of the conceptual frameworks of classical and quantum reasoning. Furthermore, the finding shed more light on how physics students with appropriate and/or inappropriate depictions of one key quantum concept also give appropriate and/or inappropriate depictions of other concepts in quantum mechanics. Pedagogical implications are discussed.

Keywords: Quantum mechanics, phenomenography, student depiction, Ethiopia

Topics: Learning

335.O2C

Development of interest in particle physics as an effect of school events in an authentic setting

Kerstin Gedigk, Gesche Pospiech and Michael Kobel
TU Dresden, Germany

The goal of physics education consists – among teaching the physical content – also to a large extent in developing the interest of students in physics and in giving an insight into the doing of physics, into recent physics research and also into the nature of physics. Furthermore more students should learn to know some of the professional tasks of physicists and develop interest in becoming a scientist. There are indications that an authentic learning environment is an appropriate tool for reaching these goals. Therefore - in order to support teachers - in Germany the “Netzwerk Teilchenwelt”, a network of particle physicists, physics teachers and teenagers has been brought to life. One of the mean offerings of this network are the national “Particle Physics Masterclasses”, inspired by the CERN International Masterclasses. These events give the students insight into actual research in the field of particle physics, e.g. the necessity of particle accelerators, especially the Large Hadron Collider (LHC), the detectors and their functioning and the huge experiments at CERN, into the collaboration of researchers, into still open and already answered questions, into scientific methods, etc. These events last between 4 to 6 hours and mostly take place in schools in order to reach as many classes as possible. Whole classes as well as selected students can take part. The authenticity is guaranteed not only by the facilitators who are particle physicists themselves but also by the whole setting: Own measurements with original data from the experiments at the particle accelerators at CERN offer the participants an authentic experience of concrete research.

To investigate which of the intended objectives the Masterclasses could actually achieve and to find hints on how to improve these events an evaluation study was implemented. The contribution deals with this study which focuses on the development of interest in physics and especially in particle physics of teenagers as a consequence of the described events, which are unconventional for German schools. Furthermore the interest in pursuing a scientific career is evaluated. To study the interest a questionnaire and a test has been developed based on the interest construct by Krapp (1992). After piloting and improving the questionnaire 25 Masterclasses were investigated in a pre/ post/ follow-up design which means that the teenagers (N = 340) were asked before, immediately after the event and again after 6 to 8 weeks. The study design additionally includes control groups. Among other things the interest in physics as subject in school, in a scientific career, the self-concept of the own ability in physics and different dimensions of interest in particle physics were evaluated. It also was investigated how teenagers perceive the Masterclasses as a whole and its authenticity. The presentation will include selected results of this study.

Keywords: Interest, particle physics, evaluation study

Topics: Experiments, Informal Physics Teaching & Learning, Learning

Session 2D, 15:30-16:50

022.O2D

A Treatment of Oscillations and Waves

Nada Razpet and Tomaz Kranjc
University of Ljubljana, Faculty of Education, Slovenia

Vibration of a string is one of the classical topics in all physics curricula. In elementary schools attention is usually brought to oscillation phenomena in nature. Sea waves are mentioned. Young people are very familiar with them but most likely they do not observe them carefully. Some science teachers also talk about waves on ponds or puddles. Even though these waves are neither transversal nor longitudinal, one can explain on a larger puddle notions like wavelength, frequency, amplitude and speed of wave propagation. Dipping a wooden rake makes the wave interference easily observable. Of course, for an easier understanding of basic concepts one has to discuss oscillations. With children this can be done on a playground or in a gym where notions like period, frequency and amplitude are introduced. Observing a swing, students change the load or the length of the chain/rope and discover how these changes affect the period. This is followed by class experiments. For example, the period of a mathematical pendulum is measured and factors that influence it are discussed. Since hands are used to make ropes and strings vibrate, experiments using the swinging of arms where students can actually feel the change of amplitude and frequency are beneficial. One has to be careful, though, not to be deceived by the feeling. The higher speed at the equilibrium position caused by a bigger amplitude can be mistaken for a higher frequency. Observations of vibrations of ropes and strings follow. Here standing waves are also observed. One can also easily see how the change of frequency of the movement of the hand influences the wavelength. A camera can be used to record the experiment and the resulting photographs can be used to determine the wavelength and the speed of the wave propagation. It is not as easy to see what happens with wave reflection. Students are told what wave reflections at a free end and at a fixed end are like. However, details of what is happening can not be seen with a naked eye. High school students are familiar with trigonometric functions and if they are introduced to the freeware GeoGebra they can by themselves create an animation that shows what happens at a fixed or a free end of a rope. Textbooks show series of pictures of wave reflection, however, the time lapse is usually one quarter of the period and therefore details are not visible. It is only when students make their own animation that one can see how well they understand the material.

Here we are going to show our findings from a nationwide assessment of student knowledge, how we conducted seminars, and what experiments were performed. It will be explained what was taught by kindergarden teachers who conducted experiments with children. We will also show how GeoGebra can be used to illustrate what is happening with the wave reflection at a free or a fixed end.

Keywords: GeoGebra, oscillation, standing waves, animation, instruction, research

Topics: ICT

124.O2D

Mechanical waves and sound in the 8th Grade – Promoting inquiry

Telma Esperança, Maria José de Almeida and Paulo Gordo
Departamento de Física da Faculdade de Ciências e Tecnologia da Universidade de Coimbra, Portugal

The implementation of students' scientific inquiry minds must be accomplished following a structural development, along time and school levels, based on a hierarchical understanding of the scientific knowledge to be learned. The necessary use of a correct scientific language can be developed exposing students to the need to explain their ideas about what they see, ear and understand.

Aiming at the promotion of an inquiry attitude since the first steps on Physics learning and with a special concern to avoid the development of scientific misconceptions, some laboratory activities and stimulating supporting documents were designed to complement the study of mechanical waves and sound in 8th grade. According to the Portuguese Curricular Guidelines, this is the first students' contact with waves and sound on the discipline Physics and Chemistry; the same subject will be further developed in 11th grade, under the general context of Communications.

An analysis of school manuals and of the literature enabled the identification of a set of fundamental concepts, of possible challenging activities to promote their deep understanding and of the most common related misconceptions. Four 45 minutes activity blocks were organized, respectively on: mechanical waves, sound propagation in different media, mechanical waves' production and "challenges". Students have to work in groups at different experimental stations, and have to change station after a determined amount of time. The sequence of activities makes them gradually more challenging, promoting autonomy both on procedural and on cognitive competences.

This methodology has already been developed during the last academic year, within a pilot test with two classrooms, an experimental and a control one. The collected results allowed improvement of the activities and of the supporting documents. The present communication reports on the extension of the project to several 8th grade classrooms, in different schools and with different teachers.

From the already obtained results one can conclude that: experimental and control samples have very similar pre-test answers; experimental samples have slightly better post-test achievements; experimental classroom teachers report higher motivation of learners and more reflecting and active students' behavior (as compared with previous academic years' students). However, teachers also report some students' difficulties on keeping time schedules, on group work organization, on documents reading and understanding and on explaining and writing their answers and supporting evidences.

Keywords: Inquiry, teaching strategies, learning styles, lower secondary education 8th Grade, sound and waves

Topics: Learning, Teaching

267.O2D

A guided inquiry based teaching and learning sequence on oscillations based on experiments and data logging techniques

Marco Stellato[1], Marco Giliberti[1], Enrico Rigon[2] and Marina Tamborini[1]
[1]*Università degli Studi di Milano, Italy*
[2]*Liceo Scientifico "A. Tosi" Busto Arsizio, Italy*

The new guidelines from M.I.U.R. (Italian ministry for research and education) prescribe the teaching of “waves” between grade 11th and 12th. A good basis for understanding waves is the knowledge of oscillations and harmonic motions.

In teaching practice, oscillations and even more harmonic motions are rarely supported by experiments and, despite the great importance they have in understanding fundamental phenomena (i.e. acoustics, optics, modern physics etc.), little time is devoted to them.

We present here a guided inquiry based teaching and learning sequence on oscillations and harmonic motions rooted in an experimental approach. The sequence is part of a wider project on teaching of normal modes of oscillation that the research group in physics education of the University of Milan is developing.

The students, divided into small groups, perform experiments by themselves using two different complementary techniques of data logging. The first technique consists in the detection of the motion of different oscillating systems by means of a sonar detector. The second technique provides measurements using an automated video analysis based on image recognition (Tracker).

The first task given to students is to describe and categorize, some oscillating systems they observe by the naked eye, into groups they decide by themselves. The second task is to analyse the forces acting on the oscillators and provide some qualitative graphics to be discussed inside each students’ group, among different groups and with the teacher. This guided procedure allows the students to classify harmonic oscillations as those that are driven by a restoring force. A quantitative analysis of the same oscillating systems is then performed via the data logging techniques cited above.

The use of data logging and video tracking allows students to face the topic of harmonic oscillations even if they have a poor mathematical background. These techniques allow also the study of coupled oscillators behaviour without the use of advanced mathematics.

This teaching-learning sequence has been proposed to two third-year upper secondary school groups of students and to forth-year students attending different schools with scientific orientation. In two cases the sequence regarded regular classes during curricular lessons. The third group was composed of motivated students coming from different fourth-year classes in the framework of PLS (Scientific Degree Plan) Italian Project, with extracurricular lessons.

Each group attended four lessons of two hours each. Two additional hours were devoted to the administration of the entry questionnaire and the final questionnaire. Some interviews were also performed.

Here we present and discuss the results of the experimentations and in particular we show the convenience of the experimental approach and the use of data logging and video tracking techniques in teaching oscillations (and harmonic oscillation in particular).

Keywords: Secondary education: upper, lab activities, oscillations, harmonic motion, data logging techniques

Topics: Experiments, Teaching

365.O2D

Teaching kinematics concepts and graphing through the context of Simple Harmonic Motion

Leanne Doughty, Paul van Kampen and Eilish Mcloughlin
CASTeL, Dublin City University, Ireland

This work involves the development of a curriculum for combining the conceptual understanding and the mathematical and graphical aspects of displacement, velocity, and acceleration using the context of a simple harmonic oscillator. These kinematics concepts and graphing skills are regularly intertwined and students' ability to apply this combination is called upon frequently in many physics contexts. Describing the motion of a simple harmonic oscillator is one such context and for our students Simple Harmonic Motion (SHM) is the first topic where they will encounter these concepts since their introductory calculus-based mechanics course, taken in the previous semester. SHM is taught as part of an introductory Waves and Optics course taken by the university's first year physics students (approximately 20 students each year).

Previous studies have identified difficulties students have with these concepts, and with interpreting and drawing graphs. We have investigated the extent to which these difficulties are present in our students and have found other difficulties from the analysis of student's responses to specifically designed test questions. The instruction designed to address these difficulties are conceptual tutorial worksheets, in the style of Tutorials in Introductory Physics. The instruction was first piloted using individual teaching-learning interviews with a small number of students. An indication of the impact of the tutorials was measured using pre/post tests.

Thus far, two different approaches have been adopted and each approach considers the situation of a mass oscillating at the end of a spring. In the first approach, students use a strobe diagram to indicate the position of the mass as it moves through one period of motion and are requested to sketch graphs of position versus time, velocity versus time and acceleration versus time for this motion. The post test results indicated that students' misconceptions surrounding the relationship between velocity and acceleration hindered their understanding. As a result, a second approach starting with the consideration of acceleration as a function of time was developed. Students began by looking at the relationship between restoring force and displacement, and used $F = ma$ to determine the acceleration throughout the motion. Position and velocity were then treated in a similar way as in the first approach. The results from the post test from this approach showed that students continued to confuse acceleration and velocity (probably not surprising considering how they would have been introduced to acceleration initially and how they would have used it in previous contexts).

The curriculum developed for these two approaches will be presented as well as the results from the pre and post tests used to examine the difficulties students have with the concepts involved. The implications of these results on the implementation of a third approach will also be discussed.

Keywords: Simple harmonic motion, conceptual tutorials, undergraduate physics

Topics: Curriculum, Learning, Teaching

Session 2E – workshop, 15:30-16:50

181.W2E

Embedding formative assessment and promoting active learning

Elizabeth Swinbank
University of York, United Kingdom

York Science (www.yorkscience.org.uk) is a project based in the University of York, UK, that is developing a large package of resources to support the teaching of science to students age 11-14.

A key component of this resource package is a wide variety of assessment tasks and questions which can be 'embedded' in normal classroom practice and provide evidence of successful learning, or of learning difficulties to which teachers can respond. The development of these items is based on research evidence about students' learning in science.

York Science uses a 'backward design' approach. For each topic, we start from a provisional learning progression and a list of intended learning outcomes. We then develop a collection of questions and tasks that could be used to get good evidence of learning; this often leads to revision of the initial list of outcomes.

The items involve students working in groups, in pairs or individually. Some might be used at the start of a topic to gauge students' prior knowledge and understanding, while others might be used to monitor progress within a series of lessons. The active nature of the tasks means that they naturally lead into further discussion and practical work.

Types of task include:

- predict the outcome of a practical task, then explain-observe-explain
- discuss, evaluate and select alternative explanations for an observation
- make a physical model of an object (e.g. the solar system)
- construct a concept map to show relationships between ideas
- sort and select statements to produce an explanation or argument
- free writing in response to a question or stimulus

Following an introduction to the York Science project and the backward design approach, delegates will be able to use and evaluate a range of assessment-for-learning items relating to physics topics including 'Light and colour' and 'Electric circuits'. Discussion will focus on the use of these items to promote active learning.

Keywords: Embedded assessment tasks, assessment for learning, active learning, backwards design

Topics: Assessment & Evaluation, Learning, Teaching

»»Session 3A, 17:10-18:30««

246.O3A

Coding scheme for assessment of students' explanatory and predictive models

Mihael Gojkošek[1], Gorazd Planinšič[1] and Josip Sliško[2]
[1]*Faculty of Mathematics and Physics, University of Ljubljana, Slovenia*
[2]*Facultad de Ciencias Fisico Matematicas, Benemerita Universidad Autonoma de Puebla, Mexico*

197 high-school students were involved in two different testing sequences with experiments. Students were encouraged to construct qualitative explanatory and predictive models for interaction of a white light beam with a prism foil (Planinšič & Gojkošek, 2011). Both, explanatory and predictive models consisted of pictorial and verbal description of unknown foil's structure and had to reproduce either observed or expected experimental outcomes. Our aim was to assess these student models objectively and to look for possible correlations between models' quality, student's cognitive abilities and other measurable variables.

We designed a coding scheme with 14 categories that addressed presence of important elements in students' models, use of physical phenomena in explanation, as well as inner consistency and sophistication of the model. Each category was graded in a four point grading scale according to different levels of students' skills. In designing our rubrics we were strongly inspired by previous work of Etkina et al. (2006) who developed a list of scientific abilities that scientists use during knowledge constructing and problem solving. We used some of their categories, added several new ones and optimized them to assess students' explanatory and predictive models. Scale nature of assigned grades was assumed so that complementary grades could be joined in single evaluation of the quality of explanatory and predictive model.

In the presentation the rubrics for assessment of explanatory and predictive models will be addressed in detail. Though this tool has been developed to assess students' models in very specific situation, we will show that with some adjustments it can be used for evaluation of diverse explanatory and predictive models.

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Keywords: Secondary education: upper, coding scheme, rubrics, explanatory model, predictive model, assessment

Topics: Assessment & Evaluation

286.O3A

Manipulating Space and Time for Active-Learning Lectures

Margaret Wegener, Michael Drinkwater, Timothy McIntyre, Deanne Gannaway, Karen Sheppard, Dominic McGrath, Matthew Davis, Warwick Bowen and Joel Corney
University of Queensland, Australia

We present a suite of approaches being implemented to overcome the architectural constraints on active learning of a traditional large lecture theatre. Our context is first-year physics (core and service teaching). A traditional, and still very common, space for learning is a large lecture theatre. The architecture funnels attention forward, tiered seating ensures that eyelines of audience members do not intersect – not conducive to interaction, and the consequent and well-acknowledged advantages of active learning. We aim to transform the atmosphere in a lecture theatre to one that resembles a small tutorial with all its inherent intimacy, promise of student engagement and improved learning outcomes – to make this become a place of learning for modern students. Similarly, virtual learning space can provide the feeling of a one-on-one, interactive experience. Time is a dimension like the three spatial ones; from a physicist viewpoint, we manipulate the use of time for learning, both inside and outside the physical lecture theatre. Educational technologies help achieve this. Our strategies consider the appropriateness of time, place and space for various aspects of learning - disseminating knowledge, individual reflection, and conversation, eg: peer instruction. Effective engagement during the lecture with the active learning process requires significant activity before the class by both students and lecturers, and therefore emphasises the importance of learning and teaching outside the physical lecture theatre. The dimension of time is also important in our strategies in terms of immediacy of feedback, some of which is made manageable for teaching staff by feedback being provided, and analysed, digitally.

The general approach is pre-lecture preparation and emphasis during class on conceptual questions with discussion and feedback. Alongside use of "clickers" with multi-choice questions are strategies that we ourselves have developed. Our techniques include analysis that can feed to the lecturer before class. An online quiz asking students for free-response text about the pre-lecture reading provides rich feedback. Use of this to tailor material for each class of hundreds of students has been made feasible through software that integrates a thematic analysis algorithm identifying common issues; and tools to use examples in class presentations, or individually email students. With less coverage of content during class, challenges are shifting lower-level transmission of information and requiring students to do more outside class. The effectiveness of this teaching approach increases as students are better prepared. Hence we aim to improve the pre-reading experience by developing original material that can be viewed on mobile internet-capable devices, and incorporate not just static text and images but dynamic activities.

Evaluation via diagnostic tests, surveys, focus groups and class observations has shown learning gains and positive impact on student engagement. A preference for this style of classes and reading format fits with the personalisation and immediacy desired by contemporary students.

Keywords: University education, active learning, student-centred learning, first year

Topics: Learning

290.O3A

Using Pencasts to find out how students think about physical ideas

James Mackay and Mary Fawcett
Wellington Institute of Technology, New Zealand

Common alternative conceptual frameworks dictate much of the way students approach their understanding of physical ideas. The considerable body of research over the last thirty years into these common preconceived ways of thinking, points to strategies that include their diagnosis and identification as important steps in their amelioration. However, common pen and paper tests often do not provide as much detail as do in depth interviews in terms of quality and depth of data collected. In this paper, we make the case for using a new technology, the Livescribe smartpen, which records both the script written on a piece of paper as well as the accompanying audio file of the conversation that accompanies writing the script (commonly called a pencast) and we outline and give examples of three ways in which we have used pencasts to affect conceptual change in the classroom. The first is by making pencasts that specifically address particular preconceived ideas. The second is to use pencasts to develop teaching techniques amongst tutors and the third id to use pencasts made by students as a way of diagnosing conceptual difficulties. In this last way, student explanations of simple physical phenomena were recorded and then revisited during an interview process. Examples of the analysis of these student pencasts from electricity and magnetism, mechanics, thermodynamics as well as from basic physics ideas in anatomy and physiology suggest that the pencasts made by the students can be used to collect valid and reliable data about how they think. An analysis of the pencasts, reveals that this process contributes substantially to the identification and amelioration of the common errors detected in the explanations generated by the students. Implications of this approach to teaching are that it can contribute substantially to conceptual change in the classroom.

Keywords: Pencasts, preconceptions, conceptual change

Topics: Learning, Teachers, Teaching

360.O3A

Designing Assessment for Learning into Physics Instruction and Comparing the Effects of Formative and Summative Systems on Student Learning

David Schuster and Chaiphat Plybour
Western Michigan University, United States

Of various research-based instructional strategies used to improve student learning, formative assessment, or Assessment for Learning (AFL), is considered to be one of the most effective (Black, 1998). The primary purpose of formative assessment is to improve learning and teaching by assessing

student understanding during instruction, with prompt feedback for improvement. Conventionally, assessment is used more for summative purposes, i.e. for grading performance, ranking students and as an extrinsic motivator. A central feature of AFL is ongoing timely feedback and opportunity to improve toward mastery, while it also enables teachers to adjust their instruction to learner needs. To achieve its full potential, AFL needs to be purposefully designed into the topic structure from the start as part of regular course operations, rather than being simply an 'add-in' here and there.

We report on a project with both development and research components. We integrated Assessment for Learning into two inquiry-based physics instructional units, and then conducted a controlled study comparing the effects of formative and summative systems on student learning and attitudes. The context was a conceptual physics course for pre-service teachers, with 24 students per section in studio format with groups of four. The instructional development component involved the design of topic content progressions, instruction, and assessments. Guiding principles were first formulated for the integration of AFL into science instructional design. On this basis we restructured two existing topic units, dynamics and kinematics, as learning progressions, then at finer grain as cognitive learning trajectories with identified Concept Aspects. Formative assessments were then infused throughout, for both in-class and out-of–class learning, including detailed learning objectives, creation of AFL problems, instructor-, peer- and self-assessment, feedback mechanisms, and opportunity to improve. Technologies such as clickers with associated software made it possible to implement AFL strategies on-the-spot in class, while an online course management system enabled (limited) asynchronous interaction on homework and tests.

We then conducted a controlled experimental study to compare the effects of formative and summative systems on student performance, attitude, motivation and learning behaviors. We implemented the dynamics and kinematics units in instruction, with two sections of the course serving as treatment and control groups. The assessment system was strongly formative for one group and conventionally summative for the other, with the two modes specified by operational models. In other respects the units were the same and taught by the same instructor. All students became familiar with both assessment methods earlier in the course. We used a crossover structural research design involving 2 instructional units, 2 student groups and 2 assessment modes, so that each group experienced one unit in formative mode, the other in summative. Students' learning gains were determined using pre- and post-tests with selected and constructed responses, and student attitudes toward each system were surveyed along with reasons. We also studied the formative effects on the instructor in adjusting instruction.

Findings were briefly as follows: for the conceptual dynamics unit, students' normalized learning gains were significantly higher for the formative mode, while for the quantitative kinematics unit the gains were similar for the two modes. Students much preferred the formative system for learning, although many also felt they needed the extrinsic motivation and reward aspects of summative. An unexpected outcome was that student evaluations of the same instructor were very different depending on mode. The AFL instructional design aspects and the research methods and findings will be discussed.

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Keywords: University education, secondary education, assessment for learning, formative assessment, instructional design, inquiry-based physics instruction, controlled comparative study, science education

Topics: Assessment & Evaluation, Learning, Teaching

Session 3B, 17:10-18:30

238.O3B

It is possible to modify the practice of experienced teachers

Pilar Segarra[1], Maria De Los Angeles Ortiz[2] and Virgen Huerta[3]
[1]*Facultad de Ciencias, Departamento de Física, Universidad Nacional Autónoma de Mexico; Centro de Investigacion en Ciencia Aplicada y Tecnologia Avanzada- Legaria, Instituto Politécnico Nacional, Mexico*
[2]*Facultad de Ciencias, Departamento de Física, Universidad Nacional Autónoma de Mexico, Mexico*
[3]*Escuela Nacional Preparatoria, Universidad Nacional Autonoma de Mexico, Mexico*

Educational research indicates that it is very difficult for experienced teachers to modify their teaching, even after various disciplinary or educational courses. It is known that they generally continue with the methods used for years, remaining as the central figure that transmits knowledge, without taking into account the ideas, interests or knowledge of their students.

With this information, we plan to investigate whether this situation persists with high school teachers in service, who have completed a master's degree in teaching. This master's degree, recently created at Universidad Nacional Autonoma Mexico (UNAM), is oriented to improve teaching professional activities in a balanced treatment of educational issues and the teaching-learning processes of physics. For this purpose we developed a questionnaire which was applied to graduates from all generations (2006-2012).

Contrary to the results of the short courses, we have found that all the surveyed teachers have modified in some way their teaching. They now prepare their classes thinking in their students as the central figure, asking themselves why the activities are done, the importance of each of the concepts, and how to introduce them. They now recognize that their students are teenagers, which require taking into consideration their ideas, interests and knowledge.

This study revealed that for the real improvement of science education, instead of continuing to organize short courses that we know do not transform teaching practice, it is preferable this kind of postgraduate that promotes significant change in teachers' pedagogical content knowledge (PCK).

Keywords: University education, teaching training, pedagogical content knowledge

Topics: Teachers

247.O3B

Considerations on the possibilities of cooperation between the university and schools: reflections on approaching the history and philosophy science to physics teachers education

Sandra Regina Gatti and Roberto Nardi
UNESP, Brazil

When one discusses the gap between innovative proposals, results of investigations in Science Education area and concrete actions undertaken in the classroom, a question arises: why the impact of the research is not felt, in order to improve the quality of education in schools?

One of the possible way to try to answer this question brings us back to think about teachers training. The initial training courses and continuing education have not, in most cases, achieved significant progress, mainly by disregarding the fact that teachers have preconceptions about what is important to teach, how to do it, what causes students' failure etc. (Levy and Sanmarti, 2001).

Many studies (Gil Perez, 1991; Mellado, 1996; Levy and Sanmarti, 2001; Gatti, Silva and Nardi, 2010; among others) have shown the existence and persistence of traditional conceptions that teachers have on science and on the processes of teaching and learning, and they discuss their influence on teaching practices.

The transition to practice consistent with new paradigms requires a discussion of the teaching and learning processes (Levitt, 2001), since the traditional model, as a paradigmatic system of concepts and beliefs, behaviors and attitudes, has a certain consistency and provides answers to most educational problems (Furió, 1994).

Garcia (1999) shows that we cannot expect that the initial teachers education would offer a final product, but it should be understood as a first step for a formation, that will extend during all the professional life. In this sense it is imperative for teachers to engaging in a continuous process of formation.

Taking these referential into consideration, we performed this research, as a case study, in which we developed training activities with pre-service physics teachers, aiming to take the History and Philosophy of Science to the classroom, during teaching internship activities.

The central research question was: what are possible contributions to the improvement of physics teaching of a training model that, from contributions by the History and Philosophy of Science, intend to involve in-service teachers and pre-service teachers in activities that seek to reflection and the development of new practices within the school context, the acceptance of innovative methodologies and building bridges of cooperation between university and school.

So we contacted a group of future high school physics teachers, who were attending the last year of undergraduate physics during the second half of 2011. Three of them accepted the invitation to participate in the research. In a first step, we conducted a survey on the views of participants on the processes of teaching and learning, on the construction of scientific knowledge and about their opinions about the limits and possibilities of the approach of the History and Philosophy of Science in Teaching. For this, we used written questionnaires and a focus group interview.

The results of this initial survey revealed influences from traditional views of teaching and learning, focusing on transmission and reception of content, and distorted conceptions about the construction of scientific knowledge and strong resistance to the possibility of a real approach to the History and Philosophy to the science teaching. This initial survey provided an overview that could be used for planning work during the semester, including the selection of materials for reading and discussion (Such as: Matthews, 1994; Aduriz-Bravo et. al., 2002; Chalmers, 1994 among others). The idea was to confront and question the participants' notions, which was made from study meetings as a starting point for the design of short courses to be developed by them.

In parallel, the pre-service teachers would be doing internship activities in a public school where three in-service teachers who had participated in a course given by the researchers agreed to receive them and guide and evaluate their activities.

The topics of the courses developed at the school were negotiated with the high school in-service teachers. Only one of the future teachers completed all stages of the research. We detach here some outcomes of this case study:

a) The meetings held at the university with pre-service teachers proved to be essential, since it was the first contact with the Philosophy of Science for all of them;

b) The activities were carried out under collaboration with the high school teacher who suggested topics for the short course, monitored and evaluated the teaching stage;

c) Despite the notions presented in the beginning of the research, Fernanda (fictitious name), a future physics teacher, reveals growth during the semester, designing a teaching proposal focused on discussions on the scientific knowledge construction;

The orientation of the teaching internship was conducted by researchers at the university and the monitoring was conducted by the high school teacher, showing a real collaborative work, since it avoided a hierarchical relationship between the pairs.

The training model suggested here can help to break the dichotomy, i.e., the problem of the separation between the scientific and pedagogical training, developed in undergraduate courses in a completely unrelated basis (Bermudez et. Al., 1994, cited in Gil Perez, 1996), allowing the pre-service teacher actively participate in the internship, living experiences closer to the reality of schools, helping to integrate the processes of initial and continuing training. This raises the need to extend the work of cooperation, seeking to involve more pre-service and in-service teachers, seen as partners and not as consumers of the results of research carried out in universities.

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Keywords: Physics teaching, physics teachers education, history and philosophy of science

Topics: Teachers

249.O3B

The evolution of future physics teachers' conceptions about the teaching of physics for youth and adults

Andréa Cristina Souza de Jesus and Roberto Nardi
UNESP, Brazil

The research aimed to investigate the performance of undergraduate physics students, future high school physics teachers, in supervised teaching practices designed for Youth and Adults Education (YAE). The YAE is designed, in Brazil, for those who did not have access or permanence in studies at elementary and high school at convenient age. Throughout this research we observed the evolution of the conceptions of undergraduate students about the teaching of physics in this modality. At first, it was verified that the ideas of the undergraduates about the YAE approached the common sense, because they described this modality as a short course and low level in terms of education quality. These ideas demonstrate that the future teachers do not know well about the structure and function of this educational modality, showing deficiencies in their initial formation. In the second stage, after they have observed YAE classes for a semester, the future teachers highlighted the diversity of these classes, which had youth, adults and even senior students. Their speeches also highlighted the difficulties that students have in relation to the school context, not only about the physics content learning but the school organization in general and the issue of class schedules, for example. These observations are close to the real characteristics of the YAE, according to experts who has investigated this teaching modality. Finally, in a last stage of the research, after the future teachers had taught for youth and adults, their speeches highlighted the participation of students, especially when the contents of physics were related to their everyday life. The future teachers reported also that the young and adult students understood very well the physics concepts taught, contradicting the idea that, because of the students' difficulties in the school context, they can't learn the physics concepts effectively. This research about the teaching of physics for youth and adults is justified because there is considerable number of YAE classes and this is a possible field of work for these future teachers; besides that, this matter has been rarely investigated in Brazil. This research with future teachers also shows to have contributed to change their ideas of common sense and approached their conceptions to the reality of YAE, so they could re-elaborate their teaching practices for this educational context.

Keywords: Youth and adult education, physics teaching, initial teachers education, discourse analysis

Topics: Teachers

250.O3B

In-Service Education of University Professors

Beatriz Salemme Corrêa Cortella and Roberto Nardi
UNESP, Brazil

This paper presents outcomes of a doctoral research that pointed out the main limiting factors to be overcome by an initial physics teachers program of a Brazilian public university, in order to achieve the profile of professional identity proposed by the pedagogical project of this program. From a survey of the intended ideal proposed in this project we analyzed the pedagogical and administrative actions undertaken in order to implement a new curriculum. Data were collected from the analysis of documents, field notes made during faculty meetings and interviews taken among 16 professors teaching in the program. It is a research for action, based in Habermasians principles. For data analysis we used analytical devices of Discourse Analysis from Pechêux's French perspective. The limiting factors found were: the identity profile of the program, double and dubious, since even pointing to the formation of a "physicist-educator", it is structured to form the "physicist-researcher"; the teaching plans, which have traits of technical rationality, inconsistent with the discourse of the program pedagogical project, which points to the practical rationality; professional profile of the professors acting in the program, most of them without pedagogical training and that bring the training model received in their undergraduate formation as physicists, which shows insufficient for effectuation of desired changes. The clippings done here aims to present the relationship between the professional profile of professors acting in this program and the marks (or absence thereof) left by an in-service training program offered to these professors during the period from 2006 to 2010 and that are perceived (or not) in their teaching practice and /or in their discourses. It was concluded that the "marks" in-service training were not evident, ie, it does not show effective in the collective actions of teachers, was not reflected in the organization of teaching plans and even technical terms or concepts used in the texts worked in meetings, appear in their speech. Research on the training of teachers in higher education, although important for the implementation of new teaching models are still incipient and there is room for further work covering this theme.

Keywords: Physics teaching, physics teachers education, in-service physics professors education, university physics teaching

Topics: Teachers

Session 3C, 17:10-18:30

102.O3C

Use of Numerical Methods on spreadsheet to Solve the Motion Equation of Newton's Second Law

Alejandro González Y Hernández[1] and Cesar Mora Ley[2]
[1]*National Autonomous University of Mexico (UNAM), Mexico*
[2]*Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada Unidad Legaria, Instituto Politécnico Nacional, Mexico*

Laboratory of Mechanics is a course of first year Physics of the Science Faculty at UNAM. In this course, our students learn the laws and principles of Mechanics from an experimental point of view. The solution of Newton's Second Law applied to dynamical phenomena of Mechanics is an important objective of the course and for this purpose it was programmed numerical methods in spreadsheet. For students, the learning of these methods are not so difficult, but they are very useful for them because they can be applied to solve complex problems of dynamics. One of these dynamical problems that we have discussed in class with our students was of knowing how was the Felix Baumgartner's jump, the skydiver who jumped to Earth from a helium balloon in the stratosphere without parachute for 39 km on October 9, 2012. The introduction of this issue is very motivating for students because they try to find not only the solution of the equation of motion of this jump in the high atmosphere, but also which is the physics of this movement.

The physical study of Felix Baumgartner's jump from the stratosphere was compared with the physical study of Kittinger's first high-altitude jump, from about 23,300 m, on November 16, 1959 [1,2]. The equation of motion of the Baumgartner's jump was developed by students with the support of the professor and the assistant of the group after of a completely discussion about the physical parameters of this jump. Then, the students working in small groups to solve the Newton's equation of this movement using the numerical methods programmed on spreadsheet previously for studying of more simple movements. Once the students had a solution of the problem, they began to move the values of the parameters that define the jump from stratosphere to fit the time and vertical displacement values given in Felix Baumgartner's jump. Finally, the students gave their conclusions about the affectivity of the use of these methods to study real phenomena in class.

The strategy of apply numerical methods programmed on spreadsheet for studying problems of real world, it was to achieve that students to deepen in the learning of physics methods, for involving them in the methods of reasoning in physics and in the understanding of physical meanings in a high level. We hope to have reached this purpose and this is the work that we present in this Conference.

Keywords: Experimental mechanics, teaching, numerical methods, strategies, high-altitude jump

Topics: Teaching

120.O3C

A Keplerian Laboratory of Didactics

Jorge Barojas and Miguel Cuauhtli Martinez
Centro Virtual de Investigación y Desarrollo en Educación, Mexico

This contribution proposes that learning Physics can be didactically promoted and organized like a scientific process when teachers explore, experiment and evaluate in a three dimensional laboratory of didactics with a Keplerian approach. Teachers working as “experimenters” in such a laboratory of didactics observe and find patterns in a dimension of individual cognitions, they build and prove explanations of those patterns in a dimension of epistemological interpretations, and they use multiple representations to think about learning phenomena in a dimension of social interactions.

It is proposed that when Physics teachers incorporate a Keplerian approach to the three dimensional laboratory of didactics, they promote and guide theirs students in order to develop three characteristics of the scientific process shown by Kepler when he described the trajectories of the planets around the Sun: creativity, capacity for synthesis and open-mindedness. The dimensions of the laboratory of didactics concern the following teaching purposes: to develop creativity in the dimension of individual cognitions when the students master technical and formal languages in order to solve problems; to build capacity for synthesis in the dimension of epistemological interpretations when the students understand and apply scientific concepts, models and theories and when they communicate appropriately what they have learned, and to promote open-mindedness in the dimension of social interactions when the students became skilled at working in learning communities and increase their educational resilience in order to overcome stress and be prepared to face pedagogical and psychological conflicts. An example of application of the Keplerian laboratory of didactics to an introductory course on classical mechanics is also considered.

Keywords: University education, individual cognitions, epistemological interpretations, social interactions

Topics: Learning, Teaching

144.O3C

Developing the Course of "Practical Theoretical Physics" for High School Students

Mikhail Tyntarev
St. Petersburg Academic University, Lyceum "Physical-Technical High School", Russian Federation

The last real physical problem, which has a simple rigorous solution, had been solved more than 100 years ago. Modern physicists face problems which have no exact analytical solution. Numerical methods are very powerful, but only analytical solution, even if not rigorous, remains the best way to understand the physical meaning. Therefore, the approximate methods are really important for theoretical research.

The author's personal experience as a theorist at the Ioffe Institute and the close communication with University colleagues (our Academic University integrates high school level, university level and research laboratories) shows that it is necessary to teach the students to use approximate methods at the high school level.

The most of the existing courses of approximate methods in physics are either elementary, using scaling and dimensional analysis (e.g. "Street-Fighting Mathematics" by Sanjoy Mahajan), or too complicated, appropriate for university students, rather than for school pupils (e.g. "Approximation methods in quantum mechanics" by A.B. Migdal and V.P. Krainov).

The course "Practical Theoretical Physics" has been specially developed to fill this gap. The course is meant for high school students, who desire to become physicists. The core of the course is the system of problems worked out to cover the main mathematical methods. In these problems we tried to avoid specially invented situations and used simple phenomenon of nature, most of which can be illustrated by in-class experiment. Nevertheless, the quantitative solutions of these problems are not very simple and require some estimations and approximations based on the fine understanding of the process.

Every lesson is a model of a scientific research: we discuss phenomena qualitatively in order to understand what happens, then create mathematical model and solve the equations with a proper precision. Finally we compare the theoretical and experimental results.

The aims of the course are:

- to study the general methods of theoretical physics, estimations, approximate methods, using mathematics understandable enough for high school students;
- to try to be physicists-theorists at our lessons.

After three years of teaching this course we can point out the main results:

- it is possible to study theoretical physics at school;
- though designed as a mathematical one, our course helps to understand the essence of physical processes and to train scientific intuition;
- students obtain confidence that they can solve any problem at least approximately;

- some points of our course can be included into standart school courses of physics.

The feedbacks we receive from our former students now studying at University prove the importance of such a course.

Keywords: Approximate methods, physics teaching, theoretical physics at high school

Topics: Teaching

146.O3C

Physics and Physical education. Can they be approached together?

Ada T. Mendez Moreno
IPN-CICATA & Palm Beach County School District-Gove Elementary, United States

This is a proposal for the teaching of physics in upper primary education level.

In this proposal, the author integrates the teaching of physics concepts contained in the Common Core Science programs with a fitness science camp that has the intention of keeping students active mentally and physically.

The classroom and notebooks are left behind. Students wear their sneakers since their active learning will entail putting to work not only their neurons, but also their bodies. While students improve physical endurance, strength and flexibility they become aware of concepts such as speed, velocity and acceleration. To name a few, there are exercises that put Newton's laws into practice and to the test while the concepts of force, energy, inertia and gravity also become integral part of the fitness science camp instruction.

Students sit to find connections between their activities and the physics concepts instead of standing up to perform physical activities to test them.

A variety of teaching techniques and activities to keep students' healthy weight and to teach physics at the upper elementary level that appeal diverse learning styles will be presented to the attendees of this talk.

Keywords: Teaching techniques, physical education, physics, elementary, active learning

Topics: Teaching

Session 3D, 17:10-18:30

196.O3D

Reconstruction of the Guided Worksheet based on Student Understanding: A Case Study in Electric Field

Thanida Sujarittham[1], Narumon Emarat[2], Kwan Arayathanitkul[2] and Jintawat Tanamatayarat[3]

[1]Institute for innovative learning, Mahidol University, Thailand

[2]Department of Physics, Faculty of Science, Mahidol University, Thailand

[3]Department of Industrial Physics and Medical Instrumentation, Faculty of Applied Science, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

Guided worksheet has been proved to be an effective teaching tool in facilitating students to become actively engaged in the learning process as well as improving student understanding. The goal of this study is to reconstruct the guided worksheet for teaching Electric Field based on student understanding. The participants of this study were 260 and 163 first-year science students in academic years 2011 and 2012, respectively. In the academic year 2011, the construction of worksheets was purely based on teachers' views. The teachers' views were normally influenced by the content and aims of the course, textbooks and teachers' experiences in teaching the subject. In the academic year 2012, the survey of student understanding in the academic year 2011 was analyzed and included in reconstructing the guided worksheet in the topic of Electric Field. The student understanding of the topic was measured by using 6 questions which were selected from the standardized test (CSEM) and leading textbooks. These questions were administered to both student groups before and after learning with the guided worksheets. The average pre- and post-test scores for the academic year 2011 were 24 % and 55 % while those for the academic year 2012 were 21 % and 74 %. An improvement of student understanding was measured by using a normalized gain. The average normalized gains of students in the academic years 2011 and 2012 were 0.41 and 0.68, respectively, and the difference was statistically significant ($p < 0.05$). The results imply that by taking into account the student understanding in reconstructing the teaching tool, a guided worksheet in this case, student learning could be enhanced significantly.

Keywords: Guided worksheet, electric field, student understanding, teacher's views, CSEM

Topics: Teaching

204.O3D

Students Classification according to their different aspect of attitudes about physics using the views about science Survey test (VASS) and measurement relation between their attitudes and learning achievements

Mojtaba Jahanifar and Nasrin Taheri Asghari
Ministry of education, Islamic Republic of Iran

This study has been conducted to classify high school students according to their attitudes about physics concepts and measurement relation between their attitudes and achievement at electricity concepts learning. This is a case study analysis about 200 participants in Iran high schools that study math sciences or empirical sciences in grade three. At the beginning participants (students) was tested by using VASS (the views about science Survey) and according to their responds to VASS items were categorized in four attitude groups: a) students with skilled thinking that in this study are called STG, b) students with above transition thinking that in this study are called ATG, c) students with below transition thinking that in this study are called BTG and d) students with slangy and folk thought that in this study are called FTG. Before starting the curriculum about electricity topics at grade 3 in high School we used another standardized test to assess primary knowledge about electricity concepts, this test that was used as pre-test was CSEM, curriculum and instruction methods that used at classes were a kind of direct instruction method like mastery learning method (a learner-based method in instruction). After four weeks, electricity topics instruction were ended and we used again CSEM as post-test. We calculated achievement gain factor (g factor) by using pre and post-test data, here are three kinds of g factor: $g < 0.23$ for low level achievement $0.23 < g < 0.52$ for middle level achievement and $g > 0.52$ for high level achievement. Then g factor- calculated for each participants - compared with his/her membership in aptitude group. Results show that membership in special aptitude groups effects on achievement level, participants in STG Group have g factor rather than 0.52 (g mean for STG was 0.79), it shows that they reach high level achievement, and participants in ATG Group reach mean of g score about 0.49, it shows that they reach middle level achievement while BTG and FTG Group Just reach mean of g score in order 0.31 and 0.19 and so they have low level achievement in electricity concepts.

Keywords: Physics education, attitude, electricity learning, VASS test, CSEM test, g achievement factor

Topics: Learning

215.O3D

Student Generated Content for Learning

Morag Casey[1], Simon Bates[2], Ross Galloway[3] and Judy Hardy[3]
[1]*University of Glasgow, United Kingdom*
[2]*University of British Columbia, Canada*
[3]*University of Edinburgh, United Kingdom*

We present two major results from a comparative study [1] of the implementation of PeerWise [2] as an online tool for student-led (and instructor-free) learning in undergraduate physics. In 2010-11, we piloted PeerWise with the level-1 physics class at the University of Edinburgh [3] and found a high quality of submissions as well as a positive correlation between student activity and end-of-course examination score; we undertook a similar study during the 2011-12 academic session, finding similar results. In 2011-12 we also successfully implemented PeerWise at level-2 physics in the University of Glasgow and found similar levels of engagement, quality of submissions and positive correlations between student activity and academic gain. We suggest, therefore, a model for intervention that can promote high-impact student learning and conceptual gain with minimal instructor intervention.

References:

[1] https://www.wiki.ed.ac.uk/display/SGC4L/Home

[2] http://peerwise.cs.auckland.ac.nz/

[3] http://proceedings.aip.org/resource/2/apcpcs/1413/1/123_1

Keywords: "Student-generated content", assessment, engagement, scaffolding

Topics: Assessment & Evaluation, ICT, Informal Physics Teaching & Learning, Learning, Teaching

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257.O3D

Data analysis of Peer Instruction

Hideo Nitta, Tomoshige Kudo, Ruita Nishimura and Masanobu Moriguchi
Department of Physics, Tokyo Gakugei University, Japan

Peer Instruction (PI) is one of the simplest active learning methods to increase students' engagement in lectures. We have implemented PI into introductory physics lectures in our University and the High-School affiliated to our University. For evaluating the effectiveness of these lectures we have performed the pre-post FCI. Combining data from FCI with those from students’ answers for clicker questions (CQ), one obtains information not only about the effectiveness of lectures but also common naive conceptions. Obtained information has been used for improving lectures in every next year. In this presentation we shall concentrate on discussing the following three topics of our research.

1. In a PI-based lecture it is crucial to find out effective CQ. For evaluating the effectiveness of each CQ, we have introduced the Peer-Instruction efficiency (PIE), of which definition is given in analogy with the Hake gain (H. Nitta, PRST-PER, 6 (2010) 020105). It is found that PIE is significantly higher than the average PIE for CQ about kinematics whereas lower for CQ about action-reaction problems.
2. We have tried to find out the effective number of students in a group discussion at PI. We found that the groups composed of four students get higher PIE than the groups of three or five students.
3. We have assumed that the cognitive processes that students change their answers from wrong to right ones in a CQ may be related with Vygotsky's idea of the zone of proximal development. Within this point of view, we have examined the correlation between the Hake gain and the rate of changing answers from wrong to right. Contrary to our expectation, we find there is weak negative correlation. Detailed discussion about the results in the above will be given in the presentation.

Keywords: University education, Peer Instruction, clicker questions, zone of proximal development

Topics: Assessment & Evaluation, Learning, Teaching

Session 3F – workshop, 17:10-18:30

077.W3F

Teaching particle physics in a research laboratory

Csilla Fulop and Eva Maria Olah
ELTE, Hungary

Conveying the key messages of contemporary particle physics at secondary school level is highly challenging. The subject is not included in the normal syllabus, most textbooks actually miss the existence of subatomic particles. Particle physics on the other hand appears regularly and successfully in public press and media, therefore it seems mandatory to bring the subject closer to the students.

Seven volunteers from the „Mechatronics" Secondary Technical School in Budapest are lucky enough to have the possibility to participate in the activities of High Energy Explorative Team at Wigner Research Institute of Physics. Researchers with experience especially from CERN are supervising projects, with properly adapted knowledge level, which the students undertake in small groups. Such projects are in close connection with the ongoing research, which gives motivation to the supervising researchers as well.

One example is a highly sensitive current meter designed for gaseous detectors, with direct current measurement precision well below 1 nA. In this case the mechanical realization, the construction of the necessary electronic circuits and calibration / testing involves key participation of the students.

An other project is a direct measurement of multiple scattering of 1.5 – 2 MeV beta radiaton in various thin construction materials, such as metallic, kapton or Mylar foils. The measurements are exploited to confirm the proper understanding of material properties by comparing with earlier measurements from relevant literature. The students are setting up a classical scattering experiment, gain insight to the methods of detection with scintillating counters.

Experience gathered during the implementation of the projects and from feed-back from students, the question is raised: to what extent actual experimental participation is necessary in raising motivation for the study of high energy physics phenomena.

Keywords: High Energy Explorative Team, sensitive current meter, methods of detection

Topics: Experiments, Teaching

»»Session Workshop night 1D, 20:00-21:30««

298.WN1D

RGB radiometry with ordinary cameras as a research opportunity for everybody

Jan Hollan
Faculty of Education, Masaryk University, Czech Republic

Many digital cameras are able to store really raw A/D data from pixels of their CCD or CMOS matrix. If a pixel is far from being saturated, count minus the noise level is proportional to number of photons absorbed. Cameras with really raw data are scientific instruments, provided they store true exposure settings as well. A perfect tool for converting raw data from dozens of proprietary formats to standard *.pgm files exists: "dcraw"; it gives exposure information too. Our contribution is an additional programme, raw2lum, which, using dcraw pgm, provides all possible kinds of radiometric output, including photometric ones (related to photopic spectral sensitivity of human eye).

Being able to quantify and visualise luminances easily is an interesting possibility for young people. Light, natural and artificially produced, is so important part of our lives - the latter being not for free. Understanding to many metrics of it and to real amounts we need physiologically is an entrance to physics of everyday and to sustainable use of electricity. Results from indoors, urbanised and natural sites, day and night ones, using various cameras will be shown, some of them achieved by students this year, or even during the very lecture.

Keywords: Radiance, luminance, digital cameras, photometry, data processing, physics of vision, environment observation

Topics: Experiments, ICT

Session Workshop night 1E, 20:00-21:30

212.WN1E

Physics Lab with Modern Technology

Radim Kusak
Charles University in Prague, Faculty of Mathematics and Physics; Dvorakovo gymnazium and SOSE, Kralupy nad Vltavou, Czech Republic

In 2012 we realized the project e-VIM (Interactive and Modern Education) at our high school. The project was focused on usage of modern technology in Science lessons – Physics, Chemistry and Biology. As part of this project we created many resources focused on lab activities.

In the first part of our workshop we will give participants opportunity to try some of these activities called Physics with iPad, USB microscope in physics, Physics in Slow motion, Wolfram|Alpha, Mobile phone in physics and Physics with Vernier probes. In the second part we will discuss concepts and issues of the lab activities with modern technology and also about feedback and evaluation of the students. All worksheets for this workshop will be available in English.

In 2013 we continue in usage of modern technology in project e-VIK (education, individualization, couching) focused on usage of notebooks and tablets in classrooms. In the end of workshop we give a comment about this project and its first results.

Keywords: Secondary education: upper, physics lab, USB microscope, iPad, physics in slow motion, Wolfram|Alpha, mobile phone in physics

Topics: Experiments, ICT, Teaching

Session Workshop night 1F, 20:00-21:30

362.WN1F

The Development and Implementation of industry informed inquiry based Physics Teacher Education (ESTABLISH)

Eilish Mcloughlin[1], Sarah Brady[1], Odilla Finlayson[1], Claudio Fazio[2], Ton Ellermeijer[3], Ewa Kedzierska[3], Marian Kires[4] and Leos Dvorak[5]
[1]*CASTeL, DCU, Ireland*
[2]*Universita Degli Studi di Palermo, Italy*
[3]*Centre for Microcomputer Applications, Netherlands*
[4]*Univerzita Pavla Jozefa Šafárika v Kosiciach, Slovakia*
[5]*Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic*

Inquiry-Based Science Education (IBSE) has been the focus of many national and international programmes and projects in recent years as Inquiry based teaching methods have been suggested as a way to encourage and motivate students in science. International reports (European Commission (EC), High Level Group on Science Education 2007, Osbourne, Dillon 2008) have identified the need for “engaging curricula to tackle the issue of out-of date and irrelevant contexts and to enable teachers to develop their knowledge and pedagogical skills”. The pan-European FP7-funded project ESTABLISH collaboration has led to the development of the project’s teaching and learning materials (ESTABLISH Units) as well as educational supports for both in-service and pre-service teachers (ESTABLISH Teacher Education Programmes) designed to promote the use of Inquiry-Based Science Education (IBSE) in classrooms across Europe. In particular ESTABLISH aims to create authentic learning environments for science education by including industry informed contexts and problems (Industrial Content Knowledge) that can be tackled in the classroom. This workshop will share the approach adopted for the development of the ESTABLISH units for physics teacher education and allow participants hands on experience with several IBSE activities that illustrate the types of industrial contexts and knowledge incorporated. These units (18 across Physics, Chemistry, Biology) have been adapted in a number of countries for use in pre-service and in-service teacher education related to professional development associated with inquiry and adapted to suit each national environment. By using these units for the teacher education programme, participating teachers can gain experience in inquiry, and gain confidence in developing their own teaching practices and incorporating industrial informed resources into their classroom practices.

References:

EUROPEAN COMMISSION (EC) and HIGH LEVEL GROUP ON SCIENCE EDUCATION, 2007. Science Education NOW: A Renewed Pedagogy for the Future of Europe. EUR 22845. Brussels: DG Research.

OSBOURNE, J. and DILLON, J., 2008. Science Education in Europe: Critical Reflections. 32. London: King's College, London.

Keywords: IBSE, inquiry, industrial content knowledge, ESTABLISH, teacher education

Topics: Teachers, Teaching

Tuesday

6. 8. 2013

»Session 4A, 13:30-14:50«

131.O4A

Cueing Effects in Physics Concept Inventories

Hani Dulli
German University of Technology, Oman

We have investigated cueing effects in two widely used multiple-choice instruments: the Mechanics Baseline Test (MBT) and the Brief Electricity and Magnetism Assessment (BEMA).

In our study, a group of 35 first-year engineering students was given, at the end of the first semester, a short-answer version of MBT followed immediately by a multiple-choice version of the same instrument. Later, at the end of the second semester, the same study was done on the same group of students using BEMA instead of MBT.

For the analysis part, we considered various responses to each pair of parallel items, i.e. items that have same content but different format. We counted the frequencies of the four possible combinations of answers (correct-correct, correct-incorrect, incorrect-correct, and incorrect-incorrect) to each pair of parallel items. We then examined both the overall cueing effect, which corresponds to the total frequencies of responding differently to parallel items, and the strictly positive cueing effect, which corresponds to the total frequencies of responding incorrectly to short-answer items then correctly to their multiple-choice counterparts. We also examined the correlation between the students' level of knowledge and the questions' level of difficulty, on one hand, and the cueing effect, on the other hand.

In our talk, we will discuss the method we used and the students' responses as well as the implications of our study on the interpretation of item response analysis and the development of new instruments.

Keywords: Education, physics, assessment

Topics: Assessment & Evaluation, Learning, Teaching

134.O4A

Three steps to successful change

Gordon Aubrecht
Ohio State University at Marion, United States

With support from the U.S. Department of Education Math and Science Partnership through the Ohio Department of Education, we have discovered a tripartite method that worked at increasing scores on high-stakes tests in an at-risk school system. The three parts are a summer content program, grade-level lesson development by teachers working together during the school year, and (most novel) the use of common grade-level formative assessment analysis by teachers. Formative assessments can allow teachers to understand what is and is not working in their classrooms for the purpose of changing how they teach various content. We have helped middle and high school teachers approach formative assessment of open-ended questions. We ask that teachers identify (written) student ideas for the pretest and see how they might affect the way they present content; then for the posttest, we ask them to identify on the basis of changes in responses and the sorts of responses how they would change their teaching of the content the next time. This study presents a model, as well as its application, for the development of formative assessments in the classroom in a rurally located, city high-needs district in the state of Ohio. Results indicate changes not only in the way teachers view their pedagogical approaches, We are attempting to see whether what has worked in the one school system also works in a different school system. Details will be discussed.

Keywords: Secondary education: lower, secondary education: upper, teacher change

Topics: Assessment & Evaluation, Learning, Teachers, Teaching

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162.O4A

Examining student problem solving behaviour with and without access to resources, and implications for open-book exams

Marsali Wallace and Ross Galloway
University of Edinburgh, United Kingdom

After university, students will have access to a range of resources, including textbooks and the Internet to help them solve problems. However, closed book exams are the common assessment method for physics exams. Open book exams (with appropriate questions) test students' application and understanding of knowledge, but one concern from instructors may be that if given resources students will solve physics problems without understanding what they are doing.

6 first year undergraduate students at the University of Edinburgh were given two physics problems and asked to think aloud whilst solving them. An additional group of 7 students were given the same two problems with access to resources. Problem solving behaviours for both groups were coded.

The results show similar trends, differentiating successful and unsuccessful students, and indicate students' problem solving behaviours when given access to the internet and a textbook.

Qualitative results were used to triangulate data from the behavioural coding. We found that if students did not understand the area then they did not know what information to look up, looked up irrelevant information, or did not apply the information found correctly to the problem.

Without the basic foundational knowledge students are unable to solve problems even with the wealth of information of the internet at their fingertips. This means that appropriately constructed, open book exams would not have been easy for these students. It is hoped that this study will provide an interesting insight into students' problem solving strategies with the availability of resources.

Keywords: University education, undergraduate physics, problem solving, open book exams

Topics: Learning

163.O4A

Analysing the Students' Performance in a Virtual Learning Environment: A case study in a Physics Teacher Training Course

Thiago Souza, Albano Nunes, Thomaz Silva, Francisco Vasconcelos and Eloneid Nobre
Universidade Federal do Ceará, Brazil

Assuming that learning assessment is not restricted to the quantitative measurement of student learning, a hybrid approach to contributing as a tool for analysis of the various phases of the educational process has been applied. This approach may contribute to the student training, where we highlight some of the factors that can be analyzed in the teacher training context: the teacher influence, the school environment, the curriculum design, assessment modality and others. Among these factors, we highlight the curricular design, as an important feature to be analyzed. In this context, a quantitative and qualitative analysis has been conducted in order to identify possible relationships among the disciplines of the first-year of a physics teacher training course that occurs in a distance education modality that use the virtual learning environment called SOLAR. This case study has been conducted at Federal University of Ceará, located in northeastern Brazil, from student performance, obtained by their disciplines' grades that belongs to the physics teacher training course. The grades was collected in the total of 126 students in 6 disciplines, with the aim to analyze the current curricular structure of the course's first-year. The disciplines analyzed were: Physics I, Experimental Physics I, Mathematics I, Experimental Physics II, Physics II and Educational Computing. The development of this study has been performed by two procedures: the first one is to check for validation of the Principal Component Analysis (PCA) applicability in the data collected. After this validation, the PCA has been used in order to indicate possible patterns that exist in the relationship among the disciplines, and thus to investigate the contribution of these relationships for the validation of the course's curriculum design.

The reliability analyzes of the data collected was high at 0.823 (Cronbach's alpha), ensuring a good internal consistency of the dataset. For the correlation coefficients, there was an emphasis on the moderate linear correlation among the disciplines that belongs to the second semester of the course, there are: Physics II and Experimental Physics II (0.843); Applied Informatics Education and Physics Laboratory II (0.699); Educational Computing and Physics II (0.573). The Kaiser-Meyer-Olkin and Bartlett's tests validate the PCA application; the first test showed a value of 0.734 and the second founded the rejection of the null hypothesis of the correlation matrix. Finally, the first two principal components (PC) selected corresponding to the most of variance explained (77.17%) of the original data. Analyzing the relationship between these two PCA, it was founded two clusters of disciplines, where the first cluster is related to the disciplines of the first semester which encompasses introductory disciplines. In the second cluster, the disciplines are related to the second semester of the course. These results obtained agree with the information that the curriculum design of the course. We conclude that the PCA is an important tool for data analysis related to educational context, in view of it seeks intrinsic and latent variables in the dataset analyzed, thus enabling new analyzes from new perspectives.

Keywords: Universty teaching, principal component analysis, teacher trainning, data analysis

Topics: Assessment & Evaluation, Curriculum

Session 4B, 13:30-14:50

072.O4B

Qualitative Video Analysis for Magnetic Breaking with Magnetic Sheet

Fumiko Okiharu, Akizo Kobayashi and Tomoyuki Imai
Niigata University, Japan

A dropping strong magnet through a long hollow nonmagnetic metal pipe falls slowly with constant velocity. The magnet is slowed by upward force from magnetic field created by induced current in the wall of the pipe. Because the force on the magnet increases as the speed of the magnet increases, the magnetic force balances the gravitational force, and the magnet achieves constant velocity. This phenomenon is called magnetic breaking. This interesting phenomenon will attract students to study Lenz's Law.

There were several trials to treat this phenomenon as an introductory education of Lenz's Law (1-2). For example, to analyze visually, permanent magnets were fixed with the two sides of the rectangular plastic tube, and a nonmagnetic metal piece was used as a dropping object in Ref. 2. In Japan, to visualize phenomenon, a copper pipe with slit is commercially available as a teaching material.

However, our experimental results showed crucial difference of the terminal velocity when we use the copper pipe with slit, and the copper pipe without slit. In order to qualitative evaluation with the theoretical model, usage of the pipe with slit does not fit the purpose.

Therefore, in order to visualize motion of the dropping magnet through the pipe without slit, we wrap the magnetic sheet around the pipe and record the motion by a camera. With this procedure, one can measure various kind of pipe, including its width, length and kinds. We present our qualitative approaches for our experimental results comparison with theoretical model.

References:

1. Yan Levin et al., "Electromagnetic breaking: A simple quantitative model", Am. J. Phys. 74 (2006) 815.

2. J.A. Molina-Boivar and A.J. Abella-Palacios, "Magnetic Breaking: A Video Analysis", Phys. Teach. 50 (2012) 412.

Keywords: ICT, magnetic breaking, video analysis, teaching material

Topics: ICT

096.O4B

Experiences of secondary schools teachers with electromagnetism presented in different ways

Ilsa Basson[1], Jeanne Kriek[1], Miriam Lemmer[2] and Aletta Zietsman-Thomas[2]
[1]*University of South Africa, South Africa*
[2]*North West University, South Africa*
[3]*University of the Witwatersrand, South Africa*

From a variation perspective to learn implies to experience, understand, perceive or see something in a different way (Runesson 2006). For this reason an exploratory study was done to reflect on experiences of upper secondary teachers after an eight hour workshop on electromagnetism. The teachers were from semi-rural areas in the central part of South Africa and have few resources for teaching.

The aim of the workshop was for teachers to experience a certain pattern of variation in the teaching and learning of electromagnetism. The focus of the pattern was to work from a real life situation through various representations to abstraction as presented by graphical and/or mathematical representations. The workshop therefore started with a real life situation, followed by using hands-on equipment and/or simulations to represent the real situation. Teachers were then asked to record their observations by drawing pictures. Then they were guided to draw diagrams. In the final stages they were shown how to capture data from the setup and represent the situation in graphical and/or mathematical form.

An example would be to use an unmarked magnet and determine the magnetic field lines experimentally. Various scenarios where then further investigated by using PhET simulations. Teachers were then guided to draw diagrams and a graph and come up with an idea of the strength of the field.

We will be reporting on the ways in which this workshop enabled teachers to experience and see the relation between everyday life situations and abstract graphical and mathematical representations.

References:

Runesson U 2006. Scandinavian Journal of Educational Research, 50(4):397-410.

Keywords: Teacher training, variation of experience, representations

Topics: Teachers

194.O4B

The coil in a magnetic field

Václav Piskač
Gymnázium tř.Kpt.Jaroše, Brno, Czech Republic

The behavior of a coil with a current in a magnetic field is well known for almost 200 years. I prepared the set of aids for easy and convincing demonstration experiments. The crucial part of the set is the big horse shoe magnet - the area 10×10×5 cm of almost homogenous magnetic field. The experiments follow all steps from a single wire to a commutator motor including the simple galvanometer.

All aids can be easily made at the school workshop - they are descibed in details in on-line articles (see http://fyzikalnisuplik.websnadno.cz/elektro/vodic_v_magnetickem_poli.pdf).

Keywords: Coil, magnet, electric motor, Lorentz force

Topics: Experiments

295.O4B

How students think about and use integration in an electromagnetism context

Leanne Doughty, Eilish McLoughlin and Paul van Kampen
Dublin City University, Ireland

Integration is a mathematical tool that is widely utilized in various physics topics. In an intermediate level university physics electromagnetism course, it is employed e.g. in the basic calculation of the total charge on an object of varying charge density and the more complex calculation of the electric flux due to a non-uniform electric field. It has been found that upon entry to electromagnetism courses students do not have the integration skills necessary to complete these types of problems.

To date, research on students' use of integration in electromagnetism has primarily been interview-based and has focused mainly on (i) how integration is cued and (ii) what difficulties students have when integrating. We have extended this work to semi-quantitative research into these questions in an Irish university with cohorts of about 50 students. We have found that for many students integration is unlikely to be cued. However, we have confirmed and quantified earlier results that recognizing dependency on a variable is a strong cue for students to integrate, and that technical difficulties with integration prevent almost all students from getting a completely correct answer to standard electromagnetism problems involving integration.

We have investigated (iii) what integration cues, i.e. what students' views on integration are, before they enter the electromagnetism course, and interpret the results in terms of their concept images of integration. We have found that students primarily see integration as a process of evaluation, and

not as summation. In fact, the majority of students have no conceptual aspect in their concept image of integration, suggesting that students difficulties are unlikely to be caused by the lack of transfer from maths.

We have also examined (iv) how students interpret integrals in basic contexts, i.e., do students know the physical meaning of simple integrals? Here, our results, which corroborate with those found when examining (ii) and (iii), show that some students do not consider the infinitesimal term or how it changes the meaning of the integral, while for many students evaluation remains their only form of response when presented with an integral (even when explicitly told that for an interpretation there was no need to do so).

This presentation shows detailed results from these four questions and the implications for teaching. Changes made to instruction and the effectiveness of this instruction will also be discussed.

Keywords: University education, electromagnetism, integration, concept image, cues, technical difficulties, implications for teaching

Topics: Curriculum, Learning, Teaching

Session 4C, 13:30-14:50

084.O4C

Integrating Didactical Strategies to Facilitate Meaningful Learning in Introductory College Physics

Mara Fernanda Parisoto and Marco Antonio Moreira
Universidade Federal do Rio Grande do Sul, Brazil

RESEARCH QUESTIONS: this research was organized into three studies, in which the first one attempted to answer the following research questions: 1) How to integrate, in a didactical proposal, situations of physics applied to engineering, the Potentially Meaningful Teaching Units (PMTUs), and the Project Method so that this integration could work towards facilitating the meaningful learning of physics concepts? 2) What problem-situations that can help engineering students to give meaning to physics concepts of thermodynamics? 3) Can the students learning of concepts of physics, which may derive from the implementation of this proposal, be considered meaningful? 4) How to integrate college physics with high school physics?

RESEARCH METHODOLOGY: qualitative and quantitative methods were triangulated, and research instruments were validated and tested for their reliability. The qualitative methodology chosen for this research was ethnographic (André, 2005), while the quantitative one was based on descriptive and inferential statistics (Dancey e Reidy, 2007). Data gathering used a quasi-experimental design for time equivalent samples (Campbell e Stanley,1979).

SOME RESEARCH FINDINGS: based on the research questions, a proposal for integrating the project method (Rogers, 1977) and the PMTUs (Moreira, 2011), which were composed by problem-situations (Vergnaud, 1993) that had been proven effective in providing meaning to physical concepts of thermodynamics, was applied. We identified, through the use of various instruments, what can be considered evidences of the occurrence of meaningful learning (Ausubel, 2002), based on data stemmed from theimplementation of this proposal, as well as what seemed to be an improvement in the representation that engineering students had of physics, since they started to perceive this discipline as vital in their field of professional practice. From the collected data, we also inferred ways of integrating school and university classes.

PERSPECTIVES: The findings suggest additional studies aimed at answering related questions: 1) What contents of thermodynamics can be used to support the teaching of the interaction of radiation with matter? 2) What kind of problem-situations can give meanings to concepts involving theinteraction of radiation with matter when they are applied to medical science? 3) What is the prior knowledge students bring to physics classes that can be used in the teaching of physics concepts applied to engineering? 5) What are the operational invariants students possess in the field comprised by this proposal? 6) Can integration among problem-situations of physics applied to engineering, the PMTUs, and the Project Method be a better facilitator of meaningful learning than traditional classes (expository classes followed by problem solving)? 7) How can situations of physics applied to medical science, the PMTUs, and the Project Method be integrated in order to facilitate the occurrence of meaningful learning of physics concepts? 8) What kind of prior knowledge is brought by the students to physics classes that can be used in the teaching of concepts of physics applied to medical Science?

Keywords: University education, secondary education: upper, engineering, thermodynamics, project method, potentially meaningful teaching units

Topics: Teaching

103.O4C

The socio-scientific issues-based approach and the in-service physics teacher situation

José Roberto Bernardo
Universidade Federal Fluminense, Brazil

Introduction

This article presents a study that investigated the actions of four experienced physics teachers who were involved in a partnership project between the university and four public high schools in the city of Rio de Janeiro, Brazil. One workgroup was formed to collectively develop didactic strategies seeking to introduce a socio-scientific issue (SSI) in the classrooms of the partner high schools. More specifically, the research question was: How did a group formed by four in-service physics teachers experience the challenge that the SSI-based approach represents?

Theoretical Framework

Viewed as a humanistic perspective to science education (Aikenhead, 2008), the Science-Technology-Society (STS) approach has been recommended as an alternative to prepare citizens who are able to deal with socio-scientific issues (SSI) and controversial topics in a responsible way (Santos & Mortimer, 2009). Many authors have sought to contribute to the definition of SSI. Reis e Galvão (2009) draw attention to the controversies that should characterize these issues, while Bernardo (2008) indicates the potential SSI have to function as catalyzers of argumentative processes in the classroom.

Methodology

The didactic material used was produced and organized to introduce the following SSI in physics classes: "Production of Energy by Means of Nuclear Plants". The activities were implemented in six classrooms, and the SSI was introduced in the classes given by the experienced teachers. The research data were obtained through recorded semi-structured interviews with the experienced teachers and were guided by the following question: What aspects made it easier and/or more difficult to introduce the planned activities in the school?

Discussion

Teacher's autonomy was identified as a crucial element for teachers who intend to use the SSI-based approach in face of the challenges posed by school programs and the school culture. However, the interviews also revealed that the arguments developed by the students are mainly based on what is offered by the various means of communication.

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Keywords: Socio-scientific issues, science-technology-society, teacher training

Topics: Socio-cultural Issues

183.O4C

Teachers' concept image of energy: a challenge for curriculum development

Yaron Lehavi[1] and Bat-Sheva Eylon[2]
[1]*The David Yellin Academic College of Education, Israel*
[2]*The Weizmann Institute of Science, Israel*

The present study examined mid-school science teachers' (N=54) views and knowledge against the main principles of the views presented in the position paper (PosP) of the Girep 2010 workshop: "Teaching about energy. Which concepts should be taught at which educational level?" [1]. The PosP, presenting the main ideas developed during the workshop, summarized the educational challenges encountered in teaching the concept of energy and offered an approach to address them. This approach presented the bases for a curriculum development for 7th and 9th grade students [2].

The following table summarizes the PosP views and the corresponding examined views of the teachers:

Views extracted from the PosP

(A) Energy as the language of changes:

(A1) Processes: Different processes in nature, characterized by changeable properties (parameters/indicators), can be quantified by energy change.

(A2) Co-variations: Changes in nature are always accompanied by other changes, which are characterized by increase and decrease of changeable properties (and thus can be described by increase or decrease of energy).

(B) The nature of Energy:

(B1) Unification: Energy is one concept that can change only quantitatively (energy can only increase or decrease). Different "types" or "forms" are labels for different processes in which energy increases or decreases (and thus are not essentially different).

(B2) Measurability: Quantitative changes in energy are subject for experimental verification.

(B3) Conservation: In an isolated system*, the gain in energy corresponding to some changes equals the loss in energy corresponding to the opposed changes.

The questions examining teachers' views

(a) Energy as the language of changes:

(a1) What are energy "forms/types?" How do we know that they are essentially the same?

(a2) What are energy transformations/ transfer? How do we know that the nature of energy does not change when a system transforms from one state to another?

(b) The nature of Energy:

(b1) What should be defined and how?

(b2) What should be measured and how?

(b3) What is the meaning of energy conservation and how can we convince that it has an empirical ground and thus, in principle, is refutable?

The teachers' views were addressed by a questionnaire administered during workshops. The questionnaire was composed of questions asking for the teachers' views and comments and by conceptual closed questions. The questionnaire was followed by interviews with some of the teachers.

Our findings indicate that the teachers hold a fragmental image of the concept of energy and have difficulties in justifying their views. For example, many responses suggest that forms of energy are inherently different one from another and that justifying that energy is one concept was rather difficult. We also found that the teachers' declarative knowledge was not always in accord with their conceptual knowledge. For example, many teachers view energy as relative but exhibited difficulties in applying this view to kinetic energy. These findings should be considered in any curriculum development concerning energy and in particular a curriculum which follows the PosP guiding principles.

Implications for teachers training (both in-service and pre-service) are discussed.

*) An Isolated system can be defined empirically as a system for which any (measurable) change within it does not correspond to any (measurable) change in its surrounding.

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Keywords: Energy concept, teachers knowledge, teachers training, curriculum development

Topics: Curriculum, Learning, Teachers

198.O4C

Transforming the Learning Environments of Undergraduate Physics Laboratories to Enhance Physics Inquiry Processes

Gregory Thomas, Al Meldrum and John Beamish
University of Alberta, Canada

Concerns persist regarding the lack of promotion of students' scientific inquiry processes in undergraduate physics laboratories. The consensus from the literature is that, especially in the early years of undergraduate physics programs, students' laboratory work is characterized by recipe type, step-by-step instructions for activities where the aim is often the confirmation of an already well-established physics principle or concept. In response to evidence of these ongoing concerns at their large metropolitan university in Canada, the authors conducted this study to address the aforementioned concerns, primarily by re/designing the activities that students performed in the laboratory to engage them in more inquiry oriented thinking and activity. A mixed-method design was employed. In the 2011/12 academic year of the study baseline data were collected. A quantitative survey, the Undergraduate Physics Laboratory Learning Environment Scale (UPLLES) was developed, validated, and used to explore the following dimensions of students' (n = 476) physics laboratory environments: Inquiry Orientation, Integration, Student Community, Instructor Support, and Material Environment. Interviews employing a hermeneutic dialectic circle were also conducted with 19 students at the end of the Fall semester to ascertain their views about their physics laboratory learning environment/s. The baseline findings confirmed the concerns evident in the literature and in a previous evaluation of the nature of the laboratories undertaken in 2001 by one of this paper's authors.

In September 2012 (Fall Term), newly developed laboratory activities and tutorials related to modern work in physics were designed and implemented for the first time with a first-year physics class of over 700 students. These changes were accompanied by structured training of teaching assistants and changes to the structure of the evaluation of students' laboratory performance. At the term's end, the UPLLES was administered to a representative sample (n = 266) and students were

interviewed (n = 16) to explore their perceptions of the new laboratory activities. Analysis of UPLLES data using independent samples t-test procedures and effect size calculations identified statistically significant differences ($p < 0.001$) across all dimensions, and effect sizes of 0.82 to 1.3, between the views of students in the first semester physics classes of 2011/12 and 2012/13, thus suggesting positive changes in the laboratory inquiry orientation. The students confirmed these positive changes in interviews. In this paper we detail the changes implemented and report major findings from across data sources. This study adds to the literature on undergraduate physics education, highlighting the potential for change in physics laboratories to encourage students' inquiry oriented thinking which is a major goal of physics education.

Keywords: Undergraduate physics education, inquiry, laboratory learning environments, activity design

Topics: Learning, Teaching

Session 4D, 13:30-14:50

020.O4D

A trial using Q-drum as a teaching material in dynamic classes

Osamu Hirayama
Tokyo University of Agriculture and Technology, Japan

The author has been in charge of dynamic classes for first year students in a mechanical systems engineering course in a university. The author adopted the 'Q-drum' as an advanced topic in the teaching process of rigid body dynamics in this semester. The Q-drum is a container invented for many people in developping countries to carry water. A Q-drum has a hole through which a rope can be bound to the drum and people can easily carry the drum filled with water by rolling it on a ground. The purpose of this trial is to promote the students concern and understanding to the rigid body dynamics by having them realize that the acquired knowledge in the rigid body dynamics classes can be applied to these kinds of invention.

The material consists of the following parts. 1.What is Q-drum? 2.What kind of friction force is applied to a Q-drum rolling on the horizontal plane at uniform velocity? 3.Estimate of the magnitude of the tension force required to pull a Q-drum rolling on the horizontal plane. 4.Calculation of the acceleration of a Q-drum rolling down a slope.

In the first part the author explains the role and the structure of the Q-drum to the students. In the second part the author explains the mechanism of the rolling friction force and derive the order of its magnitude. In the third part it is assumed that a rope is bound to the drum through the hole and the drum is pulled by the rope at the unifom angular velocity rolling on a horizontal plane. The angle between the rope and the horizontal plane is kept constant. The balance equations for the forces and torques applied to the drum are constructed and the magnitude of the tension force is derived by using the actual size of the drum. In the last part the students are asked to calculate the acceleration of the Q-drum filled with water rolling down a slope. Two kinds of assumptions on the motion of water inside the drum are imposed, one is a rigid body rotation and another translational motion. Before this class an experiment is conducted to record the motion of the drum and make the velocity-time graph. The calculated values of the accelerations of the drum in each cases by the students are compared with the experimental value and it is clarified which assumption is appropriate.

After the class a questionnaire survey was conducted, and many students wrote affirmative impressions or opinions to this trial.

Keywords: University education, rigid body dynamics, Q-drum

Topics: Experiments, Teaching

199.O4D

Are inertial forces real? Understanding professor Stanley's Machist interpretation of newtonian inertia

Paulo Lima Junior[1], Fernanda Ostermann[1] and Flavia Rezende[2]
[1]UFRGS, Brazil
[2]UFRJ, Brazil

Despite philosophy has played important roles in Physics, there is an escalating number of contemporary scientists regarding the study of philosophy of science as an unproductive loss of time. This abstract reports an analysis of how reading Ernst Mach's philosophy has brought an ordinary professor (named Stanley) into developing a radically different way of approaching the newtonian concept of inertial forces to his undergraduate students. Stanley claimed that most Physics books are wrong in interpreting inertial forces. Actually, most books stress that inertial forces (such as the centrifugal force) are not real, but ingenious tools for analyzing mechanical systems under those reference frames for which the laws of Newton do not hold (these are called non-inertial frames). When we first met Stanley, he was already known for arguing that inertial forces are as real as any other force in nature. Intending to bring inconsistencies out of Stanley's thought, we had him interviewed. Data collected was carefully transcribed and analyzed under Bakhtin's approach to language. Through analysis, we surprisingly observed that Stanley's seemed-to-be-inconsistent interpretation of mechanics would be better described as a creative hybridization of the Machist and the realist philosophical standpoints. It is precisely form this hybridism that Stanley's discourse becomes an anti-dogmatic and insightful device for students' looking beyond the traditional interpretations of mechanics and observing that there might be more than one legitimate interpretation to classical mechanics' most basic concepts.

Keywords: University education, inertial forces, philosophical interpretation, mechanics, Ernst Mach

Topics: Teachers

331.O4D

An evaluation of students' understanding of Newtonian Mechanics

Kevin Goldstein, Deena Naidoo and Douglas Clerk
School of Physics, University of the Witwatersrand, Johannesburg, South Africa

The Force Concept Inventory (FCI) pretest [1] comprising of 30 multiple choice questions was administered at the commencement of the academic year to ~950 Engineering students registered for a full-year Mechanics I course. The purpose of the diagnostic assessment was to acquire information on students' prior knowledge of their understanding of basics concepts of Newtonian Mechanics. In addition, this instrument has been utilized to ascertain areas of weakness in students' understanding which could be targeted during the academic year and to evaluate the possibility of applying the test to assess the effectiveness of instruction. The class attained a weak average mark of 33% which is similar to results reported in [2]. The collective responses for individual questions have been evaluated and will be discussed in terms of students' misconceptions.

In order to ascertain whether the FCI data gives evidence of any correlation to interactive classroom activities, the results of the first class test based on dimensional analysis, force vectors and vector operations in vector geometry and vector algebra formulation were compared with the FCI responses. A found a roughly linear correspondence between the FCI data and class test results with R2 ~0.16. The classroom activities included the use of “clickers” to promote active learning, obtain direct information on student’s misconceptions and hence modify the flow of lectures activities accordingly. This interactive approach was applied in the majority of lectures which allowed instructors to pose questions to students and instantly accumulate and assess their responses. Prior to tutorial exercises, students prepared exercises independently which were then discussed in small group (<30) formal tutorial sessions based on the principles of cooperative learning, self-reflection and feedback processes.

The class average was for the test was 53 % and the pass rate in the region of 56 %. Although the test coverage was limited to a very small basic component of Mechanics, a refined analysis shows that students who performed well in the FCI test also produced good class test results – amongst students who attained 60% or more for the FCI, the pass rate for the class test was 88 % and of the students who failed the class test, only 3 % achieved 60 % or more for the FCI. Conversely, competence in the class test was not strongly correlated with the FCI test – of the students who passed the class test, only 16 % obtained 60 % or more for the FCI while the class test pass rate amongst students who attained less than 60 % for the FCI was 52 %. In order to validate these preliminary findings, upcoming class tests and examinations scores will be compared with the FCI test results. The impact of teaching and learning will be re-evaluated by conducting a FCI post-test after the completion of the syllabus on statics and dynamics which will be reported in the paper.

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

Keywords: Force Concept Inventory, prior knowledge, classroom activities

Topics: Assessment & Evaluation, Learning, Teaching

332.O4D

The overlooked challenge of learning to extrapolate three-dimensionality

Cedric Linder[1], Urban Eriksson[1, 2], John Airey[1] and Andreas Redfors[2]
[1]*Uppsala University, Sweden*
[2]*Kristianstad University, Sweden*

Learning astronomy has many learning challenges due to the highly diverse, conceptual, and theoretical thinking used in the discipline. One taken for granted challenge is the learning to extrapolate three-dimensionality. Although we have the ability to see our surroundings in three-dimensional terms, beyond a distance of about 200m this ability quickly becomes very limited. So, when looking up at the night sky, learning to discern critical features that are embedded in dimensionality does not come easily. There have been several articles addressing how fruitful 3D simulations are for astronomy education, but they do not address what students discern, nor the nature of that discernment. Taking the concept of discernment to be about noticing something and assigning meaning to it, our research question is: In terms of dimensionality, what do astronomy/physics students and professors discern when engaging with a simulated video fly-through of our Galaxy and beyond?

A web-based questionnaire was designed using links to video clips drawn from a well-regarded simulation-video of travel through our galaxy and beyond. 137 physics and astronomy university students and teaching professors, who were drawn from nine countries, completed the questionnaire. The descriptions provided by them were used to formulate six categories of discernment in relation to multidimensionality. These results are used to make the case that astronomy learning that aims at developing the ability to extrapolate three-dimensionality needs to be grounded in the creation of meaningful motion parallax experiences. Teaching and learning implications are discussed.

Keywords: Extrapolating three dimensionality, discernment, higher education

Topics: Teaching

Session 4E, 13:30-14:50

001.O4E

Teaching students metacognition

Jorge Flores and David Anzules
Escuela Superior Politécnica del Litoral, Ecuador

Student registered in physics courses, at university level, lack of metacognitive strategies which allow them to plan, monitor, and evaluate their own learning. Therefore the purpose of this study was to teach students the metacognition, in order to improve the metacognitive skills and learning from lectures, by using the instructional model of R. Gagne. The subjects were 20 students, who are taking physics in an Ecuadorian university. All of the participants were aged between 18 and 19. The instructional task was the unit of thermodynamics and the topic presented in this paper was the concept of thermodynamics systems. The pretest and the posttest on thermodynamics systems contained six true or false items and six essay questions. The procedure was as follow. On the first session, students received an explanation of the Strategies General Plan (Plan, Apply, Monitor, Assess, and Evaluate), then the professor explained the cognitive strategies for understanding lectures, next they took the pretest. On the second session, they received an explanation of the concept of thermodynamics system and finally they took the posttest. This procedure was applied during the teaching of the unit of thermodynamics. The paired t-test used to analyze the relationship between the pretest and posttest gave a value of t = 10.17; df = 19; p < 0.0001. The results of this study support the effectiveness of teaching metacognition using the active learning. A limitation of this study was not to teach the use of problem solving and critical thinking strategies.

Keywords: University students, self-regulation, metacognition, metacognitive strategies, active learning

Topics: Teaching

179.O4E

Students of the 21st century learning science: The use of History of Science and High Energy Physics to teach physics.

Márcio Medina[1], Marcia Begalli[2] and Anderson Ribeiro[1]
[1]*Colégio Pedro II - Campus Niterói, Brazil*
[2]*Universidade do Estado do Rio de Janeiro, Brazil*

We present here a description of a successful experiment, done at Colégio Pedro II, a public school in Niterói, in the outskirts of Rio de Janeiro, Brazil. It can bring high school students closer through a television screen and a computer. Our school has a multimedia classroom fully equiped and a Computer lab with 20 PCs. The students come from lower and middle class families.

Around 2008–2010, claims about the production of stable micro black holes and the creation of hypothetical particles called strangelets were widely explored in the media, on the Internet and at times through the courts. This awake the interest from high school students about Particle Physics. This interest has been accelerated by the sitcom "The Big Bang Theory" from Warner Channel, which became a catalyst for us teachers to pick up the interest of our young people for science. The students are invited to join our meetings in order to better understand all the jokes in that sitcom. We clearly state they will enjoy it much more.

Every week, the students and their teachers get together for a debate, a lecture about any issue in Physics or a movie session about science during their lunch time, namely 12am till 1pm. The activity presented covers issues such as Modern Physics: The Atom, Particle Physics, Standard Model; History and Philosophy of Science and the Solvay's Conferences debates. There are also Brazilian productions about our physicists Cesar Lattes and José Leite Lopes, about our aeronautical engineer Santos Dumont, showing that science can be done by anyone of us.

Before, during, and after each class the issues are discussed with the students. The teacher is the mediator for all opinions and questions that may arise during the presentation of the activity, indicating literature, websites and articles where the students can learn more if they want to.

Our initial goal is to teach the atomic model from its origin, conceived by Democritus, then by Dalton, arriving to the experiments that underpin the model taught at school. We take the interest of students to discuss about the evolution of scientific thought in the twentieth century, reaching the Standard Model and the Higgs boson.

Along the school year, the students also take part in the International MasterClass - Hands on Particle Physics, at the State University of Rio de Janeiro (UERJ). This is an outreach program about High Energy Physics from CERN and is done in collaboration with CERN (Switzerland) and Fermilab (USA), building a bridge between technology and knowledge in an area not yet approached by our national curriculum.

At UERJ we do the Masterclass activities along the whole year (in most places around the world all activities are concentrated in 1 day). At Colegio Pedro II we teach introductory concepts of High Energy Physics along the three years in high school. This is a collaborative work between students of different levels and abilities. We support students aiming to bring them to discuss science and particle physics. How it works, why the government should invest in it, why youth should turn their attention to this kind of scientific work, etc. Showing them that science is always changing over the decades, and this "standard model" is a model that is working well, we are making good discoveries, but it is not the final model.

Keywords: Teaching physics, popularizing science, masterclass, hands-on science

Topics: Informal Physics Teaching & Learning

346.O4E

A critical analysis on “Active Learning” in the light of Cultural-Historical Activity Theory (CHAT): Implications to Physics Education and to experimental activities as a particular case

Juliano Camillo and Cristiano Mattos
University of São Paulo, Brazil

This is a research paper in which we discuss “active learning” in the light of Cultural-Historical Activity Theory (CHAT), a powerful framework to analyze human activity, including teaching and learning process and the relations between education and wider human dimensions as politics, development, emancipation etc. This framework has its origin in Vygotsky's works in the psychology, supported by a Marxist perspective, but nowadays is a interdisciplinary field encompassing History, Anthropology, Psychology, Education for example.

Based on CHAT, we analyze some current ideas on "active learning", widely spread in Physics Education nowadays. From that, we advocate CHAT as a comprehensive framework to analyze teaching and learning process. As a particular case, we use examples from experimental activities in Physics education, focusing on the subject-object relation (here taken quite broadly) seeking to better understanding how the activity can evolve and how knowledge can be produced and appropriated by the subjects. Finally, we present some implications to think Physics Education from this perspective.

Keywords: Cultural-historial activity theory, constructivism, experimental activity

Topics: Experiments, Learning, Teaching

357.O4E

Hands-on experiments in the Practicum: repositioning student teachers' autonomy

André Rodrigues and Cristiano Mattos
University of São Paulo, Brazil

Following a worldwide trend, the Initial Teacher Education (ITE) Programmes in Brazil are recently searching for ways of integrating practice into curriculum. It raises question about what practice must be integrated and how. Notably, university-based courses are disconnected from school and have low commitment with school issues (Zeichner, 2009).The student teacher induction into school daily life is not an easy task, mainly when the practitioners are transforming physics classroom practice toward an active learning. Drawing on cultural-historical framework (Wolff-Michael Roth & Lee, 2007; Vygotsky, 1978) this study addresses the articulation between Practicum in Physics Classes and the Hands-on Experiments (HoE) used throughout the Practicum. Although in a different level, both Practicum and HoE are linked with an idea of practice. Particularly, this study focuses on how

HoE might foster student teachers' autonomy and agency in the Practicum. Data was gathered in the course Practice of Physics Teaching at University of São Paulo/Brazil in 2010; in a cohort of 60 student teachers doing a year-long Practicum in urban school in São Paulo city. Data was analysed using qualitative research methods (Roth, 2005), based on 14 interviews and video records of the student teacher preparing the HoE for Practicum we will present in general lines the role of HoE for student teacher autonomy.

From the set of analysed data the following points that impact straightforward the student teacher autonomy and agency. HoE is a rich and highly complicated task for novice teachers demanding extra attention throughout practice. Nevertheless, it is also a novel element for most mentors. It means that those who are supposed to support and provide careful guidance are learners as well. Hence mentor's support might be limited. Indeed, it is a situation where ITE encounters in-service teacher education. It is, above all, an opportunity for university to co-generate mechanisms to support mentors in their daily work. Since teachers educators' main object is the student teachers learning, they may not be completely aware on the mentors needs. Hands-on experiments demand from student teachers an accurate, deep and solid disciplinary knowledge. Whereas it is the strength of this approach, it also shifts student teachers' focus mostly toward disciplinary aspects leaving pedagogical aspects aside. The student teacher commitment is centred on the university task. The main concern expressed in the written reports was in fulfilling the lab guideline. Therefore, little attention was paid to student learning. Our finds indicate that the commitment with university task was brought to the foreground and even the student teacher own learning were left out of reflection. Specifically in our studied case the nature of science and its related topics remain untouched over the Practicum. It also indicates that more time is needed in preparation with student teachers and mentor for open up the philosophical implications of HoE approach.

In conclusion we agree with the current literature about the benefits of HoE approach in science classrooms and for active learning. Nevertheless, it also presented as complex and quite demanding for student teachers, that needs even more support and guidance in the Practicum.

Keywords: Hands-on experiments, Practicum, practice of physics teaching, Activity theory

Topics: Teachers

Session 4F – workshop, 13:30-14:50

229.W4F

Workshop on Photonics Explorer

Tomasz Greczylo[1] and Amrita Prasad[2]
[1]*Division of Physics Teaching, University of Wroclaw, Poland*
[2]*Photonics Explorer Team, Vrije Universiteit Brussel, Belgium*

The main aim of the workshop is to familiarize participants with outcomes of the Seventh Framework Programme of the European Community 'Photonics Explorer' intra-curricular educational kit which has been developed by an international team of teachers and experts in pedagogy from 11 EU countries [1]. It has been set to fit into diverse educational systems and teacher cultures and brought together European industry, scientists at universities, teachers in secondary schools and students.

The leaders of the workshop will present an overview of the initiative emphasizing the research and development stages [2,3,4] and will encourage participants to perform a number of experiments developed during the project. They will make extensive use of the experimental kit which has been tested with nearly 2000 students in 7 EU countries and is currently being used by over 18000 students EU wide. The devoted didactic content which will be presented is currently available in 8 EU languages: Bulgarian, Czech, Dutch, English, French, German, Polish and Spanish.

The presentation of the experimental components and educational modules will be treated as a starting point for the discussion preceded by demonstrations of specific educational strategies. The leaders of the workshop plan to distribute a number of kits to the participants of the workshop. The workshop will be considered a teacher training where attending teachers will receive Photonics Explorer kits to implement in their classroom.

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[3] Photonics Explorer: revolutionizing photonics in the classroom, A. Prasad et.al. Proc. SPIE 8481, Optics Education and Outreach II, 84810H (October 15, 2012)

[4] Teaching optics with an intra-curricular kit designed for inquiry-based learning, Nina Cords et al 2012 Phys. Educ. 47 69

Keywords: Secondary education: lower (ages about 11-15) and upper (ages about 15-19), active learning, teaching strategies, light and material sciences, intra-curricular, educational material

Topics: Experiments, Learning, Teaching

»»Session 5A, 15:00-16:20««

043.O5A

Bridging conceptual change and sociocultural analysis: toward a model of conceptual distribution

Alexsandro Pereira
Universidade Federal do Pampa (UNIPAMPA), Brazil

Drawing on the ideas of Lev S. Vygotsky, Mikhail M. Bakhtin, and James V. Wertsch, I outline a particular approach to conceptual change, based on the notion of “conceptual distribution”. This proposal is an attempt to reconsider the problem of conceptual change from a sociocultural perspective. According to this model of conceptual distribution, both misconceptions and scientific conceptions are taken to involve an irreducible tension between active agents and the textual resources they employ, especially textual resources in the form of explanations. In the parlance of contemporary cognitive science, conceptions are viewed as being “distributed” in two related, but analytically distinct senses: (1) socially, in small group interaction, as well as; (2) instrumentally in the sense that they involve both people and instruments of knowledge. In the case of social distribution, many researchers have examined the process of meaning making in “collaborative” learning activities. Instrumental distribution, the focus of what follows, involves agents, acting individually or collectively, and items such as globes, computer simulations, or explanations. This model differs from other theories of conceptual change in suggesting that conceptions in science are best understood as a form of mediated action. From this perspective, conceptual change is viewed as “transformations of mediated action”, which is associated with the emergency of new forms of mediation, especially scientific explanations. Implications of this model for active learning on physics are presented.

Keywords: Conceptual change, conceptions in science, sociocultural analysis, conceptual distribution, explanation as cultural tools

Topics: Learning, Socio-cultural Issues

083.O5A

Application of Cues, Prompts, Questions and Gestures (CPQG) in Physics Teaching and Learning

Augustine Okoronka[1] and Kodjo Donkor Taale[2]
[1]*Adamawa State University, Mubi, Nigeria*
[2]*University of Education, Winneba, Ghana*

Physics is a physical science which is concerned with the interactions between energy and matter. Both the phenomena of energy and concept of matter adopt atomistic and holistic explanation frameworks. The atomistic viewpoint paints a picture of the mechanism of unknown processes on the ideal of a multitude of independently existing, occasionally interacting units. These units are usually too small to be seen or perceived. On the other hand, the holistic explanation of phenomena

holds the view that there is a continuum of which every part affects everything (Hare, 1978). The continuum may equally assume a macroscopic level that cannot be comprehended at once or as one whole. These inherent characteristics of most concepts in physics have implicitly contributed the perception of learners of physics as difficult and abstract (Okoronka, 2004). They have often not been adequately addressed by physics educators, physicists and physics education researchers in themes of physics instruction/design and physics teaching and learning. This default is irrespective of whether the instructional technique is in the face-to-face or in the online electronic formats.

These researchers propose that physics by its very nature, demands the integration of cues, prompts, probes, questions and gestures in all its instructional design formats particularly in today's changing world of technologies. This is the only way to make its learning "interesting" to the average learner who ordinarily may not be able to make the kind of "connections" expected in maximizing physics teaching and learning. The need for the learner's active engagement in learning process (personal construction of knowledge) is the hallmark of the theory of constructivism made popular by von Glasserfield (1995) and given a boost by Novak (1993; Dunlap (1995) and Lebow (1993). The theory proposes that educational environs should provide learners with personal interactions including collaboration (Bostock, 1998). Okoronka (2011) submitted that when cues, prompts, probes, questions and gestures are used with respect to behaviourist theories, they are viewed as reinforcers and are directly linked with observable behavioural objectives. As cognitive tools, they are useful in stimulating cognition especially when applied as "think-aloud-protocols". Here we must verbalise explicitly "the self regulating cues". In the same vein, when these tools are utilized as instructional tools from the constructivist theorist point of view, they foster connections which the learner can make between new knowledge and old ones as well as engender engagement in self analysis, reflection and awareness (Okoronka, 2011) essential to optimum physics teaching and learning.

Cues, prompts, probes, questions and gestures have their theoretical underpinnings in the behaviourist, cognitivists and constructivist ideologies of learning (Okoronka, 2011). This tends to rationalize why their application in physics teaching in particular and science in general should be highly encouraged. This forms the rationale for this paper.

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Keywords: Cues, prompts, questions, gestures, learners active engagement in learning proces, theories of learning, nature of physics

Topics: Teaching

113.O5A

Technology-Assisted Active Learning in Large-Enrollment Introductory Physics Classes

Tetyana Antimirova
Ryerson University, Canada

Research on student learning in discipline-based science education have uncovered a wide gap between the typical objectives of the instructions in traditional instructor-centered science courses and the actual level of students' achievements. Research also provided a mounting evidence of the importance of social interaction in an active student-centered learning environment. For example, small-group collaborative active learning environment is known to be much more effective for developing conceptual understanding in introductory physics than the traditional lecture setting. Yet, due to the demographic and fiscal constrains the universities and colleges across North America are pressed for continuous class sizes increases, in particular in introductory science courses for pre-medical and engineering programs. This paper will provide some insight on how peer training and collaborative small-group activities (including those based on interactive lecture demonstrations) help turn a traditional introductory physics lecture-based class into a more interactive and collaborative environment. As a case study, we will discuss an introductory physics course for all science majors in a large urban Canadian university. We will demonstrate how the available technology tools (personal response systems (clickers), video-based analysis and real-time data acquisition capabilities) can be used to support the active learning even in a very large lecture setting. We will also provide data on the effectiveness of our teaching strategies.

Keywords: Active learning, educational technologies, student-centered learning, physics, personal response systems, clickers, video analysis, interactive lecture demonstrations

Topics: Experiments, ICT, Learning, Teaching

221.O5A

A study on the effects of a potentially meaningful learning unit in the learning of the concept of field in the predicative and operatory forms of knowledge

Glauco Pantoja[1] and Marco Antonio Moreiro[2]
[1]*Universidade Federal do Oeste do Pará, Brazil*
[2]*Universidade Federal do Rio Grande do Sul, Brazil*

In this work we present the results of the implementation of a recently published teaching strategy by Moreira (2011), entitled Potentially Meaningful Learning Units (PMLU), which takes for granted premisses from construtivistic approach and from cognitive psychology issues to the teaching-learning processes. The PMLU are teaching-learning sequences envisaging the facilitation of meaningful learning in both predicative (verbal) and operatory (action) forms of knowledge. This work is dedicated to study the teaching-learning processes related to the concept of field, firstly because researches in classroom learning of this concept are few, and also because the PMLU focused the prospective facilitation in the learning of the concept of electromagnetic field. Moreira (2011) describes his proposal of PMLU as a sequence of eight steps: 1. Definition of the subject to be taught, 2. Creation of problems, 3. Proposition of problems that are tied up to the students' prior knowledge, 4. Presentation of the content accordingly to the ausubelian principles of progressive differentiation and integrative reconciliation, 5. Retrieval of the more general features of the content in a greater complexity level, 6. Following of the sequence with the progressive differentiation and the integrative reconciliation, 7. Presentation of more complex problems, 8. Carrying out of a summative evaluation. We took as references for developing the teaching unit, the works of Martin & Solbes (2001) that presented a teaching sequence based on inquiry teaching, Krapas & da Silva (2008) that discuss the multiple meanings regarding the concept of field, and Pocovi & Finley (2005) that point the mistakes presented by two textbooks considered as reference worldwide. For the data analysis we approached the content analysis by Bardin (2008) and we used the Conceptual Field theory and Mental Models theory both to interpret data and to develop the concept of Meaningful Learning to the operatory form of knowledge. We show evidences of mechanisms of meaningful learning and of development of reference to reality by the students (situations concerning the concept of field), pointed by Vergnaud as a crucial point in conceptualization.

Keywords: Meaningful learning, field, teaching strategies

Topics: Learning, Teaching

Session 5B, 15:00-16:20

037.O5B

The use of mathematical elements in physics – views of grade 8 students

Gesche Pospiech and Erik Oese
TU Dresden, Germany

The use of formula in physics lessons in school is much debated and considered as complicated. But as mathematics is inseparably connected to physics an insight into their interplay, especially the structural role of mathematics for physics is central to an understanding of the nature of physics.

Mathematics in physics does not only mean the use of formula but also the use of geometrical objects and graphical means which all play an important role for the description and explanation of physical processes. But the views of students in lower secondary school on this interplay are not known. Only some studies exist on some aspects of formula as seen by students: They concern e.g. preferences with respect to writing of formula (Strahl 2010), the role of formula for physics and physicists (Krey 2009) or their use by teachers (Strahl 2012). Often it is said that formula would be too difficult or even prevent understanding. A detailed analysis of stratgies in problem solving shows very specific problems in structural aspects of the transfer between physics and mathematics for students in lower secondary school (Uhden 2012). Concerning high school, problems in text books or problems of final exams are being analyzed with respect to their mathematical level, (Schoppmeier 2012). However, it is not known which views the students have on the role of mathematics in physics right from the beginning of learning physics. This might be important for developing appropriate leaching learning sequences. In order to throw a light onto the thinking and the abilities of students with respect to the mathematics-physics interplay an exploratory study was conducted.

The study covered the use of formula, diagrams and verbal explanations and their interrelations. The instruments were a questionnaire concerning the view on physics lessons in general and the interrelation of formula, diagrams and explanations, a short knowledge test and interviews with some (n = 20) of the students. The focus of the interviews was on the individual description of perceived problems in mathematization in physics lessons. In the study 192 students in grade 8 (mostly age 14) took part. Students showed several aspects of understanding physics and a differentiated view towards formula in physics with negative as well as positive aspects. The questionnaire addressed the view on the structural role of formula in physics lessons, on the technical role of mathematics in physics lessons, especially the use of formula and calculating, the role of diagrams and the view on physics lessons in general. Four groups of students could be identified significantly differing with respect to their views: quite positively thinking students, quite negatively thinking students and students with a mixed view, mainly referring to the role of diagrams or formula, respectively. The test contained tasks on the interrelationship between algebraic, graphical and verbal representations, the handling of formula and diagrams as well as the interest in special problems.

The results of the study as a whole show that the students have a differentiated view on the role and the use of mathematics in physics lessons. Difficulties arise if not all the steps are explained in great detail. In order to find ways to address successfully the difficulties further research on the learning processes and students concepts in the use of mathematical concepts in physics is needed.

Keywords: Mathematics in physics, representations, students concepts

Topics: Learning

182.O5B

Can math for physics teachers impact their conceptual knowledge of physics?

Yaron Lehavi[1], Bat-Sheva Eylon[2], Esther Bagno[2] and Elisheva Cohen[2]
[1] *The David Yellin Academic College of Education, Israel*
[2] *The Weizmann Institute of Science, Israel*

The present study investigates the impact of a course in mathematics, specially designed for preparing physics teachers to participate in Quantum Mechanics and Electro-Magnetism courses in which the interplay of mathematics and physics played a central role. These courses were at the heart of the Weizmann-Rothschild MSc two years program for excellent teachers.

The present study addresses similar questions as those presented by Pospiech and Matthias [1] and complements a previous study which reported on the construction of a QM course and its impact on teachers' self-confidence and knowledge [2]. The study follows the instructor further development of the course, covers a new topic (EM) and addresses more teachers' populations: first year, second year and graduates of the program.

The study compares the goals of the course with respect to its impact on the teachers' ability to develop a better understanding of the physical content of the QM and EM courses to the teachers' actual knowledge. The goals of the preparation course were revealed by interviewing the instructor and by observing videos taken during classes. In specially, the observations addressed the implementation of the following five interactive components: exploring learners' pre-instructional knowledge, the content analysis from the educational perspective, identifying the learners' needs, fostering the reconstructing of knowledge and meta-cognitive activities [3]. The teachers' knowledge was examined by a questionnaire based on the QMVI and the QMCS [4, 5] and by interviews conducted with some of the teachers from the three groups. The teachers' were asked in the interviews to reflect on how they conceived the goals of the course and its impact on their content knowledge.

The findings indicate that the instructor strengthen his view with regard to the need to make a clear distinction between the goals of the teachers' courses and those of graduate courses designed for future scientists. The instructor made further effort to suit the level of mathematics to that of the teachers and put more emphasize on the logic behind the formulas in order to develop their sense of understanding. The teachers' achievements in the conceptual questionnaire did not follow behind those of the regular graduate students and in some aspects were even better. The teachers indicated that the course developed their confidence in coping with mathematical challenges and that this confidence assisted them in their understanding of the physical content of the QM and EM courses.

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Keywords: Physics and mathematics, physics education, teachers training

Topics: Learning, Teachers

197.O5B

An Attempt to Combine Math and Physics in STEM at Meijo University

Tatsuhiro Uchida
Meijo University, Japan

In the recent education, many physics teachers only use math as tools, and math teachers don't know why we should need to learn math, in spite of both physics and math are developed by a mutually complementary relationship. To improve the above problem, we implemented an experimental curriculum based on SOGOSURI program [1] into "mathematical science I and II" for undergraduate students as one part of STEM of Meijo University. In addition, we introduced the ideas of Lady Cats[2] into this curriculum. Notable features are that the curriculum has four basic contents: history of science and technology, experiment, low-cost material, essential theme, and four teaching methods: promotion of ingenuity, interactive teaching, recognition of difference between real and theory, leave room for thinking. After three years experiments, we got some conclusive evidence that the curriculum worked well. In this paper, we explain our ideology and contents of the curriculum and its results for improving how to combine math and physics in STEM.

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Keywords: University education, teaching method, SOGOSURI program, combined math and physics education

Topics: Curriculum, Experiments, Teaching

226.O5B

The role of mathematics in physics

Carl Angell
University of Oslo, Norway

The impact of the "science for all" movement and the focus on science literacy has been considerable for many years (see e.g. Millar, 2006; Millar & Osborne, 1998; Rutherford & Ahlgren, 1990). In order to make physics more interesting and attract more students broad and descriptive topics such as for example climate or cosmology has been emphasized in many country's curricula (e.g in Norway and Sweden). Consequently, less weight has been put on mathematics and the more formalistic characteristics of physics.

The main aim of this paper is to use Norwegian and Swedish data from The TIMSS Advanced study in 2008 to explore the relation between mathematics and physics and in particular the students' lack of fluency in handling algebra (Nilsen, Angell, & Grønmo, in press). We have categorized all TIMSS Advanced physics items into two distinct categories based on whether algebraic manipulations are involved or not. To reveal substantial changes in the characteristic patterns we computed the mean p-value (per cent correct answers) for all the items for each category for Norway and Sweden respectively, and then calculated the difference (in percentage points) between the country mean and the average for all the participating countries (Lie, Angell, & Rohatgi, 2012).

In average the Norwegian students in 1995 scored about 15 percentage points higher than the international average. And there were almost no difference between the two categories of items. The Swedish students scored particularly well on the algebraic manipulation items compared to the international average. The situation has changed notably to the worse in 2008, and by far most strikingly for the item category algebraic manipulation, especially for Sweden. The change is rather dramatic; from 16 percentage points above the international average to 5 percentage points below. Also for Norway the difference is remarkable; from 15 percentage points above to 1 percentage points below.

The symbolic language of algebra could be especially demanding for students. And the transfer between mathematics and physics could be even more demanding for students that lack prerequisite algebraic fluency. When engaging in physics, students' cognitive capacity could thus be preoccupied with basic algebra rather than the physics phenomenon under study (Nilsen et al., in press).

Both physics as research area and school physics have a strong relationship to mathematics. However, the mathematics used even in upper secondary school physics is not very advanced. The physics curriculum in many countries includes only relatively simple arithmetic and algebra, and this is so for the physics test in TIMSS Advanced as well. It seems that many students in our two countries have noteworthy weak skills in manipulating algebraic expressions and equations and only to a small extent can deal with manipulating fundamental quantitative concepts in physics (Lie et al., 2012). This is serious, because quantitative understanding of physical concepts is crucial for the students' development of competency in physics.

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Keywords: Physics and mathematics, TIMSS advanced, physics education

Topics: Learning

Session 5C, 15:00-16:20

056.O5C

Quantitative and qualitative analysis of the kind of mental models deployed by undergraduate students in creating explanations for thermally activated phenomena

Claudio Fazio, Onofrio Rosario Battaglia and Rosa Maria Sperandeo-Mineo
University of Palermo, Italy

In this contribution we describe a research method aimed at pointing out the quality of mental models undergraduate engineering students deploy when asked to create explanations for phenomena/processes and/or use a given model in the same context. The phenomena are related to thermal physics and, in particular, to systems for which a process is activated by overcoming a well-defined potential barrier, *DE*, and is therefore described by an equation containing the Boltzmann factor $e^{-\frac{DE}{kT}}$, where *T* is the system temperature and k is the Boltzmann constant. Student responses to a specially designed and validated written questionnaire are initially analyzed using researcher-generated categories of reasoning, based on the Physics Education Research literature on student understanding of the relevant physics content. The inferred students' mental models about the analysed phenomena are categorized as practical, descriptive, or explanatory, based on a statistical implicative analysis of student responses to the questionnaire. A qualitative analysis of interviews conducted with students after the questionnaire administration is also used to deepen some aspects which emerged from the quantitative analysis and validate the results obtained. The implications of this analysis for the design of a learning environment focused on the understanding of some aspects of the world at the level of causation and mechanisms of functioning are discussed.

Keywords: Thermally activated phenomena, quantitative analysis methods, statistical implicative analysis, qualitative analysis methods, mental models

Topics: Learning

129.O5C

Exergy in school?

Tomaz Kranjc and Nada Razpet
Faculty of Education, University of Ljubljana, Slovenia

Students at all levels of physics instruction have difficulties dealing with energy, work and heat in general and, in particular, with the concepts of efficiency and ideal heat engine, and the maximum performance of refrigerators and heat pumps (Cochran and Heron, 2006; Bucher, 1986). The reason for the difficulties is an insufficient understanding of the second law of thermodynamics (Kesidou and Duit, 1992). In order to make these topics less difficult, the concept of exergy—well established as a powerful analytical tool in technical thermodynamics—describing the "quality" of energy, seems in our judgment to be worthy of inclusion in the physics curriculum at all levels. Its introduction does not add another law. It facilitates the understanding of irreversibilities (as the destruction of exergy) and gives a deeper meaning to the second law. In the treatment of heat engines the second-law efficiency throws a new light on the notions of an ideal and a real engine (similarly for a refrigerator or a heat pump). Exergy introduces, in a natural way, a distinction between various forms of energy according to its quality—availability for performing work. "Energy reserves", which can be better understood with the help of exergy, are of practical interest. From the thermodynamic point of view, a more correct term would be "availability reserves"; all around us, there are huge quantities of energy (in atmosphere, in oceans etc), but of very limited availability, i.e., of limited exergy.

In order to identify common misconceptions and difficulties encountered by students in the learning of the first and second law of thermodynamics, particularly in connection with heat engines and similar cyclic devices, we conducted a combined research among students of the Primary School Education at the Faculty of Education (UP PeF) and of Biodiversity, Bioinformatics and Mediterranean Agriculture at the Faculty of Mathematics, Natural Sciences and Information Technologies (UP FAMNIT) of the University of Primorska. Based on interviews and questionnaires given to two groups of students—an experimental and a control group—in the beginning and the end of the semester, we investigated the influence (and possible advantages) of the introduction of the concept of exergy and the second-law efficiency.

In the presentation, we show a few examples that were treated with the experimental group in order to motivate the students and to make them familiar with the concept of exergy: the "energy losses" of a car engine and an analysis of improvements still allowed by nature; exergy loss associated with heat conduction; a simple exergy analysis of a heating house system (considering energy and exergy fluxes). We list some of the problems encountered by the students and the most common misconceptions as could be identified from the tests, questionnaires and interviews. An additional goal of the investigation is to test a longer-term knowledge of students.

From our research it would appear that exergy and the second-law efficiency are useful concepts which make it possible for students to get a better grasp of the material and to not only obtain a clearer understanding and knowledge of standard topics like heat engines, but also a broader view and insight into the meaning of energy and both the first and the second law, and their interrelation.

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Keywords: Heat, exergy, second-law efficiency

Topics: Learning

178.O5C

What, if anything, is entropy trying to tell us?

Rainer Mueller
TU Braunschweig, Germany

The notion of entropy is commonly regarded as one of the most challenging concepts in classical physics. Many learners have difficulties to develop an intuitive understanding of entropy as a physical entity.

While in statistical mechanics, an interpretation of entropy can be based on microscopic models (especially with the help of computer simulations), the situation is much more unpleasant in phenomenological thermodynamics. We will argue in the talk that many difficulties originate from the fact that in the thermodynamic definition of entropy $dS = dQ/T$, a state variable (entropy) is defined via a process variable (heat).

The entropy definition of Lieb and Yngvason (1999) which is based on the concept of "adiabatic accessibility" has been a major advance in the foundations of thermodynamics. Unfortunately, because of its mathematical complexity, it is hardly accessible for students. In the talk we will present a variant of this new entropy definition in an elementary formulation that should be accessible to undergraduate students. In this formulation, a direct link can be established to the idea of "degradation of energy". With simple examples, we will give an operational meaning to the term "degradation of energy" and point out how it is related to the traditional entropy definition.

While the notion of entropy belongs to the school curricula in some countries (e. g. Germany), the concept addressed in the talk is aimed at undergraduates. We will report about the first results of testing the concept with pre-service physics teachers.

Keywords: Thermodynamics, entropy, learning difficulties

Topics: Curriculum

201.O5C

Understanding Thermal equilibrium through activities

Shirish Pathare, Hemachandra Pradhan, Madhura Nachane and Saurabhee Huli
Homi Bhabha Centre for Science Education, India

The concept of thermal equilibrium is introduced to undergraduate students with the statement: ‘Two systems in thermal contact with each other attain thermal equilibrium when their temperatures become equal’. This introduction is often not sufficient for the students to understand the concept. It is essential for the students to understand that the net heat flow between the systems becomes zero when they attain thermal equilibrium. We asked about 300 (first year and second year) undergraduate students from different colleges in India the following question:

If two bodies of equal volume (one copper and other wood), initially at room temperature, are transferred to an enclosure maintained at 60 °C, what would be their temperatures be after a sufficiently long time?

We found that most of the students felt that even after sufficiently long time, the copper cube would have a higher temperature than the wooden cube.

We felt that appropriate activities could be designed (and tested) for helping the students to enhance their understanding of thermal equilibrium and to address their alternative conception such as the above.

This paper describes four such activities.

The first activity uses two chambers separated by adiabatic/diathermic walls. Temperatures of both the chambers are measured using thermocouples. The heat flow between the two chambers is shown by a specially designed heat flow indicator.

The second activity uses a liquid flow analogy to understand thermal equilibrium. The net liquid flow is shown by a low cost liquid flow indicator designed in our laboratory.

The third activity is the visual representation of the above question asked to the students. It uses a copper cube and a wooden cube of same volume and shape. The temperatures of these cubes were monitored through a data acquisition system.

The fourth activity is a liquid flow analogy of the above question asked to the students. It consists of a reservoir cylinder connected to two more cylinders through pipes of different diameters. This activity also explains the role of thermal conductivity in understanding thermal equilibrium.

Keywords: Thermal equilibrium, alternative conception, learning activities

Topics: Experiments, Learning

Session 5E, 15:00-16:20

030.O5E

Chain reaction: the use of interactive kits to create a physics popularization network

Miguel Garcia, Bertha Michel and Edgar Ramos
Universidad Autonoma de Zacatecas, Mexico

Interactive experimental workshops are excelent activities to get the public, specially young students, involved with physics in a participative manner. They allow participants to interact physically, mentally and emotionally in order to build knowledge through fun experiences. This activites are centered on users and based on experimental devices that show physical principles in action.

Over the last 20 years the Science Museum at the Universidad Autonoma de Zacatecas, in Mexico, has worked on the development of interactive physics workshops in order to develop a scienteific culture. During this time we have worked with over 150,000 people in Zacatecas and 15 other states in Mexico, both in formal and informal learning enviroments. This effort has helped people learn and have fun with physics but hasn´t reached enough people yet and we have realized it´s hard to have a much broader reach with our small team (which has 6 professionals and 50 volunteers).

Six years ago we started working on the creation of new physics popularization networks through interactive experimental collection; first with a mobile science hall -which included 24 devices- and later with an interactive activities kit with over 30 different activities. Both this projects worked with different physics subjects such as classical mechanics, thermodynamics, electromagnetism, optics, astrophysics and quantum mechanics.

Now we´re working on a bigger project that will work in several states in Mexico through a network of science popularization institutions, based in a new interactive kit for the knowledge society. This kit features activities on three physics related lines of work of great relevance in today´s world: Nanoscience and nanotechnology, Alternate Energy Sources and Telecommunications. Each line involves 5 different interactive activites that provides participants with a general perspective of the subject.

Although we intend to help young people understand physics better through experimental activities that can be related to everyday situations, our main goal is to create a self replicating network: prepare teams that will be able to develop activities and create new teams that will carry the effor even further in what we intend to be a physics learning chain reaction.

Keywords: Interactive physics learning, physics popularization, informal physics education

Topics: Informal Physics Teaching & Learning

061.O5E

Analysis of Historical Content in Modern Physics Chapters in High School Physics Textbooks

Kübra Eryurt and Eray Şentürk
Middle East Technical University, Turkey

The increased competition between countries puts the science education in the limelight of all nations. Science education is no doubt very fundamental component of general education so that all individuals become scientifically literate. The use of the history of science (HOS) in science education allows educators to present rich and invaluable context to understand when, why and how scientific ideas were proposed and developed within a scientific process. This valuable resource (HOS) has been recognized by science historians and science educators to be used for educational purposes since late nineteenth century. However, science in conventional classrooms has not gone far beyond representing science as a collection of static scientific knowledge without mentioning human endeavor as well as the scientific process that minimize the value of doing science. The concerns regarding diminishing value of science and rejection of science kindled science curriculum revisions across the world (i.e. Australia, Ireland, Canada, and Turkey) in last twenty years. In Turkish high school physics program, science process skills and science-technology-society-environment related objectives took their places as major components of teaching/learning physics in the curriculum in addition to scientific content, and curriculum changes brought with the revisions of physics textbooks accordingly. Even though the use of HOS has been recommended to improve conceptual understanding by referring to concept development in science, provide more realistic portray of nature of science, and humanize science as a product of human's effort in the literature, how sufficient was the HOS integrated into these new physics textbooks? In this respect, the current study aims to investigate how HOS contents were used in high school physics textbooks.

The sample of the current study consisted of three (10th, 11th and 12th grade) physics textbooks, which are the only textbooks permitted by Ministry of Education to be used in high schools. Unlike previous studies, modern physics chapters were selected for historical content analysis rather than analysis of whole textbook owing to the fact that these chapters are mostly associated with well-known contemporary physicists and their contributions to science in high school physics program. For textbook analysis in terms of historical content, Leite's (2002) checklist was selected due to its comprehensive structure. The checklist was validated by analysis of five textbooks. Differences among textbooks were shown as evidence that the checklist is able to distinguish diverse aspects of historical content. The instrument consists of 8 major dimensions (i.e. 1.Type and organization of the historical information) and several sub-dimensions (i.e. 1.1 Scientists, 1.2 Evolution of science) which specify details under each dimension. These sub-dimensions were quantitatively analyzed, and frequencies of occurrence were reported. Also, qualitative analysis has been done to emphasize quality of used historical materials by providing examples from the textbooks.

In general, our findings, in the same line with Leite's (2002) results, revealed that the modern physics chapters are almost never able to give students a sufficient image of what was done by scientists as well as of science. In chapters, besides, the discoveries and the results of researches were given directly without referring to scientists' efforts during painstaking process of their researches. This may be resulted in the emergence of an idea as science is the geniuses' job, not for ordinary people.

Furthermore, the researchers could not find any contents such as scientists' life stories (e.g. married, having children, etc.) and description of the time they lived to overcome the negative image of scientists. Moreover, scientists' photographs presented in textbooks were generally old. For that reason alone, we speculate that many students may think wrongly that the most of scientists have found their discoveries in their old ages. Another point is the given format of scientists' experiments. They were figured as simple setups, and this may bring about the underestimation of how science develops, how scientific research conduct, and how scientists work. Above all, the findings of this study will provide a framework about how historical content might be integrated in modern physics chapters of high school physics textbooks. In this respect, the results can be extended for teachers and textbook writers worldwide about the use of HOS in science education.

Keywords: Secondary education: upper (ages about 15-19), history of science, physics textbooks, modern physics

Topics: Curriculum

287.O5E

Contextual categorisation of academics' understandings of teaching

Scott Daniel, Llewellyn Mann and Alexander Mazzolini
Swinburne University of Technology, Australia

Background

Despite large-class research-based instructional strategies being firmly established in the literature, traditional lecturing remains the norm. This is particularly the case in physics, where Physics Education Research (PER) has blossomed as a discipline in its own right over the last few decades, but research-based strategies are not widely implemented.

This variation in practice is underpinned by variations in beliefs and understandings about teaching. Studies investigating the spectrum of understandings of teaching held by teachers and, in particular, academics have almost uniformly identified a single dimension from teacher-focussed to student-focussed. These studies have used a phenomenographic approach to capture the variety of experiences of teaching, but have excluded contextual issues like class size.

Research Question

How does class size affect academics' experiences of teaching?

Method

This study used an online survey to compare and contrast respondents' experiences of small and large classes, and in particular lectures. The survey was promoted to Australian university academics from a range of disciplines, predominantly science, technology, engineering, and mathematics (STEM). Responses to the sets of small-class questions were analysed independently from the sets of equivalent large-class questions. For each respondent their small-class responses were categorised, where possible, as reflecting either a student or teacher focus, and likewise, independently, for their large-class responses.

Results

107 survey responses were received. Of these, 51 had the sets of both their large- and small-class responses unambiguously categorised. Five of these reflected a student focus regardless of class size, and 17 of these reflected a teacher focus regardless of class size. All of the remaining 29 responses reflected a teacher focus in large classes, but a student focus in small classes. Conversely, none of the responses showed a student focus in large classes with a teacher focus in small classes.

Implications

This result demonstrates that the one-dimensional analysis of understandings of teaching along the spectrum of teacher-focussed to student-focussed is too simplistic. Understandings are contextual. At the very least they depend on class size, and perhaps other factors.

It confirms the hierarchy of understanding from teacher-focussed to student-focussed reported elsewhere in the literature, with the added feature of an intermediate stage of differing focus depending on class size. One recommendation from this finding is that teaching professional development programs should be tailored to suit these different groups. Moreover, further research on context-specific understandings of teaching need to be explored.

Keywords: University education, lecturing, phenomenography

Topics: Teachers

349.O5E

Inquiry Based Science Education and Getting Immediate Students' Feedback about Their Motivation

Martina Kekule[1], Vojtech Zak[1], Zuzana Jeskova[2], Katarina Kimakova[2], Maria Ganajova[2] and Marian Kires[2]
[1]*Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic*
[2]*University of P. J. Šafárik, Slovakia*

The Establish project

The objective of the project ESTABLISH (funding from the European Community's Seventh Programme [FP7/2007-2013] under grant agreement no 244749) is the wide use and dissemination of inquiry-based teaching method for science education (IBSE) at secondary schools across Europe. Over the course of the project, a number of ESTABLISH teaching and learning materials (units) have been developed and adapted for the use in classrooms in participating countries.

The rationale for ESTABLISH lies in creating authentic learning environments for science by bringing together and involving all relevant stakeholders, particularly the scientific and industrial community, policy makers, parents, science education researchers and teachers to drive change in the classroom.

The aim of the paper and methods

For collecting evidence of the impact of the Establish project on students two questionnaires based on the existing tools have been used. Questionnaire 1 is a part of Intrinsic Motivation Inventory (IMI) based on the Self-determination theory developed by Ryan and Deci (2000). It is aimed at assessing students´ interests, their perceived choice and usefulness of implemented learning units and should be answered after each learning unit/several IBSE activities. Several items of CLES questionnaire are included there as well. Questionnaire 2 assesses the impact on students' attitudes towards science and technology and on their knowledge about nature of building up science knowledge. Both questionnaires exist in the lower and upper secondary school versions (12-15/16-19 year-old students).

The paper presents data and results which were obtained by addressing the Questionnaire 1, so that the focus is on getting students' feedback about their intrinsic motivation. Our assumption is that active learning is associated with positive intrinsic motivation of students. That is why we find as very important educators have a possibility to understand the phenomenon more deeply. We aim to present the reliable tool for getting the feedback and to present a way of data processing which does not need advanced statistical methods, so that teachers (as well as science education researchers) can use and analyze data obtained by the tool.

Participants

The number of participants included in the questionnaire survey is more than 1500 (mainly 16-19 year-old students).

Results

Means and standard deviations for items of the subscales Interest/Enjoyment, Perceived choice and Value/Usefulness were computed. To determine the consistency of results, the Standard Pearson correlation coefficient was computed for all items within the subscales. Based on the findings, we can conclude that participants´ answers (questionnaire results) were consistent (not responded mechanically).

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ESTABLISH project, available on <http://www.establish-fp7.eu>

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Keywords: Students´ feedback, motivation, questionnaire, IBSE

Topics: Assessment & Evaluation, Learning, Teaching

»»Session 6A, 16:40-18:00««

094.O6A

The Current Situation of Students' metacognition of the High School Science Classrooms in Thailand

Warawun Chantharanuwong[1], Kongsak Thathong[1], Chokchai Yuenyong[2], Khajornsak Buaraphan[3] and Gregory P. Thomas[4]

[1]*Science Education, KKU, Thailand*

[2]*Khon Kaen University, Thailand*

[3]*Mahidol University, Thailand*

[4]*University of Alberta, Canada*

This study aimed to explore students' metacognition within their high school science classrooms in Thailand. The Self-Efficacy and Metacognition Learning Inventory-Science (SEMLI-S) was the instrument employed. It measures students' metacognition, self efficacy and constructivist science learning processes. The SEMLI-S has 30 items and five sub-scales. These five sub-scales, each reflecting a dimension of students' self-perceived metacognitive science learning orientation, are: Constructivist Connectivity (CC), Monitoring, Evaluating, & Planning (MEP), Science-Learning Self-Efficacy (SE), Learning Risk Awareness (AW), and Control of Concentration (CO). Statistical data were collected from 5418 high school students from 40 schools across Thailand. The data were analyzed using One-Way Analysis of Variance (ANOVA) statistical techniques. The analysis of the data suggests that statistically significant variations exist in students' metacognition in relation to their science learning according to their gender ($p < 0.01$) and their regional location within Thailand ($p < 0.05$), and their grade level ($p < 0.05$). No statistically significant variation was found according to participants' age.

In relation to the MEP dimension, Male students reported statistically significantly higher levels than female students ($p < 0.05$), students from the North of Thailand reported statistically significantly higher levels than the others regions ($p < 0.05$), grade 10 students reported statistically significantly higher levels than the other grade levels ($p < 0.01$). In relation to the CC dimension, male students reported statistically significantly higher levels than female students ($p < 0.001$). No statistically significant variations were found according to and region, grade, and age of students. In relation to the SE dimension, male students reported statistically significantly higher levels than female students ($p < 0.001$), students from the North of Thailand reported statistically significantly higher levels than the others regions ($p < 0.001$), and grade 10 students reported statistically significantly higher levels than the other grades ($p < 0.05$). No statistically significant variations were found according to the age of students. In relation to the AW dimension, only the South region students reported statistically significantly higher levels than the other regions ($p < 0.05$). No statistically significant variations were found according to the gender, grade, and age of students. In relation to the CO dimension only the South region students reported statistically significantly higher levels than the other regions ($p < 0.001$). No statistically significant variations were found according to gender, grade, and age of students. The implications of these variations are discussed.

Keywords: Metacognition, science classroom learning, Thailand

Topics: Learning

Sequential Reasoning in Electricity: Developing and Using a Three-Tier Multiple Choice Test

Hildegard Urban-Woldron
University College for Teacher Education Lower Austria, Austria

Electricity is one of the areas in physics most studied in terms of learning difficulties. There are three categories of student difficulties: inability to apply formal concepts to electric circuits, inability to use and interpret formal representations of an electric circuit, and inability to qualitatively argue about the behavior of an electric circuit (McDermott & Shaffer, 1992). Misconceptions are strongly held and stable cognitive structures, which differ from expert conception and affect how students understand scientific explanations (Hammer, 1996). Therefore, there is need for conceptual understanding tests which are useful in diagnosing the nature of students' misconceptions related to simple electric circuits and therefore, can serve as a valid and reliable measure of students' qualitative understanding of simple electric circuits. A test instrument should be applicable both for physics education research and for the teachers in the classrooms to measure students' qualitative thinking. As ordinary multiple choice tests with one-tier were highly criticized in overestimating the students' right as well as wrong answers, two- and three-tier tests were developed by researchers. In addition, the author has already developed a questionnaire as a diagnostic tool using two-tier test items to identify common misconceptions in electricity where she could identify ten different alternative conceptions in the context of basic electricity (Urban-Woldron & Hopf, 2012). Although, there is much research related to students' conceptions in basic electricity, there is a lack of instruments for testing electricity concepts of students at grade 7, especially addressing an electric circuit as a system. In consequence, the context of the present study is an extension to the development of the instrument described above for testing electricity concepts of students at grade 7 on only two specific aspects in depth: first, to develop three-tier items for figuring out sequential reasoning, and second, to distinguish between misconceptions and lack of knowledge.

The participants of the study included 339 secondary school students from grade 7 to 12 (183 female; mean age = 14.7 years, SD = 1.7; 18 forms, 7 schools) after instruction about electricity. Content validity was proved by presenting the test as well as the objectives to expert teachers to ensure that the domain was adequately covered. Construct validity was evaluated through confirmatory factor analysis. Extensive analyses supply prime examples that a correct test answer is not yet proof that the student had really understood the underlying concept and that definitely correct answers are overestimated if researchers and/or teachers use only one tier in a multiple choice instrument. Findings from ANOVA reveal a main effect of the particular school, respectively the particular teacher for correct answers. Surprisingly, there are no dependences on students' misconceptions neither according to their gender nor to their age. Sequential reasoning and viewing a battery as a source of constant current seem to be two negatively related concepts. In conclusion, the findings of the study suggest that four items for uncovering students' sequential reasoning can serve as a valid and reliable measure of students' qualitative understanding of the systemic character of an electric circuit. Additionally, findings of a case study, specifically addressing students' misconceptions related to sequential reasoning, by conducting teachings experiments and by using the test instrument mentioned above will be reported.

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Keywords: Three-tier test items, sequential reasoning in electricity, student conceptual understanding, viewing an electric circuit as a system

Topics: Assessment & Evaluation, Learning, Teachers, Teaching

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347.O6A

Examining Factors that Influence High School Physics Students' Choice of Science as a Career

Ann Cavallo, Ramon Lopez and Greg Hale
University of Texas at Arlington, United States

In recent years in the U.S. there has been strong emphasis on the need to increase the pipeline of students choosing to pursue science careers, and especially science teaching as a career. Programs to recruit future science teachers, like the National Science Foundation Noyce Scholarship program, as well as future scientists depend on a better understanding of the factors that influence students' choices whether or not to study science at the university. This study on high school physics students examined various factors referenced in the literature that may be related to choices in pursuing science careers. These factors include: students' learning approaches (meaningful versus rote), beliefs about Nature of Science (NOS), self-efficacy toward success in science, scientific reasoning, spatial ability, and science enjoyment. These factors were analyzed according to gender and science career choice. The specific purposes of this study were to: 1) explore possible differences and interactions between these factors among male and female high school physics students, and 2) determine relationships and possible predictive influences of learning approaches, beliefs about NOS, self-efficacy, scientific reasoning, spatial ability, and science enjoyment on male and female students' intentions to pursue science careers. High school physics students in three different high schools (N = 138) were administered questionnaires to measure the selected factors. Among the results to be reported, there were significant differences in learning approaches between males and females, with males using more meaningful learning compared to females who tended to learn more by rote; students pursuing science careers have greater self-efficacy toward success in science; and males have higher spatial ability compared to female physics students. Self-efficacy was a significant

predictor among females choosing to pursue science careers, whereas meaningful learning was the most significant predictor among male students.

Keywords: High school physics, science career choices, meaningful learning, spatial ability, reasoning ability, self-efficacy, gender differences

Topics: Learning, Socio-cultural Issues

364.O6A

The development of Physics Teacher Education Programmes in Inquiry Based Science Education (ESTABLISH)

Eilish Mcloughlin[1], Sarah Brady[1], Odilla Finlayson[1], Claudio Fazio[2], Ton Ellermeijer[3], Ewa Kedzierska[3], Marian Kires[4], Leos Dvorak[5] and Christina Ottander[6]

[1]CASTeL, DCU, Ireland

[2]Universita Degli Studi di Palermo, Italy

[3]Centre for Microcomputer Applications, Netherlands

[4]Univerzita Pavla Jozefa Šafárika v Kosiciach, Slovakia

[5]Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

[6]Umea Universitet, Sweden

International reports have identified the need for “engaging curricula to tackle the issue of out-of date and irrelevant contexts and to enable teachers to develop their knowledge and pedagogical skills” (European Commission (EC), High Level Group on Science Education 2007, Osbourne, Dillon 2008). The FP7 funded project ESTABLISH ('European Science and Technology in Action Building Links with Industry, Schools and Home') aims to promote the use of Inquiry-Based Science Education (IBSE) in the classroom by developing and implementing innovative units and teacher education programmes, and adapting them for each country across Europe. In particular ESTABLISH aims to create authentic learning environments for science students by including industry informed contexts and problems (Industrial Content Knowledge) that can be tackled in the classroom. This approach is targeted at achieving increased use of IBSE methodologies by teachers and thereby impacting positively on student's intrinsic motivation in science and technology, improving scientific literacy, promoting student involvement in experiential learning and informing science career choices by students.

This presentation will discuss the approach adopted by ESTABLISH consortium for the development of teacher education programmes, that facilitate participating teacher’s gaining experience in inquiry using ESTABLISH teaching and learning Units and activities. In particular, four key elements of these programmes in relation to physics teacher education will be discussed: I. Introduction to Inquiry; II. Industrial Content Knowledge; III. Teacher as an Implementer; and IV Teacher as a Developer. The adoption of these programmes in several countries will be presented and results of implementing these programmes with Physics Teachers and the impact on them and their students will be highlighted.

Keywords: IBSE, inquiry, teacher education, ESTABLISH

Topics: Teachers, Teaching

Session 6B, 16:40-18:00

239.O6B

History Sheds Light on the Difference of Nature between Physics and Mathematics Guiding Physics Educators to Better Understanding Mind Preferences of Students

Lina Vinitsky-Pinsky[1] and Igal Galili[2]
[1]*Achva Academic College & The Hebrew University of Jerusalem, Israel*
[2]*The Hebrew University of Jerusalem, Israel*

Physics and mathematics are two areas of intellectual activity that have been deeply interwoven throughout the long history of science. One may appreciate the nature of each by realizing their difference. Aristotle's ideas expressed in his Physics (Aristotle, 1984) – his account for Zeno paradoxes among them – may illustrate seeking rigor as exceeding physics ideology consolidated with time. History added numerous examples such as when great mathematicians ardently pursued calculation of pi number, ignored by physics colleagues who never tried proving existence of motion. Physicists used velocity as derivative without care of uncertainty of the ratio of two infinitesimals. Science educators may employ historical examples for better understanding the ideologies of both realms – mathematics and physics – identifying the specific mind features displayed by the two. The relationship between physics and mathematics is complex. Mutual appreciation and intuitive separation of interests are sometimes striking and sometimes invisible. Different perspectives imply different values. The state of being different in nature but still deeply interwoven and mutually dependent creates a special uncertainty regarding school curricula which deserves clarification.

The case of our system of education may be illustrative. While mathematics is mandatory, physics, for a long time, remained elective and chosen by a minority of high school students. The latter presumed to excel in math. Is that precondition really justified? Does physics and math require the same intelligence? What level and what kind of math do students need to manage with school physics? These questions we posed in our study for which our historical review served as a guiding background, a vertex of triangulation. We analyzed interviews with practitioners and experts in physics education performed in a constructive-qualitative format of qualitative research. Our sample included teachers of physics, mathematics and physics, science, physics professors experienced in school teaching, science education researchers, and the chief supervisor of physics teaching in the Ministry of Education. The teachers work in rural and urban schools different in socioeconomic settings. Our findings inform about the experience that although mathematics preparation apparently correlates with students' performance in physics class, it cannot guarantee students' success in learning physics equal to that they had in math. The claims for the need of good math knowledge for learning physics were interwoven with those stating that the learner hardly needs more than algebraic technique to perform well in physics class. We found that the dependence of physics on mathematics deserves more elaboration and that the notion that logico-mathematical intelligence as what one requires for learning science and mathematics should be refined and historical knowledge may help in that process. Seemingly, the two subjects appeal to different features of intelligence (Vinitsky-Pinsky & Galili, 2013a). The opinions of "bright minds" among physics and mathematicians, their practices may shed additional light on the subject and can guide physics educators to better understanding of the mind preferences of our students. The difference of intellectual interests, skills, and abilities imply a need of delicate balance between mathematical and physical aspects of knowledge to be reflected in the physics curricula. Complementarity might be the feature elucidating this balance. The structure of cultural content knowledge (CCK, Galili, 2011) may be useful to represent physics-mathematics relationship in the curricula (Vinitsky-Pinsky & Galili, 2013b).

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Keywords: History, physics nature, mathematics nature, mind, preferences

Topics: Curriculum, Learning

296.O6B

Understanding physics equations and PCK: The case of centripetal acceleration

Ricardo Karam
University of Hamburg, Germany

Previous works on students' understanding of physics equations have adopted different frameworks to define what "understanding equations" means. Among them, Sherin (2000) states that students learn to understand physics equations in terms of symbolic forms, where each form associates a simple conceptual schema with a pattern of symbols in an equation. Bagno et al. (2008) take the multiple task perspective to argue that students can demonstrate their understanding of a formula by presenting an association map, describing its components with their own words, identifying special cases and applying it in problem solving. In this work, I first intend to add some aspects to that list of demands, by including the need for an "epistemological categorization of equations". Such categorization would allow one to distinguish between equations that represent definitions (e.g. $v = \mathrm{d}r/\mathrm{d}t$ and $p = mv$), principles/axioms ($\sum p = 0$ and $\delta S = 0$), empirical relations (e.g. Balmer's formula), from other equations that can be logically derived from definitions and principles (e.g. $a_c = v^2/r$ and $E = mc^2$). Even though this distinction is not always sharp, being aware of it should enable physics teachers to prepare lessons according to the different epistemological status of the equations they teach.

Equations that belong to the latter category seem to demand a particular kind of instruction that should include some sort of formal derivation. The centripetal acceleration equation ($a_c = v^2/r$) is an example of this kind because although one can get a physical intuition of its relation with the velocity and the radius, a mathematical derivation is needed to understand the quadratic dependence of the speed. The present work reports a qualitative exploratory study, in which 28 physics teacher students were asked to design a lesson plan on centripetal acceleration and to describe how they would explain this equation to their students. It is noted that only 3 students mentioned the need for a derivation of this equation and, among them, just one actually presented a possibility. During instruction, the students were presented with different ways of deriving the centripetal acceleration equation and discussed about them with the whole class. Using semi-structured interviews and the students' responses to a post-instruction questionnaire, we were able to assess their views on the role of derivations in teaching about centripetal acceleration. The preliminary results of this study are presented and discussed.

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Keywords: Mathematics in physics education, understanding equations, PCK

Topics: Learning, Teachers, Teaching

300.O6B

Mathematical reasoning and knowledge organization: Comparing students' conceptualizations of the electrostatic field

Ricardo Karam and Terhi Mäntylä
University of Hamburg, Germany
University of Helsinki, Finland

Although the concept of field is one of the core theoretical constructs of physics, it is also among the most abstract ones and, therefore, its teaching/learning poses a major challenge for physics education. In fact, a deep understanding of this concept seems to correlate with one's ability to represent it in different ways (e.g. field lines, vectors, functions, differential operators, etc). Considering the electrostatic field, for example, one student taking a course at university level will be introduced to numerous representations of this concept (e.g. $\vec{E}=\frac{\vec{F}}{q}=\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}=\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^3}\vec{r}$, $\vec{E}=-\mathrm{grad}\,V$, $\oint\vec{E}\cdot\hat{n}\mathrm{d}A=\frac{Q}{\varepsilon_0}$, among others). In this sense, to understand the concept of electrostatic field would be associated with the ability to recognize these different mathematical representations, to identify their applications as well as their limitations, and also to connect them through reasoning. Concerning this latter aspect, we are mainly interested in the following question: What is the relation between a sound knowledge of various mathematical formulations and one's ability to perceive the relations between different conceptualizations; of the electrostatic field?

In this study we analyze the influence of mathematical reasoning in the way physics teacher students structure their knowledge of electrostatics. A semester course called Concepts and Structures of Physics was given with the goal of deepening students' understanding of the electromagnetic theory and also to introduce them to a particular way of representing their knowledge with concept networks (similar to concept maps). A part of the course was dedicated to the teaching of central concepts, experiments and principles of electrostatics. One of the final products of the course was the students' creation of concept networks that express their knowledge of the electrostatic field and encompass the development of this concept. Together with the networks, the students wrote reports where they explained in detail the meaning of each node (concept, principle, experiment, model or law) and their connections. In this work, we compare the explanations given by the students and the kind of connections presented in their networks, taking into account the different mathematical formalisms used in their reports. Preliminary results indicate that students who made use of more formal (abstract, advanced) mathematical representations (e.g. differential form, vector field, integrals) were able to make deeper connections between different conceptualizations of the electrostatic field when compared with the ones that presented less mathematical (more "conceptual") reports. Some of these specific differences are presented and possible reasons are discussed.

Keywords: Mathematics in physics, electrostatic field, knowledge structure, concept networks

Topics: Learning, Teachers

Session 6C, 16:40-18:00

107.O6C

The Interference of Representations as Production Condition in the Physics Teaching

Maria José P. M. Almeida[1] and Roberto Nardi[2]
[1]*State University of Campinas –UNICAMP, Brazil*
[2]*UNESP/FC, Brazil*

Large number of studies already carried out on alternative conceptions related to physical content showed that individuals already have representations about the physical world, even before any interaction. Many of those alternative conceptions are not consistent with the knowledge accepted by the scientific community. Studies on conceptual change have shown possibilities and limits for overcoming of those conceptions. With this communication we argue that in order to organize production conditions of teaching physics, in addition to teaching strategies, content knowledge and alternative conceptions about such content, it is also necessary to take into account the representations of another type. With this goal, this work is based on the notions of discourse analysis and follows the proposal initiated in France by Michel Pêcheux. In this theory, the language is not considered to be transparent, the discourse is effect of senses between interlocutors and the production conditions are the immediate, but also the socio-historical. The interpretation is affected by ambiguity and the representations are associated with imaginary backgrounds that interfere in discourse production and interpretation. For example: between the conditions of production of a class there are the imaginary of the students about who is the teacher. In addition to the theoretical exploration of the notion of representation and to highlight how some representations interfere in the production of meanings by students and teachers, we also examine aspects of some responses from researchers of teaching physics to the question: "The production and growth of the area of science education have interfered in the way we form teachers in Brazil? Why? (for negative answers) And how? (for positive answers). In this case, we look for what had contributed to the researcher give such answer (discourse). The main contribution of the study is to suggest that we should consider in the teaching of physics some aspects of the imaginary of those who teaches and of those who should learn. All those aspects are very often overlooked.

Keywords: Representations, discourse analysis, physics teaching, production condition

Topics: Teaching

111.O6C

Grade 12 students' conceptions of gravity and gravitation

Subramaniam Ramanathan[1] and Siew-Lin Lee[2]
[1]*Nanyang Technological University, Singapore*
[2]*Academy of Singapore Teachers, Singapore*

Textbooks often use the terms, gravity and gravitation, in different contexts. For example, phrases such as acceleration due to gravity and universal law of gravitation, implicitly portray that the key words used – gravity and gravitation, are somewhat different. In other words, whilst gravitation is perceived to be the force of attraction between two objects, gravity is perceived to be the pull of a celestial body on an object in it. Whilst scientifically they are the same, it is possible that the way textbooks (and, by extension, teachers) use the terms in different contexts could seed misconceptions in students that the two terms are different and this could come in the way of students achieving a holistic understanding of the topic. With a view towards understanding the prevalence of the misconception, a study was conducted on Grade 12 students (N = 180) to elicit their understanding and conceptions of these two terms. They were asked to explain their understanding of these two terms in two open-ended questions. The responses to these two questions were then analyzed using the grounded theory approach. The students' responses to each of these questions were classified into the various categories which emerged from the analysis of the data. The different categories which emerged were then checked by two experienced physics teachers. They were in broad agreement with the classification of the categories. Cohen's kappa and inter-rater reliability for the categories were determined as well and found to be acceptable. Results showed that a significant number of the students viewed the two terms differently while others thought they were similar. Cross-over variations of the definitions were also encountered. The variation in the responses of the students to the two terms can be traced to how textbooks portray these concepts and also how these are taught in class. Some suggestions for resolving these differences are suggested as well as implications for teaching.

Keywords: Gravity, gravitation, Cohen's kappa, inter-rater reliability, grounded theory

Topics: Curriculum, Learning, Teaching

161.O6C

Is there a similarity between a cup of coffee and an electric capacitor?

Lea Valentina Lavrik and Vladimir Meir Shunyakov
Lifshitz Academic College, Israel

Differential equations are important instruments of physical science

The creating of the physical science coincided with the creation of the differential equations theory, since only one single person Sir Isaac Newton was their author. Differential equations are perhaps the main mathematical language in the physical science. Physical laws, which are taught at school, such as the Newton's second law, the Ohm's law, the electromagnetic induction law, the Newton's law of cooling bodies, the law of radioactive decay, etc., may be described by differential equations.

The pedagogical problem

But this fact is usually hidden from the students. It is believed that this branch of mathematics is too difficult and inaccessible to secondary school students. On the other hand, students of universities and colleges need to have a pre-physical intuition, in order to master the theory of differential equations.

Method

In this regard, it is useful to recall the statement of the famous mathematician V.I. Arnold about the relationship between mathematics and physics: “Mathematics is a part of physics. Physics is an experimental science, a part of natural science. Mathematics is the part of physics where experiments are cheap”. So simple physical experiments done online - mode, can help students develop their physical intuition. Therefore, these experiments can serve as a launching pad for entry into the world of differential equations.

Our proposition

In this work we consider theoretically and experimentally two phenomena, which have different physical nature, but are described by those same differential equations. They are the processes of a cooling hot body and a capacitor discharging. Using a mathematical analogy between these processes, we can predict, for example, in which case the coffee cools down faster if you add cream in it at the beginning of the cooling or at the end, using the results of the experimental discharge capacitor. A second additional capacitor, connected to the first capacitor by parallel, is the analogue of a cream which is added to the hot coffee.

This paper presents the experimental data and comparing these results with theoretical solutions of corresponding differential equations. We hope that this work may be intended for university and college students and for teachers in secondary schools.

Keywords: Equations, discharging, cooling

Topics: Teaching

Using analogies and problem solving for studying electric circuits: results from several schools' teaching in practice

Andreia Salvador, Maria Almeida and Margarida Ramalho
CEMDRX, Physics Department, Faculty of Sciences and Technology, University of Coimbra, Portugal

This study is part of an educational investigation on Physics teaching aiming at minimizing Portuguese students' learning difficulties when progressing from lower to upper secondary school. The report is focused on simple electric circuits. Curricular Orientations in Portugal suggest that 9th level students (age 14-15) should "build some simple circuits, identify its components, measure currents and potential differences and analyze energy transfers". Students learn "rules" based on experimental evidences. Nowhere in the Orientations can one find any concern about promoting students' understanding of the meaning of all these abstract concepts. Based on an analogy between the behavior of "Children in a school yard", subject to different stimuli, and Drude's free electron model, a methodology was created to develop students' deeper understanding of the simplest abstract concepts of this scientific model. This analogy helps students understanding the roles of the different circuit components and inferring correlations of behaviors, enabling them to preview consequences of changes in electric circuits. Parallel and series circuits, open circuits and short circuits are easily understood, as well as Ohm's law. One objective of this methodology is to avoid the creation of future misconceptions and to correct any of the well-known very common scientifically wrong preconceptions.

To analyze the development of students' ideas, we complemented this approach with problem solving, specially designed to foster students' explanations of their answers.

This work began with a pilot study with two experimental classrooms, A and B, and one control one, classroom C. The analogy was only used in classroom A, both classrooms A and B solved the same number of specially designed problems, and class C followed closely the manual, strongly influenced by the Curricular Orientations. Every student solved the manual's problems and worked with the experimental set ups mentioned in it. The students answered the same pre- and post- tests.

The pilot study results point towards a meaningful positive influence of the problem solving methodology on the students' learning (classrooms A and B), being much higher on classroom A, where the analogy was also used. Furthermore, existing misconceptions revealed on the pre-tests were corrected up to almost 100% in classroom A.

After designing support documents for teachers, the reported experience was disclosed to another 9 teachers who are running it in 14 classrooms. The results of their experiences will be reported in the presentation.

Keywords: Secondary education: lower (ages about 11-15), misconceptions, electric circuits, analogies, problem solving, teaching in practice

Topics: Teaching

Session 6D – workshop, 16:40-18:00

099.W6D

Simple and Beautiful Experiments VI by LADY CATS and Science Teachers' Group

Kyoko Ishii[1], Fumiko Okiharu[2], Masako Tanemura[3], Mika Yokoe[4], Haruka Onishi[5], Masa-Aki Taniguchi[6], Tasuhiro Uchida[6], Junichiro Yasuda[7], Hisashi Kogetsu[8], Shinjiro Ogawa[9], Takanari Sasaki[6], Kazuhiro Tokuda[6], Shinnosuke Suzuki[6], Shuhei Miyamoto[6], Takahiro Shogenji[10], Shuji Mikami[11] and Hiroshi Kawakatsu[6]

[1]*Fukui University, Japan*
[2]*Niigata University, Japan*
[3]*Osaka Kyoiku University, Japan*
[4]*Daishogakuen High School, Japan*
[5]*Nishinomiya-inazu Senior High School, Japan*
[6]*Meijo University, Japan*
[7]*Gifu University, Japan*
[8]*Doshisha High Schoo, Japan*
[9]*Waseda University Senior High School, Japan*
[10]*Kyoto Tachibana University, Japan*
[11]*Kyoto University of Education, Japan*

LADY CATS (LADY Creators of Activities for Teaching Science) is an organization of science teachers. Our group includes a lot of female teachers, which is rather unusual in the field of physics.

Our concepts of experiments are follows: the "simple" experiments which the teachers in the world can utilize by lesson easily, the "beautiful" experiments that children get interested, and the "essential" experiments which can demonstrate the principles of physics. We aim to develop excavate and spread such experiments.

Effective teaching materials will be presented on our hands-on workshop. Let's enjoy with us!!

Keywords: Hands-on experiments, low-cost, essential, female

Topics: Experiments

Session 6E, 16:40-18:00

244.O6E

The Impact of Inquiry Based Physics Modules on Students' Motivation within the PROFILES Project in Georgia

Marika Kapanadze[1], Ekaterine Slovinsky[1] and Claus Bolte[2]
[1]*Ilia State University, Georgia*
[2]*Freie Universitaet Berlin, Germany*

PROFILES (2010) is a four year European FP7 funded project in the field of "Science in Society". Inquiry based science learning (IBSL) is in the centre of the PROFILES project (Bolte, Holbrook, Rauch, 2012). A major feature of PROFILES is the professionalization of science teachers through continuous professional development (CPD).

PROFILES aims at improving teachers' self-efficacy in implementing PROFILES modules based on a philosophy of Inquiry-Based Science Education (IBSE) through a socio-scientific approach which recognizes the importance of science education as more than content and skills and the need for an education through science perception.

In the frame of the PROFILES project in-service physics teacher CPD programmes were conducted at Ilia State University, Georgia. PROFILES modules were created and adapted with respect to the Georgian National Curricula. These modules are discussed and optimized by the participating physics teacher during the CPD courses and implemented in Georgian schools.

How the teachers are adapted and implement PROFILES should be detectable by characterizing changes and outcomes of the PROFILES lessons that the students experience throughout the duration of the PROFILES intervention. Implementation of the PROFILES modules are evaluated by means of the MoLE (Motivation Learning Environment) questionnaire (Bolte, 2006; Bolte, Streller, 2011).

Our MoLE pre-post test analyses show that the "PROFILES students" are more motivated to learn physics compared with the finding of the control group students.

In our the presentation PROFILES modules ("Traffic Accident – who is to blame?" and "What should we take for hiking - Coca Cola or Coca Cola Zero?") will be described and discussed as well as the results of MoLE questionnaire.

References:

Bolte, C., Holbrook, J., & Rauch, F. (2012; eds.). Inquiry-based Science Education in Europe: First Examples and Reflections from the PROFILES Project. Berlin: Freie Universität Berlin. Print: University of Klagenfurt (Austria).

Bolte, C. (2006) Evaluating Science Instruction by using the Motivational Learning Environment Questionnaire. Proceedings of the Annual Meeting of the American Educational Research Association (AERA). San Francisco, USA

Bolte, C., Streller, S., (2011) Evaluating Student Gains in the PROFILES Project. Proceedings of the European Science Educational Research Association (ESERA), Lyon, France.

PROFILES (2010): www.profiles-project.eu

Keywords: Inquiry-Based science education, continuous professional development, motivation learning environment

Topics: Learning, Teachers, Teaching

256.O6E

Learning about simple electric properties in early childhood

James Thomas[1] and Aletta Thomas[2]
[1]*Sebaka sa Kgolo NGO, South Africa*
[2]*Univeristy of the Witwatersrand, South Africa*

Very young children are often not receiving opportunities in learning (and playing with) the basic concepts of physics – it is regarded as too difficult. In the cyclical design experiments reported on here, under-privileged children and teachers participating in the early childhood development (ECD) phase are embedded in inquiry-based instruction; embedding not only cognitive development also spatial manipulation and language development in social contexts. The competency (using Piagetian and Vygotskian tasks) of four and five year old children to participate meaningfully in the lessons is established.

The paper reports on a pilot study with play and learn activities in six crèches, with six teachers and 120 children participating. The researchers, crèche teachers and a teacher-researcher develop and lead the lessons. Existing ECD lessons such as those used in the Head Start programme in the USA are adapted for use, with preference for lessons with play and peer talk. The data are generated from video-taped competency experiments and lessons at one crèche (one of the poorest).

For this report, the interactions of four children are studied in detail, with the opportunity to reference and clarify findings from other video-tapes.

The analyses of children's competency in conservation tasks show similarities with international findings in the Piagetian competency tasks (e.g. that the five year old participants are unable to conserve) and unexpected complexities emerging, such that children are clearly amazed at the static electrical phenomena they observed but were unable to venture explanations. This indicates a serious design flaw in our first design cycle. Data and the analyses from one lesson on simple electrical circuits are presented and changes based on the complex findings are suggested.

Keywords: Early childhood education, children's competence, learning physics

Topics: Informal Physics Teaching & Learning, Learning, Teachers

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280.O6E

Pedagogical content knowledge through video-based lesson analysis of a Colombian high school physics teacher on electric fields

Lina Viviana Melo Niño, Florentina Cañada Cañada and Vicente Mellado Jiménez
Universidad de Extremadura, Spain

In view of the current debate in Colombia about training science teacher, a qualitative study was undertaken involving a purposeful sampling pedagogical content knowledge (PCK) of a Colombian high school physics teacher that he have do numerous innovations about physics teaching. The objective is to show, the importance of this knowledge in in-service training physics teacher, and the necessity of design intervention programs based on reflection for developing of PCK in particular topics.

Data were obtained using video recordings from 6 classroom observations of the teaching and learning of the following topics/concepts: (1) methods of charging (2) Coulomb’s Law, (3) superposition of electric forces (3) electric field, (4) electric potential. This video analysis was triangulated using data from a interview, an open choice questionnaire, the planning template, and, the matrix designed by Loughran, Berry & Mulhall (2006) to represent content (ReCo), to which some modifications were made in the number of questions and the form of selecting the core ideas on teaching electric fields.

The findings revealed a static PCK whit tendency to traditional model of teaching. The belief about the high level of abstraction of electric field, in comparison with other topics of his curriculum, and institutional requirements limit the teaching strategies used. This statement justifies a more focused education in the teacher, where the logic that articulates the content ignores the reflections that the teacher has done on the needs and difficulties of their students about learning the electric field.

References:

Abell, S. K. (2007). Research on science teacher knowledge. In S. K. Abell & N. G. Lederman (eds.), Handbook of Research on Science Education (pp. 1105-1140). N.J.: Lawrence Erlbaum Associates Inc.

Loughran, J., Berry, A., & Mulhall, P. (2006). Understanding and Developing Science Teachers’ Pedagogical Content Knowledge. (Eds) Sense Publishers

Furió, C., y Guisasola, J. (2001). La enseñanza del Concepto de Campo Eléctrico basada en un modelo de aprendizaje como investigación orientado. Enseñanza de las Ciencias. 19 (2), 319-334.

Keywords: Pedagogical content knowledge, electric field, video-based analysis-of-practice

Topics: Teachers

310.O6E

Secondary Students' Understandings of Electric Circuits Based on the Microscopic Surface Charge Model

Seungman Kim and Junehee Yoo
Seoul National University, Republic of Korea

In conventional public school science curricula, the concepts of static electricity and electric currents are taught in isolation, despite being integrally related to one-another. Despite the importance of static charge (i.e. surface charge) distribution in electric circuits, little to no attention is given to it until the later years of post-secondary education. A teaching approach based on surface charge model for secondary level students to bridge electrostatics and electric circuits fostering electric field and electric potential concepts is presented.

The teaching sequences starts from demonstrations (e.g., the movement of metal wrapped ping pong ball between two metal plates connected to and charged by Wimshurst electrostatic generator) introduced to guide student relate surface charge density with the concept of electric field and potential difference. To improve the way these concepts are demonstrated to students in electric circuit, we developed interactive circuit boards (ECL_WB; Electric Circuit Learning White Board) using uninsulated aluminum tape in place of insulated wires, which enables students to relate surface charge distribution to electric voltage by applying a voltmeter at any place in the circuit. The ECL_WB is well-suited for laboratory lessons since it uses recognizable circuit topology (i.e. simplified simple and parallel circuits) set against a whiteboard background, which allows students and demonstrators to write visual cues (e.g. +/- for potential difference, arrows for electric field, etc…) on the circuit board to further explain the behavior of the circuit.

Embedded assessment and electric circuit concept test result show that the developed teaching intervention helped students to understand electric circuit phenomena in more microscopic model aspect and improve electric circuit concepts especially in the area of micro and qualitative questions, electric potential and voltage, and circuit as a system.

Keywords: Surface charge model, Electric Circuit Learning White Board, measurement and visualization, electric circuit concept

Topics: Curriculum, Experiments, Learning, Teaching

Session 6F – workshop, 16:40-18:00

165.W6F

Concept driven activities with simple experiments: a MUSE* workshop about selective absorption of light

Laurence Viennot[1], Andreas Mueller[2], Gorazd Planinsic[3] and Elena Sassi[4]
[1]*Université Paris- Diderot (Paris 7), France*
[2]*Université de Genève, Switzerland*
[3]*Faculty for Mathematics and Physics, University of Ljubljana, Slovenia*
[4]*Department of Physics, Science Faculty, University of Naples "Federico II", Italy*

The goal of this workshop is that the participants (N≈25) may experience and then discuss a particular kind of teaching-learning activities. The objective of these activities is conceptual construction/understanding of a given content – here selective absorption of light by a transparent medium. The first phase of the workshop will immerse participants in the kind of intended learning situation, while in the second phase the participants will analyze the content and the staging of the first phase. As a whole, the workshop will simulate a situation of teacher education. Concerning the conceptual content, the suggested activities are centered on selective absorption of light. It is designed in order to make one aware of considering not only the spectral composition and intensity of light but also the multiplicative status of absorption rate by a filter or a solution. Thorough understanding of this aspect, indeed, is essential to reconcile common school knowledge about colour and observation of various phenomena, such as colour of the sun or the moon at different heights, or else dichromatism of some solutions. The influence of thickness of the absorbing medium on these phenomena will be examined, and the sequence of experiments presented to illustrate, step by step, how exponential dependence arises from multiplicativity and a basic property of the exponential function. Finally, a whole group discussion will be centered on the transfer of the workshop to different audiences (students, teacher educators). All participants will receive written material with descriptions of the experiments, including handouts directly usable in the class or to be adapted to different contexts.

*MUSE: More Understanding with Simple Experiments; an initiative of the Physics Education Divisionof the European Physical Society (http://education.epsdivisions.org/muse)

Keywords: Conceptual construction, absorbance, exponential dependence

Topics: Experiments, Learning, Teachers

»»Session Workshop night 2D, 20:00-21:30««

228.WN2D

Thermal sensitive foils in physics experiments

Zdeněk Bochníček and Pavel Konečný
Masaryk University, Czech Republic

Thermal sensitive foils (TSF) are used for an approximate measurement of the temperature. They change their colour with temperature and now are commercially available also in larger sizes.

The set of experiments with TSF will be presented during the workshop. They can be used for the qualitative demonstration of thermal conductivity of solids, thermal capacity, gas heating and cooling in adiabatic compression and expansion, gas flow in aerodynamics and for the detection of infrared radiation. These experiments can be helpful in physics education at all types of schools, from elementary to universities. Some of the experiments are very easy to prepare and provide and do not require any special equipment.

At the workshop the participants will make their own simple kit for demonstration of thermal conduction, temperature changes in adiabatic processes and finally the cheap VIS cut filter for imaging in infrared light. The real transmission spectra of hand made filters will also be possible to measure at the workshop.

Maximal number of participants: 20.

Keywords: Measurement of temperature, thermal properties, aerodynamics, infrared radiation

Topics: Experiments

Session Workshop night 2E, 20:00-21:30

152.WN2E

Toward understanding of liquid crystal display: School experiments with liquid crystals

Mojca Cepic, Jerneja Pavlin, Maja Pecar, Katarina Susman and Sasa Ziherl
Faculty of Education, University of Ljubljana, Slovenia

Students, but also everybody else, meet liquid crystals every day. They are hidden within the screen of their mobile equipment: phones, pads and portable computers. Liquid crystals are also a vivid part of academic and applicative research, number of researchers counting several thousand. These two facts, the research significance of the topic and the content related to everyday life, makes liquid crystals a valuable topic for introduction into the teaching and learning of physics at all levels, from primary education to the university [1].

This workshop consists of two parts: The experimental support for developing students' understanding of the elementary unit of the liquid crystalline screen – the pixel, and the set of more elaborated experiments allowing university students for constructing the understanding of the (usually rather complex) conoscopic figure of transparent anisotropic material.

The first part will allow attendees to perform a set of experiments that were used in the high school within the tested unit on liquid crystals. This part of the workshop is complementary to the work presented by Pavlin et al [2], as it gives additional information on the practical work of students such as: the phases of the liquid crystal, the ordering of the liquid crystal, the construction of the model pixel.

The second part of the workshop will allow attendees to perform a set of experiments, which together lead the University students to understanding of the concept of double refraction and birefringence and the measurements of the two such as the light direction dependence of birefringence, the influence of the thickness, direction and the material on the transmission of light through the anisotropic material between crossed polarizer and the construction of a simple model conoscope. Anisotropic properties of transparent materials are traditionally measured by conoscopes, by evaluating the conoscopic figure according to the cook book recipes. The set of experiments scaffold the understanding of the conoscopy as an experimental method as well. The second part of the workshop is complementary to the study presented by Pečar et al [3], as it provides additional personal experiences with experiments that were used with students in the study.

The workshop will be organized in an active way, each participant will have an opportunity to perform discussed experiments personally.

References:

[1] M. Čepič, Liquid crystals in education: the basics. European Journal of Physics Education, 2012, vol. 4, no. 3, str. 27-33.

[2] J. Pavlin, M. Rožič, V. Babič, N. Vaupotič, M. Čepič, Evaluation of Liquid Crystals Display Course for Secondary School Students, Book of abstracts, ICPE-EPEC 2013.

[3] M. Pečar and M. Čepič: From sellotape and polarizers to conoscopy in the classroom, Book of abstracts, ICPE-EPEC 2013.

Keywords: Liquid crystals, liquid crystal display, conoscopy, anisotropy

Topics: Experiments

Session Workshop night 2F, 20:00-21:30

311.WN2F

Semiconductors at work

Leoš Dvořák
Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic

In our modern world, semiconductors are around us in great numbers in practically all devices more sophisticated than a hammer. Though most such devices are just “black boxes” for their users, physics education can (and should) provide at least some knowledge about how semiconductor components work. However, quite often the information on semiconductors are presented rather theoretically and even physics teachers do not have much practical experience with behaviour of basic semiconductor components.

Workshops and seminars oriented to simple experiments with semiconductors were introduced into the in-service teacher training in the Heureka project for Czech physics teachers several years ago and were tried also outside this project (once even in Slovenia, see report [1]). Experience shows that teachers appreciate this type of work quite a lot, especially a possibility to build some very simple circuits and teaching aids by themselves.

Workshop “Semiconductors at Work” on ICPE-EPEC 2013 will show just some parts of the activity that usually takes the whole weekend seminar. Nevertheless, the participants will have the opportunity to do both qualitative experiments and some quantitative measurements on very simple circuits with LEDs, diodes and bipolar transistors using simple devices that can be built by teachers or students. (One of main advantages of such little “gadgets” made on small wooden boards is the fact that they are by no means black boxes and their price counts in cents or euro-cents.) Also, there will be a possibility, at least for some participants who would like to do so, to build their own simple devices, from a circuit with two LEDs and one resistor to a simple circuit with bipolar transistors that can detect electrostatic charges [2].

References:

[1] Koudelková V., Faletič. S: Teachers explore electronics. Physics Education 45 (March 2010), p. 125.

[2] Dvořák L.: Bipolar transistors can detect charge in electrostatic experiments. Physics Education 47 (July 2012), p. 434-438.

Keywords: Semiconductors, electric circuits, simple experiments, teacher training

Topics: Experiments, Teachers

Thursday

8. 8. 2013

⋙Session 7A, 13:30-14:50⋘

032.O7A

Active learning in physics classrooms for enquiry-based instruction: Lessons learned from the PISA 2006 study

Kwok-Cheung Cheung
University of Macau, Macao

OECD's Programme for International Student Assessment (PISA) conducted its first full-scale scientific literacy study for the 15-year-olds studying in secondary schools in 57 participating economies in 2006. The research data collected were then made public in the official website (i.e. http://www.oecd.org/pisa/). Researchers are welcome to make use of the test and questionnaire data to answer questions pertaining to quality and equity of science education provision in schools of the participating economies. In PISA2006, both "knowledge of science" and "knowledge about science" are assessed. Students are asked to demonstrate their competence in three aspects of science learning outcomes: (1) explain phenomena scientifically, (2) evaluate and design scientific inquires, and (3) interpret data and evidence scientifically. Earning full credit to the test items necessitate deployment of three types of knowledge, namely content, procedural and epistemic knowledge. The concerned knowledge is drawn from the physical, living, and earth science and space knowledge systems appropriate to the developmental level of the 15-year-olds. In addition, students are required to exhibit various types of favorable dispositions and attitudes, such as interests in science, environmental awareness and valuing approaches to scientific inquiries.

Although it has never been the intention of PISA2006 to link assessment directly to the participating school's physics, chemistry and biology implemented curriculum, students are required to demonstrate their "knowledge of science" and "knowledge about science" by responding to a number scientific and technological issues (e.g. health and diseases, hazards, environmental quality) presented in personal, local, national or global contexts. Given such a rich and good quality database, the present study seeks to analyze the student's performance on the released PISA2006 test units from a comparative education perspective so as to allow teachers to know what aspects of scientific literacy are needed fostered in our students so as to help them become scientific literate persons in the new millennium. The analysis results are valuable to guide teachers on how to foster active learning in physics and other science classrooms for enquiry-based instruction.

Keywords: Scientific literacy, scientific enquiry, assessment and evaluation, physics learning

Topics: Assessment & Evaluation

042.O7A

Promoting cognitive engagement through Peer Instruction method in a Brazilian university context

Alex Vieira, Ives Araujo and Eliane Veit
IF-UFRGS, Brazil

The implementation of teaching activities focused on the students' cognitive engagement could be seen as a crucial challenge faced by physics teachers. In the international scenario, the combined use of Peer Instruction (PI) and Just-in-Time Teaching (JiTT) methods had been revealed as promising choices to promote such engagement. In opposition to traditional teaching methods based almost exclusively on lectures, PI+JiTT involves students pre-class Reading Assignments (RA) and classroom interactions promoted by conceptual questions posed by the teacher to approach students difficulties mapped through the RA feedback. Several studies in the literature has shown this methodology can foster student's conceptual understanding and improve their attitudes about physics. However, most of these studies were carried on educational institutions in USA or Europe which background and infrastructure to support innovative initiatives are not the same of institutions on less-developed countries. Because of the difference between the educational cultures, even student's resistance to perform the pre-class RA as preparation for the classroom activities during the academic period could be more challenging in the latter than in the former. From this perspective, and considering the significant role that RA plays for the methodology success, we posed the following questions: Will the students demonstrate sustained engagement with Reading Assignments throughout the semester? What will be the level of engagement they would demonstrate with the reading assignments? In this paper we present our preliminary results from an exploratory case study designed to answer it, implemented in an introductory physics course of Electromagnetism at Federal University of Rio Grande do Sul in Brazil. There were two sections of 16 physics majors enrolled, one section taught in the Fall of 2011 and the other in the Spring of 2011. Both sections had 14 students at the end (N = 28). In each RA the students had to read three or four sections from a textbook regarding the content to be discussed in the next class meeting. Also, they were asked to answer two questions about the reading and one question about their difficulties and doubts. After, they should send their answers electronically for the teacher. The students received credit for doing RA (15 % of the total grade). The evaluation criteria were students' efforts demonstrated in answering the questions, not if their answers were correct or wrong. We gathered data from records of 26 RA (for semester) answers and individual interviews with them. Nearly 80 % of the students did each RA along the semester and about 90 % of the students' submitted answers demonstrated engagement. As example of evidence of student's engagement, we considered the justification for a submitted answer, discussion of the content they found difficult, or discussion of the content they found motivating. Spite of initial resistance by the students in the beginning of the semester, these results strongly suggest a highly acceptation of the pre-class activities. In the continuation of the work, we will further investigate the main factors of success for the engagement achieved carrying out an explanatory study.

Keywords: Peer Instruction, Just-In-Time Teaching, cognitive engagement, physics education

Topics: Learning, Teaching

053.O7A

The Practice Teaching and Effectiveness of Peer Instruction in Chinese Introductory Physics

Xiumei Feng
Central China Normal University, China

Peer Instruction, always with Clicker System, has recently been developed in the international physics teaching and its effectiveness in inspiring students' interest and facilitating their effective learning is being tested. In our physics teaching, peer discussion was adopted when the first vote showed students' answers dispersed, then students were asked to revote to show how they learn from the peer discussion. The preliminary results illustrate more than 80 % students like this kind of teaching, the attendance rate is 20% higher than the traditional class. Students' achievements raise about 9 % because the middle students gain most. Peer discussion can improve students' understanding in most physics concept questions. However, when the question is too hard and students' initial right answers are too low, peer discussion can't show its effectiveness. The gender difference in performance is reduced with male students advance more. The reasons why peer instruction can result in these improvements and some unexpected problems in our practice are discussed.

Keywords: Peer Instruction, clicker system, active learning

Topics: Learning, Teaching

075.O7A

Evaluation of Tutorial and Non-Tutorial of Lecture-Based Classes of Forces and Motions by Using the Model Analysis Technique

Suttida Rakkapao and Teparksorn Pengpan
Prince of Songkla University, Thailand

This study aims to assess the force and motion conceptual understanding of students in two groups: tutorial and non-tutorial of lecture-based classes. Samples are science freshmen (n = 420); called group 1, and engineering freshmen (n = 434); called group 2, of Prince of Songkla University, Thailand. In the force and motion classes, both groups were taught by using the lecture-based method, including show some physics animations from academic websites. The same instructional materials were applied to both groups but instructors are different. At the end of the classes, participants in group 1 were asked to do the take-home exam by themselves, and the solution will be put on the internet next few days. These samples are named non-tutorial group. In contrast, participants in group 2 were given an extra class for solving the exam by instructor. It is called tutorial group. The Force and Motion Conceptual Evaluation (FMCE) test was administrated to both groups before and after the classes around one month.

Results have showed that, for both groups, the post-test mean scores were greater than the pre-test mean scores at 0.05 significant level proved by the paired *t*-test. To examine the students' improvement of knowledge, we have calculated the average normalized gain (<*g*>). It has revealed <*g*> = 0.12 0.04 for group 1, and <*g*> = 0.04 0.03 for group 2. These have indicated the low level of student's learning gain. Moreover, it has disclosed that both groups had the lowest learning gain on the cluster of the first and second laws of Newton of the FMCE. We then analyzed the characteristics of these students' mental models on that topic by using the model estimation of the model analysis technique. Based on the largest eigenvalue and its eigenvectors, as well as the model plot, it obviously exposed that both pre-and post-class model states of both groups were still in the misconception state. Although there was greater probability for students in group 1 in using a scientific concept to solve the FMCE, most students, from both groups, still held alternative concepts at the end of the classes. These findings suggested that a more active instructional approach is required for freshmen physics lecture classes.

Keywords: University education, model analysis, forces and motions, normalized gain

Topics: Assessment & Evaluation

Session 7B, 13:30-14:50

100.O7B

Teachers views on the role of experiments in upper secondary physics education

Simon Holmström[1], Ann-Marie Pendrill[2], Nina Reistad[1] and Johan Zetterberg[1]
[1]*Lund University, Sweden*
[2]*NRCF, Sweden*

Experiments are one of the fundaments of physics, and also of physics education. Laboratory work is used with a number of different aims for student learning, often only tacitly assumed, but not communicated, nor evaluated. The recent curricular reform in Sweden has brought a larger emphasis on experimental skills, including planning and design, as well as assessment of these skills. How do teachers respond to these changes?

In focus groups physics teachers in different schools have discussed their choice of experiments in upper secondary physics, as well as their goals and assessment practices. As introduction, the teachers were asked to describe a favourite experiment and explain why they like it. The discussions and previous observations reveal different preferences: From precision experiments using advanced instrumentation to measure fundamental constants to experiments with simple equipment to demonstrate measurement techniques, fundamental principles or everyday physics. From carefully guided instructions to open investigations. From hand drawn graphs on paper to linear regression on calculators or computer aided mathematical analysis. In their discussions, teachers discern possible alternative approaches, with advantages and disadvantages. They also become increasingly aware of the small role often played by the assessment of experimental skills for the final grade.

Keywords: Upper secondary education, role of experiments, curriculum change, tradition

Topics: Assessment & Evaluation, Curriculum, Experiments, Teaching

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140.O7B

Intended, implemented and attained MST curricula researched by SECURE project across the Europe

Job de Meyere[1], Dagmara Sokolowska[2], Marja van Graf[3], Barbara Rovsek[4] and Wim Peeters[5]
[1]*Thomas More, Vorselaar, Belgium*
[2]*Jagiellonian University, Krakow, Poland*
[3]*Nationaal expertisecentrum leerplanontwikkeling SLO, Enschede, Netherlands*
[4]*Faculty of Education, University of Ljubljana, Slovenia*
[5]*Dienst Katholiek Onderwijs vzw, Antwerpen, Belgium*

SECURE is founded as a collaborative project under FP7 to provide research results of current mathematics, science and technology (MST) curricula across Europe. The research focuses on the MST curricula offered to 5, 8, 11 and 13 year old learners in 10 European countries. The consortium invited 60 schools from each partner country to participate in the project. Altogether almost 9000 pupils, 1500 teachers and 600 schools took part in study.

The research framework was constructed upon the curriculum spider web (van den Akker, 2003), in which curriculum is represented on a spider web with Rationale located in the center and nine other components (Aim and Objectives, Content, Learning activities, Teacher role, Materials and Resources, Grouping, Location, Time, Assessment) placed around it, becoming the nine threads of the spider web. The instruments used in the study consist of a transnational comparative screening instrument for MST curricula and of the school data collection instruments: teacher questionnaires, learner questionnaires (limited to 8, 11 and 13 year olds) and interview protocols for all age groups of pupils and their teachers. A mixed method approach for the analysis of the MST curricula is applied throughout three different representations of the curriculum: the intended curriculum (formal curriculum documents), the implemented curriculum (the actual process of teaching) and the attained curriculum (focus on learning experiences of the learners).

The overall aim of the SECURE project is to make a significant contribution to the European knowledge-based society by providing relevant research data that prompt public debates on this issues. Based on good practices and other research results SECURE will formulate a set of recommendations for policy makers and other stakeholders on how MST curricula and their delivery can be enhanced in order to ensure the balance between the training of the future scientists and broader societal needs.

During the presentation a comparative study of written MST curricula in 10 countries and their general trends will be shown. Examples of the national results on several items of the spider web with use of triangulation approach will be also presented.

Acknowledgement

This work is based on the SECURE research project (No SIS-CT-2010-266640), which received funding from the European's Unions Seventh Framework Programme for Research and Development.

References:

van den Akker, J. (2003). Curriculum perspectives: An introduction. In J. van den Akker, W. Kuiper, U. Hameyer (Eds.), Curriculum landscapes and trends (pp. 1-10). Dordrecht: Kluwer Academic Publishers.

Keywords: Primary education (ages about 6 – 10), secondary education: lower (ages about 11-15), curriculum, MST education, European programme, research in education, spider web

Topics: Curriculum

186.O7B

Extended project work for school physics students

Elizabeth Swinbank
University of York, United Kingdom

This session will focus on individual extended project (EP) work undertaken by school physics students aged 16-19, and will present guidelines for helping such project work to be successful.

A key word here is 'extended'. The project work considered in this session takes about 120 hours of class time, plus a similar amount of private study time, and is carried out over the course of 1-2 years. It is far more extensive and demanding than project work taking 10-20 hours over the course of 2-3 weeks that has for several decades been part of some highschool physics curricula such as the UK Nuffield, Advancing Physics, and Salters Horners programmes. In the UK, extended project work is recognised through a new qualification, the Extended Project Qualification (EPQ), which is now part of the national qualification framework used for university entrance.

The session is intended to be of interest to physics teachers and educators in countries where physics project work is already undertaken in schools, and those who are interested in exploring how it might be introduced and implemented.

Questions addressed in this session will include:

- What are the differences between an EP and problem-based learning (PBL)?
- What are the benefits of individual EP work?
- What preparation and teaching do students need before they start an EP?
- How can teachers effectively manage and supervise EPs?
- How can physics-based EPs be encouraged?
- What makes a good physics EP?
- How can individual EPs be assessed and graded using common criteria?
- How can EP work be scheduled within a highschool timetable?

The session will be illustrated with examples of physics EPs and will include feedback from teachers and students who have successfully undertaken such project work.

Keywords: Extended project, independent learning, project work in schools

Topics: Assessment & Evaluation, Learning

191.O7B

The questions for assessment (QfA) scheme in a physics class: an alternative assessment method for improved metacognitive awareness, concept retention and transfer?

Resty Collado and Lydia Roleda
Miriam College High School, Philippines
De La Salle University, Philippines

Low comprehension of any subject matter content impedes higher cognitive skills. Previous studies show that writing questions based on read text improves one's understanding of the material, and serves as a metacognitive strategy as students recall and reflect on what they have learned. This study attempted to extend such assertion to a local high school physics class. Two identical senior high school classes were given similar instructions in physics for 8 weeks. However, one group (N = 36) received the Questions for Assessment (QfA) scheme while the other (N = 34) was given the typical teacher-made assessment tasks. The QfA scheme consisted of requiring the students to construct multiple choice questions as part of their homeworks, seatworks and quizzes. Credits are awarded depending on the cognitive skill a question involves such that questions requiring higher cognitive skills (Bloom's taxonomy) are awarded higher credits. About 1500 multiple choice questions were constructed by the students in the experimental group within the duration of the study. Results from 3 achievement tests showed that the students from experimental group obtained higher mean scores than those in the control group, with increasing difference in each of the tests. Furthermore, students in the experimental groups showed better retention as confirmed by their better performance in each of the three unannounced tests given during the course of the study. However, no significant difference in the performance of the two groups across the three transfer tests was observed, although the difference is nearing significant levels as the study progressed in time. Finally, for the metacognitive awareness, Schraw and Dennison's Metacognitive Awareness Inventory was administered at the beginning and end of the study. It was found that, although each group showed increased metacognitive awareness, the experimental group posted larger increase. Therefore, the QfA as an alternative assessment resulted to improved concept retention and metacognitive awareness but not concept transfer.

Keywords: Secondary education: lower, multiple choice questions, assessment of learning, improvement of comprehension, metacognition, physics education

Topics: Assessment & Evaluation, Learning

Session 7C, 13:30-14:50

023.O7C

Physics Teacher Professional Development - Closing the Knowledge Gap

Mark Greenman
Boston University, United States

During the summers of 2008 through 2012 five cohorts totaling 114 secondary school teachers responsible for teaching physics concepts enrolled in a Massachusetts Department of Elementary and Secondary Education funded summer institute hosted at area Universities to enhance the teachers' physics content knowledge and to improve their use of research-based best practices in teaching physics.

The average paired fractional gain for these participants on the Force and Motion Conceptual Evaluation (FMCE) was .68 with teachers in every comparison group showing strong gains (.57 to .74). Just as encouraging, these gains showed little decay over time. The content knowledge gap between male and female science teachers was reduced from a gap of 25 % to 6 %, and the gap between physics majors teaching physics and other science majors teaching physics was reduced from a gap of 31 % to 8 %.

The presenter will share data highlighting the large variance in the physics concept knowledge of teachers depending on a variety of factors and how a 60-hour professional development institute based on active learning strategies and the engaging science methodology of Interactive Laboratory Experience can significantly close these conceptual gaps between comparison groups.

Keywords: Teacher training, professional development, teaching methods, teaching strategies

Topics: Learning, Teachers, Teaching

166.O7C

Validating the Force Concept Inventory with Sub-Questions

Jun-Ichiro Yasuda[1] and Masa-Aki Taniguchi[2]
[1]*Gifu University, Japan*
[2]*Meijo University, Japan*

When conducting a survey using a diagnostic tool such as the force concept inventory (FCI), it is necessary to analyze its validity from various standpoints. In this study, we address the structural validity of the FCI, that is, whether respondents who answer the FCI questions correctly have an actual understanding of the concepts of physics tested in the questions.

First, from the qualitative analysis of the interviews, we found that some students were able to provide the correct answer to Q.6, Q.7 and Q.16 even when using the incorrect reasoning.

Next, in order to examine these inadequacies, we used sub-questions that test students on concepts believed to be required to answer the actual FCI questions. Our sample size comprises more than one hundred respondents; we derive false-positive ratios for pre-learners and post-learners, and then statistically test to judge the significant difference between them.

Preliminary analysis shows a significant difference at the 0.05 significance level for both Q.7 and Q.16, implying that it is possible for post-learners to answer both questions without understanding the concepts of physics tested in the questions; therefore, the structures of Q.7 and Q.16 are invalid.

By quantifying the significance of these acknowledged inadequacies, we try to estimate a systematic error of FCI.

Keywords: Physics education research, force concept inventory, validation

Topics: Assessment & Evaluation

180.O7C

Just how deterring are formulas? Results of an empirical study

Alexander Strahl and Rainer Müller
TU Braunschweig, IFdN, Abt. Physik, Germany

In an empirical study we tried to identify and quantify the variables that govern the appraisal of physical formulas. We asked 662 secondary school and university students to indicate for 38 formulas to what extent they perceive the formula to be deterring.

The participants had to complete a questionnaire in which they rated each of the 38 formulas on a scale from 1 (not at all deterring) to 5 (very deterring). The formulas have different lengths and comes from all fields of physics. The result is surprisingly simple. We are able to model the student response with only a single variable: the length of the formula. We give an explicit model equation (saturating exponential) to fit the data.

In a separate questionnaire we investigated whether there is a "standard form" for physics equation. Fractions, for example can be written in several different ways. We obtain surprisingly clear preferences for certain forms.

The results of our research should help educators and authors to write formulas more readable.

Keywords: Formulas, mathematics, deterring

Topics: Assessment & Evaluation

192.O7C

Innovative Problems for Development of Creative Thinking

Václav Meškan
Department of Applied Physics and Technology, Faculty of Education, University of South Bohemia, Czech Republic

The contribution deals with development of creative thinking of pupils in teaching of physics at elementary school. Ideational process connected with creativity and creative problem solving is often described as convergent and divergent thinking: during the creative problem solving process, the phase of generating multiple different ideas how to solve this problem is pivotal. This mental process is called divergent thinking. Yet the vast majority of assignments occurring at school are of convergent type, which means that to solve them, the convergent thinking aiming on the only correct answer is involved. The aim of the contribution is to present so called divergent physical problems which allow the developing of the divergent thinking and which can be completely integrated into physics curriculum at the same time. This presentation includes also quantitative numerical divergent problems as the solving of quantitative problems is traditionally strongly emphasized in teaching of physics in Czech Republic.

Keywords: Creativity, creative problem solving, divergent thinking, divergent physical problems

Topics: Teaching

Session 7D, 13:30-14:50

003.O7D

Construction of Low Cost Laboratory Equipment

Carlos Mario Montes Jiménez
Universidad Pedagógica Nacional, Colombia

During the course named Construction of Laboratory Equipment, belonging to the Bachelor of Science in the Teaching of Physics at Pedagogic University (Licenciatura en Física – Universidad Pedagógica Nacional Bogotá, Colombia), there is a proposal for prospective teachers (BS students) to turn to their theoretical and empirical bases to design, build, and validate laboratory equipment.

During the design stage, a needs analysis is made. It emphasizes the study of the need and intention to develop laboratory equipment; the consideration of robust and manageable designs; the use of low cost materials, and the development of documents to guide experimental practices. In the construction stage, the experimental assembly and its corresponding guidance document are obtained as the final products. All the previous stages are carried out by taking into account: the calibration of measurement instruments, the way to get data, the aesthetics of the equipment, and the relationship among the use of the equipment, the physical concepts involved in the practice, and the guidance document. Finally, during the validation stage, an article is written and submitted. It includes the description of: the design and construction of equipment process, the use of the equipment during the implementation stage, the data collection, the data processing, and the conceptual development that can be achieved with the support of the equipment and the guidance document.

This practice has been led for two years with about 60 prospective teachers and by the end of the courses, it has been found that they strengthen the ability to design and develop laboratory equipment. In addition, they improve their ability to design and write guidance documents for handling build didactic materials. Moreover, they test and validate the built equipment and documents in real teaching practice sceneries. Finally, it has been observed that they acquire tools and strategies focused on the practice of future professors.

Keywords: University education, teacher training, design laboratory equipment, build low cost laboratory equipment, guidance document, teaching practice

Topics: Experiments, Teachers

074.O7D

Construction and analysis of a solar oven as a practical non-formal activity in the physics education

Eloneid Nobre[1], José Sarmento[1] and Silvany Santiago[2]
[1]Federal University of Ceara-Program of Professional Master in Teaching of Sciences and Mathematics, Brazil
[2]Federal Institute of Education, Science and Technology of Ceará/ Program of Professional Master in Teaching of Sciences and Mathematics, Brazil

The objective of this work is to build a solar oven, using low cost materials, using it as a teaching tool in the application of the concepts of Thermodynamics, Energy, Electromagnetism and Radiation Blackbody. Furthermore, issues such as sustainability and ecology are also worked, because the construction of the solar oven prioritizes the use of recyclable materials, low cost, using solar energy, a permanent, renewable source of abundant energy, that does not pollute or adversely affects the ecosystem. This work seeks to explore Physics in more attractive way, so that students feel themselves motivated to study it, seeing its applicability in practice, without the need of using laboratories since many times, unfortunately, the lab yet is not part of the reality of some schools of that region. The Northeast of Brazil is a region very conducive for using alternative methods of use of solar energy, because this is a region near the equator, with a high rate of solar incidence almost all year round. Estimates of solar radiation are shown in several studies. Results from studies conducted in the Federal Universities of Pernambuco and Santa Catarina show that solar radiation in the country can reach a maximum of 22 MJ/m^2, equivalent to about 6.7 kWh/m^2 during the day. The smaller variations occur in the months from May to July, when radiation can reach 5.0 kWh/m^2. The solar oven developed in this work is of type panel, that uses reflective mirrors. These mirrors were replaced with cardboard coated with aluminum paper foil. To calculate the power and performance of the oven, we used the theoretical procedures related to the contents learned in the classroom. The materials used in the construction of solar oven were collected by the class teacher with the help of his students. The practical application of the oven was confirmed with the cooking of various kinds of food. The teacher suggested to his students to cook some vegetables, considered of difficult baking in conventional ovens: chayote, carrots and beets. Another kind of food suggested by the teacher, was the corn couscous, a typical dish of the region. The times of baking of the foods are shown in table below:

Food	Time of baking (hours)
Chayote	1:50
Carrots	2:30
Beets	2:30
Couscous	2:25

The construction of the solar oven promoted the experimental work of various contents covered in classroom. In addition to promote a meaningful learning, this activity made the students felt themselves encouraged to know more the Physics, and also see it in a fun and attractive way. The reached performance of 23.35 %, can be attributed to the fact that the experiment has been performed on a day when the sky, unusually, was partly cloudy. New results are being worked by repeating the experiment. As a future perspective of implementing this project, the students who are

participating of this experience are being trained to visit poor communities in the region, promoting knowledge and widespread use of solar ovens among people with low incomes. These people, nowadays, use mainly firewood stoves in their homes. We hope that if the use of solar oven becomes popular, the persons, replacing the using of wood for the sun energy, begin to adopt a more careful stance with nature.

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Keywords: Secondary education: upper (ages about 15-19), solar energy, solar oven, learning and teaching of physics, low cost experiments

Topics: Experiments, Learning, Teaching

172.O7D

Developing Physics Laboratories in the Developing World

Muhammad Sabieh Anwar
Lahore University of Management Sciences (LUMS), Pakistan

In this presentation, I would like to discuss the various aspects of establishing a contemporary and low-cost University physics laboratory. This exercise brings to light special challenges as well as unique opportunities, when performed in a developing country such as Pakistan. This presentation is largely a personal recollection providing useful insight to laboratory developers as well as the University administration.

In particular, the process of laboratory development requires various fine balancing acts. First, indigenization based on locally available resources is to be balanced with the importation of technology. The latter is not only costly but one has to also face bureaucratic import rules and the unwillingness of foreign companies to deal with particular developing countries. Second, there is a cultural philosophy prevalent in many Asian countries of considering experiments a handmaiden to theory. Therefore, laboratory courses are mostly always tied up as "parasites" to theory courses. This, I believe, does not reveal the unique spirit of the experimental culture that has a life of its own! Third, there are various internal pressures and conflicting demands imposed by the local University administration. For example, development of laboratory is considered to be inferior to classroom teaching or doing "elite" physics. Workloads are not defined commensurately either. The constant pressure of publication of research further dampens the spirit of lab development. Universities are also hesitant in hiring of staff or students for development work.

I will present the example of the Physics Laboratory at the Lahore University of Management Sciences (LUMS) where all of these challenges, arguably, have been successfully addressed.

For example, several parts of the developing world have dying traditions of "folk industry" and "domestic craftsmanship". We engaged several of these domestic, homegrown enterprises into scientific instrument making, e.g. in glass blowing, machining, metal-working, molding and wood work wherein we provided the technical expertise whereas the craftsmen produced the instruments. This exercise eventually culminated in the establishment of a mini-workshop on our premises, resulting in the bringing down of imports and costs saving.

Costs were further reduced by employing off-the-shelf webcams for tracking of physical events, sound cards for the acquisition of physical signals and recently Arduinos for hardware control, timing and triggering. In the first four years of the laboratory's life, students were given some formal experiments while in most cases, students were asked to develop new experiments for their peers and juniors. This not only gradually add to the repertoire of experiments, but was also a luring incentive for students (in addition to course grades!) who feel that they played an active role in establishing the laboratory curriculum for their own very institute! The design of new homegrown experiments instead of the importation of educational kits has the advantage of transparency where the instrument's inner working is exposed to students and the teacher alike, and troubleshooting becomes much easier. This is really important in our context where maintenance budgets are non-existent and several expensive instruments are seen languishing in corridors!

Keywords: University education, laboratory development, contextualization of physics education

Topics: Experiments, Socio-cultural Issues

255.O7D

Experiments with CanSat

Mária Pető
Székely Mikó High School, Romania

My presentation is based on few school projects and experiments which I used during the last school years in my classroom learning and practical activities.

The thermodynamics and electricity are part of the 10th grade physics curriculum in Romania, and they offer many opportunities to tray new teaching ways. In this context I built with my students a mini satellite named “CanSat”, with which our “Bolyai”- team participated in the 2012 European CanSat competition held by ESA and NAROM. This device is similar to a real satellite, but it must to fit inside a 330 ml soda can. On the day of the launch campaign it was delivered by an “Intruder” rocket up to a height of 1 km and then was dropped off. During the descent we made certain measurements, like: temperature, pressure, dust and solid particle density in the atmosphere. This project started with the planning phase of CanSat elements: microcontrollers, sensors, dust sensor followed by the circuit building, programming the sensors and Arduino board, provide a continuously radio communication between the CanSat and ground station and for a safe landing, we designed a parachute and a resistant outer shell for the CanSat.

Based on this idea after the contest we proceed to new measurements in classroom and extracurricular outdoor programs. We visited the local station of the National Agency for Protecting the Environment (ANPM) and there we managed to obtain the data necessary for calibrating the Cansat sensors for our region. In collaboration with the Babes-Bolyai University we built a new experiment measuring the speed of electromagnetic waves and its dependency from the pressure, temperature and humidity. By the help of a Quadrocopter we elevate the measuring device up to (400-500)m, establish a wireless radio connection between the CanSat and signal emitter/receiver. We record a lot of overtrick data from the Cansat and radio wave emitters, we compare them and calculate the speed of electromagnetic waves based on the overtrick time of the signal. The pilot tests were very convincing; the measuring errors were less 16 %, so now we keep going with this experiment.

I think it's easier to understand a theory that is a bit more complex than the classical, idealistic models but it describes the nature far more realistically. This experiment with the mini satellite could help the students to understand the theory of electromagnetic waves and also could be an excellent exemplification for new teaching opportunities.

Keywords: CanSat, Arduino-board, sensors, pressure, dust, electromagnetic wave

Topics: Experiments

Session 7E –workshop, 13:30-14:50

155.W7E

Floating and sinking during Lab Stations

Ana Rita Lopes Mota
CFP e Departamento de Física e Astronomia, Portugal

Even for an experienced teacher, bringing middle school students to a correct understanding of why things sink and float is one of the most challenging topics for student conceptual change. The teaching of this phenomenon is very delicate since everyday life experience leads students to possess certain beliefs and intuitions, often incompatible with scientific laws, about floating and sinking. This condition is exacerbated by the fact that the Archimedes' principle and the formulation of floating rules require advanced reasoning skills, not always easy to understand for young students.

Previous research has brought to light frequent alternative conceptions of students and present a number of strategies to facilitate students' conceptual change. According to them, a proper understanding of the floating and sinking phenomena must include a deep analysis of the relationship between buoyant force and gravity force.

Based on international research, it was designed and implemented two middle school lab sessions: the first one related to the buoyant force and the Archimedes' principle and the second one with floating and sinking. Each lab session, lasting 45 min, is divided into four completely independent experimental stations, each with different apparatuses / materials. The stations are diversified and range from simple tasks, such as demonstrations or simple measurements, to tasks that involve a scientific reasoning.

This interactive and dynamic model of laboratory classes has many advantages when compared with classical lab sessions: a reduction of the material requirements, a formative assessment, a better work flow from students, a higher motivation and a significant variety of experiments.

The two lab sessions were designed to help students realize the limitation of their own predictions, creating cognitive dissonance and surprise, and get ready to learn and apply scientific theories.

This workshop will consist of three parts:

I. The lab stations model will be presented and its characteristics and advantages will be discussed.

II. Students' misconceptions about floating/sinking and the buoyant force will be presented.

III. Teachers will be able to see and perform all the lab stations belonging to the two sessions.

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Keywords: Floating, sinking, Archimedes' principle, buoyant force, lab stations

Topics: Experiments, Teachers

⋙Session 8A, 15:00-16:20⋘

101.O8A

Teacher's roles during amusement park visits - insights from observations, interviews and questionnaires

Ann-Marie Pendrill[1], Cecilia Kozma[2] and Andreas Theve[3]
[1]*NRCF, Sweden*
[2]*Stockholm house of science, Sweden*
[3]*Gröna Lund, Sweden*

Amusement parks offer rich possibilities for physics learning, through observations and experiments that illustrate important physical principles and often involve the whole body [e.g. 1-4]. Amusement parks are also among the most popular school excursions, but very often the learning possibilities are underused. In this work we have studied different teacher roles and discuss how parks or event managers can encourage and support teachers in their efforts to make amusement park visits true learning experiences for their students. Teachers take on a number of different roles in connection with a visit, as known also from research at science centres [5]. Teachers may leave the class to roam around, possibly agreeing on meeting time, including a snack - described as a "soda pop visit" in [5]. Teachers may use to visit as an appetizer to start up an area of work - or as a resource or laboratory providing equipment not found in school. Lessons may be offered - also in amusement parks [4], and teachers may or may not take part together with the students [5]. Amusement parks may prompt additional roles, e.g. bag guards or an electronics support centre. These teachers' roles and types of visit influence the learning possibilities offered to the students. Integration of the visit with the educational context in school is found to be essential, including preparation and follow up [6].

During recent years, we have further developed the format for Edutainment days / Physics days at the Gröna Lund and Liseberg amusement parks in Stockholm and Göteborg, Sweden, building on experiences and materials from science days arranged at these and other parks [7]. Worksheets have been developed to encourage teachers to divide the class in groups of about 4 pupils who focus on 2-4 different rides. The groups who can then report back to the rest of the class, providing a richer experience. We have found that the use of worksheets with different rides helps circumventing long queues, where students cluster on a few popular rides. An important aspect of the design of the Edutainment days is the emphasis on the role of the teacher, supported not only through worksheets, but also by an introduction day, where teachers have a chance to get familiar with the rides, as well as sharing and discussing previous experiences from working with the material, before during and after the visit. During 2012, the teacher's role has been further strengthened by assigning teachers to assists at selected rides, bringing together teachers with different degrees of experience, as well as tutors or graduate students. We present an analysis of evaluations, including interviews, observations and questionnaires, from these events. Discussions and sharing of results about design and evaluation of other forms of informal learning activities will be encouraged.

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Keywords: Secondary education, teacher education, teacher roles, amusement park physics

Topics: ICT, Informal Physics Teaching & Learning, Teachers

141.O8A

PCK research based module formation of prospective primary teachers on energy

Marisa Michelini and Alberto Stefanel
University of Udine, Italy

Primary Teacher education is a challenge through which passes the formation to an integrated scientific culture of the future generation. In the perspective of the PCK [1], the cultural aspects, the conceptual and professional ones have to be integrated. As a result of a research conducted over several years [2-3], a formative module on energy has been designed and experimented with a group of 107 Prospective Primary Teachers (PPT) of the degree in science of primary education at the University of Udine, in the academic years 2011-2012.

The module include two parts: in the first part (CK part), a traditional approach to the concept of energy was proposed starting from the concept of work; in the second part a PCK laboratory integrate the analysis of a teaching/learning proposal based on experimental exploration and inquiry strategy by means of tutorials and the analysis of the main conceptual knots emerging from literature [4]. A CK questionnaire was administered at the end of the first part and a PCK questionnaire was included in the activity of the second part. The CK questionnaire focused on the way in which the PPT discuss expression as conserve, transform, lost energy passing from the everyday meaning of these expressions to their scientific meaning. The PCK questionnaire proposed to the PPT typical educational situations, concerning the conceptual knots on energy documented in literature, as for instance: energy associated to human or living being, as fuel-like substance which is possessed by living things [5-9]; energy possessed only by moving objects [6,10] or as product of some process and existing only during this process [8,6, 11] transformation of energy and process [7, 9, 11-12]. Data analysis, collected by worksheets used during the laboratory, the CK and PCK questionnaires and from the educational paths designed by PPT at the end of the formative module, evidence to role in the teacher formation of the integrated CK and PCK analysis of students learning knots supported by the analysis and appropriation of the research based proposal on which was centered the second part of the formative module.

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Keywords: University education, prospective primary formation, energy, PCK

Topics: Teachers

185.O8A

Competitions of the Young Debrouillards Clubs – an Interesting Way of Active Learning

Zdeněk Drozd and Jitka Houfkova
Charles University in Prague, Czech Republic

The Association of Young Debrouillards of the Czech Republic has a long experience in the organization of various competitions focused on children from pre-school age up to upper secondary school students. The main event of all yearly arranged projects is a national competition for Czech clubs of Young Debrouillards. Recently the schools from Sweden as well as from Great Britain have joined these competitions, so we are on the beginning of a new type of an international activity for youngsters that represents also an interesting example of active learning.

The authors of this contribution are active members of the steering group of these competitions and authors of the competition's tasks. The experiences obtained during the last two annual competitions – "Koumes 2012" and "Nobel 2013" will be reported and discussed on the basis of didactical aspects of such a form of active learning.

A huge increase of the solvers occurred in the year 2013 as the number of participating teams and children doubled. Almost 1500 children grouped in nearly 150 teams from the Czech Republic and others from Sweden and Great Britain compete at the "Nobel 2013".

The topics of the individual tasks represent various interesting physics problems (self-made electromotor, dynamometer, thermometer, camera obscura etc.). There are four age-categories: kindergarten and pre-school children, primary school pupils, lower secondary school students and upper secondary school students. The tasks for individual categories are based on individual approach to each age group and on adequate working methods. The aspects of such a kind of active learning method will be discussed and concrete examples of tasks and examples of their solutions (by children or students, respectively) will be presented.

Keywords: Science education, physics, competition, simple experiments, active learning, Young Debrouillards, kindergarten, pre-school, primary school, secondary school

Topics: Experiments, Informal Physics Teaching & Learning, Teaching

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213.O8A

Experiments in Science at Preschool/Kindergarten and Primary School

Jitka Houfkova, Dana Mandikova and Zdenek Drozd
Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic

The Department of Physics Education, Faculty of Mathematics and Physics, Charles University in Prague, offers a lot of activities designed to promote physics education to students of different types of schools, to pre-service and in-service teachers as well as to the general public. The contribution gives information about two long-term activities focused on children and youngster pupils and their teachers.

The authors will introduce courses for pre-school and kindergarten children and seminar for future primary school teachers. Young pupils are very inquiring, they want to know how things work and they love to do experiments. Thus it is very important to gain their interest and to motivate them to future studies and preschool/kindergarten and primary school teachers are the first ones in the school attendance who introduce pupils to the natural science.

During our courses for pre-school and kindergarten children are the children actively investigating and discovering various physics phenomena e.g. Air, Water, Heat, Electricity, Magnetism, Optics or Acoustics. The number of participants is one preschool class that means approximately twenty-eight children accompanied by their teacher. Some topics are discussed only during one session some topics are spread through more sessions.

After every session children draw pictures about what they found most interesting and are encouraged to discus it later with their teachers, parents, siblings and friends.

Our seminar for future primary school teachers is designed especially for students of Pedagogical Faculty, Charles University, Prague. In 135 minutes every week during whole term it provides an opportunity for the future teachers to familiarize with experiments from the parts of natural science that are taught at primary school and to try them themselves. The emphasis is put on hands-on activities of the future teachers and on self-production of simple teaching aids, as well as on correct explanations of shown phenomena and on ways how to present them to young pupils, and most common misconceptions are mentioned, too.

Keywords: Experiments, science, physics, preschool/kindergarten, primary school

Topics: Experiments, Informal Physics Teaching & Learning, Teachers

Session 8B, 15:00-16:20

260.O8B

It Is Never Too Late to Introduce Procedural Understanding: A Case of Physics Laboratory Course for Undergraduate Students

Rajesh Khaparde
Homi Bhabha Centre for Science Education, India

Procedural understanding is the 'thinking behind the doing' or the decision-making that goes on in performing scientific experimental activities. It is required for designing experiments, planning measurements/observations and analyzing data. It involves understanding a set of ideas like variable identification, sample size, variable types, relative scale, range and interval, choice of instruments etc. The significance of procedural understanding is subsumed and therefore lost under the rubric of 'experimental skills'. It is a kind of cognitive understanding in its own right and hence fostering procedural understanding should be an important goal of physics laboratory courses at school and college level.

Training of students in experimental science continues to be the Achilles' heel of Indian school system. Unfortunately, a very little emphasis is given to students individual experimental activities and thus there is hardly any scope to introduce and foster procedural understanding at the school level. Even at the university level, the usual practice of 'mechanically' performing a set of experiments, in a 'cookbook' mode, hardly help students appreciate and develop procedural understanding during their physics laboratory courses.

The author developed a novel laboratory course titled 'Summer Course in Experimental Physics' to encourage student's active participation and foster procedural understanding in Physics. In this paper, the author reports a fairly successful attempt of introducing procedural understanding at the second (sophomore) year of a 3 and 5 year university degree course. Further, the paper offers the details of this course organized by the author in India. The course is designed as an enrichment course and is based on "experimental problem solving" approach for undergraduate students. In this approach, students are encouraged to carry out independent experimental work on a set of 'experimental problems' in Physics. The emphasis, during the course, is on students' own thinking and planning, on moving them away from 'cookbook' instructions, from spoon-feeding. Finally, the author will try to make a case and conclude that even though usually procedural understanding is introduced at the high school level, it is never too late to introduce and foster procedural understanding even if it at the undergraduate level.

Keywords: Procedural understanding, experimental skills, training in experimental physics, laboratory course, experimental problem solving

Topics: Experiments, Teaching

284.O8B

"5-Minute Physics": Dynamic, interactive eLearning modules for student lecture preparation

Margaret Wegener, Dominic McGrath, Cavin Talbot and Timothy McIntyre
University of Queensland, Australia

The experience of accessing information for a student today is not so much about a location or an object, such as a classroom or a book, as about a digital service tied to neither time nor place. Our students' preparation for class has been implicitly telling us this for years and recent feedback has become explicit. Contemporary students are using computing devices at home, on campus and in between to engage with information. They make use of small snatches of time to learn. Educational uses of personal electronic devices can aid student preparation for class, by providing improved access and interaction, and generating analytics to inform teachers and students about class preparation. We aim to improve the learning experience of students with material that can be explored on smartphones, computers and tablets, and that incorporates not just static text and images but dynamic and interactive activities.

We have developed and assessed original interactive learning modules designed for viewing on a range of internet-capable devices. The modules are designed to aid students to become familiar with basic concepts being taught in a number of courses, particularly a first-year service course for students in the biomedical and life sciences. We have combined a range of simulations, interactive activities, text, images and video, to create content modules to appeal to our students. Initial evaluations indicate student appreciate this approach and are more likely to engage with these materials than traditional reading preparation.

Modules are built using the HTML5, CSS3 and Javascript programming standards. The advantage of this approach is that modules can be viewed with almost any web browser on any PC or mobile device, regardless of operating system (computer with Mac, Windows and Unix operating systems), tablet (Windows, Android and iOS) or smart phone). Responsive design approaches have been used to tailor materials to large and small-screen devices. Template modules have been developed with a focus on both effective student interaction and easy editing and maintenance. Currently analytics are collected through the free Google Analytics service with no other server side requirements – enabling the modules to be easily moved and embedded in LMS systems. To ensure relevance and maintainability, course teaching staff have developed content such as simulations and videos that are incorporated into the modules. Sample modules are available at
http://www.physics.uq.edu.au/people/mcintyre/fiveminutephysics/.

The effectiveness of these modules is being assessed through usage analytics, student surveys and focus groups. By embedding analytics into the HTML5 documents we are able to track when and how students use these modules. We use in-class "clicker" questions, student surveys and focus groups to evaluate how the modules are used (eg: platform, regularity) and their impact. For comparison, surveys address sections of the course that use textbook-reading and the new on-line materials for class preparation. Initial survey data has shown positive impact on student engagement and a preference for this learning style. Our initial conclusions are that this mode of interaction with information fits with the immediacy desired by today's constantly-connected students. Evaluation data is being used to guide further development.

Keywords: University education, on-line learning, multimedia, interactive

Topics: ICT

308.O8B

Series Circuit: The Real and Virtual

Marmon Pagunsan[1], Roxane Villanueva[2], Christine Joy Aban[3] and Normie Jean Sajor[4]
[1]*Southeast Asian Ministers of Education Organisation Regional Centre for Education in Science and Mathematics, Malaysia*
[2]*City of Mandaluyong Science High School, Philippines*
[3]*Mindanao State University-Iligan Insitute of Technology, Philippines*
[4]*Central Mindanao University, Philippines*

At which learning space do our students learn best, is it working on real laboratory materials or working on virtual laboratory? This presentation will share a series circuit inquiry-based actual and virtual laboratory experiments developed by the authors. The development of this inquiry-based actual and virtual laboratory experiment was anchored on developing and enhancing 21st Century Skills (Learning and Innovation Skills; Information, Media and Technology Skills; Life and Career Skills). Also, learning styles, multiple intelligences, context, adaptability, layout, paging among others were considered s well. The said laboratory experiment activity guide will be presented during the session. It's salient features will be described and highlighted. Teachers insights on its implication to 21st century physics teaching and learning will conclude the session.

Keywords: Secondary education: lower, secondary education: upper, virtual experiment, real experiment, 21st Century teaching and learning

Topics: Experiments, ICT, Learning

Session 8C, 15:00-16:20

010.O8C

Improvement in physics laboratories using the forum and Cooperative Learning

Carlos Alberto Martinez Briones, Alexander Ortega and Gabriel Castro
Espol, Ecuador

The purpose of this study was to investigate: How using an educational forum, blog and cooperative learning improves student achievement in physics labs?

Students arriving to the first half and take the matter Physics Laboratory A, come with several preconceptions about the use and handling of equipment and laboratory instruments, and more, to take experimental data from a practice, not know how to interpret the data, which is why we will work with the use of the forum and cooperative learning to improve the interpretation of the data, with the purpose to know how it affects the use of the forum, blog and cooperative learning in improving the interpretation of the experimental data taken in practice. Subjects were 60 of a laboratory course Physics A, who are pursuing the matter Physics Laboratory A in different engineering programs offered by the university. Selected instructional tasks will last twelve hours. An analysis of the final performance of different groups supported by the ANOVA F-test, with significance level of 0.05. In conducting the analysis it was found two research hypotheses.

It took 4 groups, the experimental group was instructed to review previous reports on the blog, and participate in the forum sidweb platform. From the results it can be seen that cooperative learning is a methodology that offers improvements in student learning, in terms of motivation, a greater understanding and good interpersonal skills for learning, and is also additional support to students outside the classroom to address and answer questions with questions of them.

The use of educational forums and blogs, help ensure that the student is an active part of the learning process as they serve to complement the education of teaching physics is an important tool for active learning of students, as is, cooperative learning. The development of this virtual environment combined experience of reading, observation, critical thinking and understanding. It helps make learning active and meaningful dialogue in language that occur between students, is a good opportunity for reflective participation, creating a wake in the skills and decision-making, problem solving, learning integrated, critical observation and discovery learning. The ease and development, serve to encourage students critical thinking to understand the important issues or physical problems. Given the results obtained according to research and the importance of contributing significantly to student learning, there is a vision of the role of the teacher: is a guide or facilitator? And how relevant is the use of these virtual tools to supplement the training of science and engineering for freshmen.

Keywords: Cooperative learning, educational forum, blogs
Topics: Teaching

013.O8C

Educational Data Mining Applied to Physics Education Research

Alejandro Ballesteros-Román[1], Daniel Sanchez[1] and Ricardo García-Salcedo[1, 2]
[1]*Instituto Politécnico Nacional, Mexico*
[2]*CICATA-Legaria, Mexico*

Present work shows the implementation of an Educational Data Mining platform developed to analize results obtained from posgraduate students in the Physics Education Programme at the Advance Technology and Applied Science Research Center of the National Polytechnic Institute of Mexico. The platform offers a diverse group of algorithms based on artificial intelligence and graphical analysis obtained from the evidence that the user introduces thru a Web page. The goal is to have an integrated tool that can handle diferent data and analyze different patterns of behaviour in Physics Education experiments with students.

Keywords: Lifelong learning, Educational Data Mining, physics education research, artificial intelligence

Topics: Assessment & Evaluation, ICT, Teachers

119.O8C

Context and Representations matters: Insights from transfer research on teaching physics

Dean Zollman and N. Sanjay Rebello
Kansas State University, United States

Transfer of learning is frequently considered as the ability to use knowledge in a context different from the one in which it was learned. For example, for students who have learned physics transfer can mean the ability to apply concepts to novel situations, solve problems that the students have not seen before and develop new ideas that are related to the concepts that the students have learned. Using these ideas we can see how transfer can be considered an important outcome for a physics class. However, transfer to and within physics learning is equally important. For example, much research has shown us that students rely heavily on their experiences which occurred before they studied physics when interpreting or applying the principles while they are studying physics. Thus, they transfer to physics experiences from other formal learning and from everyday life.

Using fundamental work by psychologists as a foundation (Bransford & Schwartz (1999) Review of Research in Education 24, 61-100) we have developed a framework for understanding transfer while students are learning physics. Horizontal transfer involves activating and mapping pre-constructed models to new situations. In using horizontal transfer students make associations between information of a situation and elements of model. Vertical transfer includes constructing a new model to make sense of a situation. Students must use different knowledge elements to create a new or revised model. In learning physics both types of transfer are valuable. Analyzing ones teaching in terms of a transfer framework can help us understand better students' difficulties (and successes) when attempting to learn physics.

Keywords: University education, secondary education, education research, transfer of learning

Topics: Learning, Teaching

253.O8C

Teamwork and communication structures in team-based assessments

Junehee Yoo[1], Eric Mazur[2], Kelly Miller[2], Carolann Koleci[2], Laura Tucker[2] and Brian Lukoff[2]

[1]Departement of Physics Education, Seoul National University, Republic of Korea

[2]Harvard University, United States

In a flipped, introductory physics class, teamwork is a core competency which necessitates assessment. One metric designed to assess team-based learning is the Readiness Assurance Activity (RAA). For the first forty-five minutes of the RAA, students individually complete a series of exam questions and problems. For the remaining forty-five minutes of the RAA, students convene as a team and re-complete, as a team, the SAME series of exam questions and problems. The second portion of the RAA, the team round requires discussion and negotiation amongst all team members. The purpose of this study is to investigate the communication structure of teams during the RAA, in addition to elucidating the quality of teamwork performance. Twenty-eight students' individual and team scores are analyzed longitudinally to ascertain the level of teamwork. Team discussions are also analyzed by social network analysis to determine communication structures existing within the dialogue. Results corresponding to communication structures which are classified into monopolistic and co-ownership, and the teamwork index for individual students are summarized, along with a discussion of the relationship between communication structures and teamwork.

Keywords: Team-based assessment, communication structure, teamwork

Topics: Learning

Session 8D, 15:00-16:20

068.O8D

How to use data from catalogs of astronomical objects in education

Ota Kéhar and Miroslav Randa
University of West Bohemia, Faculty of Education, Czech Republic

This contribution contains attractive examples that use catalogs of astronomical objects available at Astronomia web pages (astronomia.zcu.cz). Hertzsprung-Russell diagram will be created online from stars catalogue HIPPARCOS or SIMBAD. It is possible to change the star distance used for diagram creation. List of numbered minor planets are used to demonstrate the current position of objects in the Solar system, to construct a Kirkwood gap graph or to interactively verify Kepler's laws. On Night sky application should be demonstrated progress chart of Sun below horizon during the night. It can by used to explain twilight, sunrise and sunset. For a particular moment it can be found a list of brightest stars, constellations visible above the horizon or Messier or NGC object visibility.

Keywords: Catalogs, HR diagram, Kepler's law, minor planets, stars, Kirkwood gap, interactive, application, multimedia

Topics: Experiments, ICT, Informal Physics Teaching & Learning, Teaching

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118.O8D

Experiments with Cosmic Ray Muons in out-of-school settings and their impact on interest

Martin Hawner[1], Sascha Schmeling[2] and Thomas Trefzger[3]
[1]*CERN/University of Wuerzburg, Switzerland*
[2]*CERN, Switzerland*
[3]*University of Wuerzburg, Germany*

Since 2010 the German network „Netzwerk Teilchenwelt" (engl.: network particle world) has been built up in order to promote particle and astroparticle physics in Germany. The two main activities, which are mostly done in out-of-school settings, are the particle physics masterclasses (analyzing real data produced by the LHC at CERN) and measurements with cosmic ray muon detectors. This presentation will focus on the experiments with cosmic rays. There are currently two types of detectors with different detection methods. One uses the effect of Cherenkov light, the other one is a scintillation counter. The setup itself is accompanied with supporting materials that make it easy to work with for the students. These detectors are not only used in out-of-school activities, but can also be integrated in school lessons or longer lasting projects. The University of Würzburg is offering one-day out-of-school activities, which are the basis for an evaluation study on the development of science interest (as defined by Krapp, 2002) in out-of-school laboratories.

Recent studies have shown good results concerning the situational interest (see e.g. Pawek, 2005). However, an effect on the sustained personal interest could not be observed. There are hints, that a permanent increase in science interest can be achieved through preparation and/or wrap-up during the normal school lessons. This is supported by Mitchell's theory of „catch-and-hold-components“ (Mitchell, 1993).

In order to compare the effects on interest two laboratory settings will be evaluated in a pre-/post-/follow-up-Design. One treatment will only be the out-of-school activity, whereas in the other treatment, an additional wrap-up will be accomplished during the following school lessons. Due to previous studies (Pawek 2005, Glowinski 2007), a positive effect on the personal interest concerning the setup with the wrap-up is expected.

After giving an introduction on the network and the experiments itself, the evaluation methods and the results of the pilot study will be presented.

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Keywords: Secondary education: upper, modern physics, astroparticle physics, experiments, out-of-school activities, interest in physics, evaluation

Topics: Assessment & Evaluation, Experiments, Informal Physics Teaching & Learning, Learning

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214.O8D

Visuospatial models of the sun-earth-moon system

Shamin Padalkar[1] and Jayashree Ramadas[2]
[1]*Quality Education Support Trust, India*
[2]*Homi Bhabha Centre for Science Education, India*

Astronomy education has in the past adopted ideas from cognitive science. The 'conceptual change' and 'mental model' frameworks from cognitive psychology have supported studies on students' conceptions in astronomy (Lelliott and Rollnick, 2009). The latter studies, on ideas about the earth's shape and the day/night cycle (Vosniadou and Brewer, 1992, 1994), did not distinguish between a mental model (a dynamic representation) and the reasoning (a process) based on it. Yet qualitatively correct mental models combined with faulty reasoning can lead to incorrect explanations: adults holding a correct model of the sun-earth moon system incorrectly explain phases of the moon as shadow of the earth falling on the moon (Subramaniam and Padalkar, 2009). The framework of visuospatial thinking helps understand and address such conceptions and mental models in astronomy.

Mental rotation and perspective taking are two basic spatial abilities (Hegarty and Waller, 2005); they are called to action when spatial mental models are used to reason, i.e. to mentally simulate or 'run' a mental model. To understand the occurrence of seasons we need to mentally rotate and revolve the earth and, at the same time, change our frame of reference from allocentric (outside the model) to egocentric (with one's reference when standing on the earth), and thus describe the path of the sun in the sky. Further, we need to change our orientation on the earth to imagine the path of the sun from different latitudes.

To help Grade 8 students construct mental models and use them to draw sophisticated inferences we have developed a system of spatial tools including concrete models, gestures/ actions and diagrams (Padalkar and Ramadas, 2008). Gestures and actions help internalise the three-dimensionality and dynamic properties of models serving to link concrete models with diagrams, and also phenomena with mental models <http://web.gnowledge.org/pedagogic-gestures/>, (Padalkar and Ramadas, 2010). Padalkar and Ramadas (2011) outlined criteria for diagrams to be an effective pedagogic tool. We describe some results from use of this pedagogy with students.

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Keywords: Secondary education, astronomy education, visuospatial thinking, spatial tools, mental models
Topics: Learning

337.O8D

Identifying critical points in modernising the Astronomy curriculum of Greek Primary Education: a preliminary survey

Aristeidis Kosionidis
Biophysical Environment, Neurosciences and Learning Laboratory, National and Capodistrian University of Athens, Greece

The modernisation of the Astronomy subjects taught as part of the science course at school and college/university level is a development receiving significant research attention. In Greece, Astronomy is taught in late secondary education. We are conducting research on incorporating elements of modern Astrophysics into the late primary education curriculum (ages 10-12). As part of this effort, we conducted a preliminary questionnaire survey to identify areas where special attention will have to be paid when developing teaching materials.

Our sample was composed of 52 first-year postgraduate students at the Primary Education Faculty of the University of Athens for the years 2008-2009, 2009-2010 and 2011-2012. This particular sample was chosen because it allows us to combine two lines of investigation. Firstly, it allows us to test the overall effectiveness of the educational system in its stated aims of conferring fundamental knowledge about the Universe, and in fostering the urge to stay in touch with significant scientific developments after graduating from school. Secondly, because a significant percentage of the postgraduate students are employed within the educational system (as replacement or permanent teachers in primary or early secondary education), their answers provide initial guidelines about where serving primary education teachers will need strong support when asked to teach modern subjects.

The issues we covered in the questionnaire were: recent changes in our understanding of the Universe (4 questions), students' familiarity and understanding of scientific terminology (2 questions), and their everyday extra-curricular interaction with physics subjects, including their self-evaluation (5 questions).

Our results show that students were unaware of significant contemporary developments, such as the discovery of extrasolar planets. They also showed weaknesses in knowledge already present within the school lesson, like the number of planets in the Solar System. Students' answers on terminology exhibited significant variety, indicating personally-constructed definitions rather than a common and uniform understanding of scientific language. In addition, when confronted with unknown terms, they attempted to explain them by falling back on every-day language rather than their knowledge of terminology. Most students assess their physics knowledge as inadequate, which is supported by their answers on physics.

The results of the questionnaire research point to a failure of the educational system to teach fundamental scientific facts about the Universe, and to imbue its graduates with the motivation and tools to keep abreast of the most significant scientific developments. The results suggest that our effort to modernize the teaching of Physics must include activities and materials that actively bring teachers in touch with contemporary scientific developments, and also include efforts to deepen their understanding of the function of terminology and scientific language.

Keywords: Primary education, university education, curriculum reform, modern astrophysics, terminology

Topics: Assessment & Evaluation, Curriculum, Teachers, Teaching

Session 8F – workshop, 15:00-16:20

343.W8F

Experimenting with concept cartoons

Ed van Den Berg
Free University, Netherlands

Concept cartoons can be used to diagnose misconceptions and stimulate discussion of basic concepts and phenomena. However, the teacher can also present a cartoon and then ask students to think of experiments to further investigate the phenomenon shown in the cartoon. Our experience is that students from age 9 -18 very quickly come with creative ideas and start investigations. That is, of course, only the beginning. The teacher will have to follow the work of the students closely and help them to develop their investigation skills and critical thinking. In the workshop you will experience how to start an investigation with the cartoon and then we will focus on how to use formative assessment to improve the work of students.Through the cartoon students are involved in a complete mini-investigation with argumentation rather than only in taking measurements.

Keywords: Concept cartoons, inquiry skills, formative assessment

Topics: Assessment & Evaluation, Teaching

»»Session 9A, 16:40-18:00««

222.O9A

Assessment of the Just-in-Time-Teaching Approach on the Newtonian Mechanics Concept by Using the Model Analysis Technique

Supachoke Puttisanwimon, Suttida Rakkapao and Teparksorn Pengpan
Prince of Songkla University, Thailand

The Just-in-Time-Teaching (JiTT) is one of the interactive instructional methods in physics education research (PER). The web-based questions and the in-class activities based on misconceptions are the key elements of JiTT. It can apply to small or large class with a single instructor, and is easy to combine with other ones. This study aims to evaluate the JiTT method, which is included in the lecture physics classes, by using the model analysis technique. Samples are about 700 science freshmen, who enrolled in the fundamental physics course, from Prince of Songkla University, Thailand. Since, we focus on the topic of the Newton's first and second laws of motions, the well-known research-based multiple choice test, Force and Motion Conceptual Evaluation (FMCE), was administered to these students both before and after the lecture class mixed JiTT instruction. Results have shown that this approach gains student's learning into the middle level of the average normalized gain. Based on the class density matrix as well as the model plot of the model analysis, it obviously revealed the significant difference between pre-and post-class model states of the students. Overall, students' mental model state on the Newtonian mechanics concept has shifted to the scientific model of understanding, positioned in the mixed model region. These findings support that the JiTT is a profitably optional approach for a large physics lecture class with a few instructors.

Keywords: University education, traditional class, misconception, forces and motions, Just-in-Time-Teaching approach, model analysis

Topics: Assessment & Evaluation, Teaching

254.O9A

Effect of collaborative learning in Interactive Lecture Demonstrations (ILD) on student conceptual understanding of motion graphs

Erees Queen Macabebe[1] and Eleanor Alma Jugueta[2]
[1]*Ateneo de Manila University, Philippines*
[2]*Ateneo de Manila University, University of Santo Tomas, Philippines*

Objectives

This study aims (1) to assess effectively the influence of peer discussion in understanding concepts presented in Interactive Lecture Demonstrations (ILD) and (2) to evaluate if the conceptual understanding through ILDs and collaborative learning can be translated to actual situations such as in human and objects in motion.

Method

Ten (10) situations, each with a question involving motion graphs, were presented to 151 university students comprising mostly of science majors but of different year levels. Individual and group predictions were conducted prior to ILD. Each group, composed of 2 or 3 students, was allowed to discuss their individual prediction and was required to come up with a common answer based on their discussion. During the lecture demonstration, the position vs. time and the velocity vs. time graphs of each scenario were plotted real-time using a motion sensor and a LabPro system. The graphs were analysed after each demonstration and an assessment that integrates the ten situations into two scenarios was given to evaluate the conceptual understanding of the students.

Findings, results and discussion

Analysis of the results shows a significant increase in the number of correct answers after peer discussion. For situations involving human motion for instance, from an average of 85.26 % in the individual prediction, the average number of correct answers increased to 98.97 % after peer discussion, an improvement of 16.08 % of the average individual score. From the individual prediction, many found difficulty in visualizing the velocity vs. time graph of (1) an object given an initial push and (2) an accelerating object, both moving along a frictionless track. After the group discussion, the number of correct answers increased by 29.80 % and 9.27 %, respectively. This improvement indicates the positive effect of collaborative learning. To assess whether the ILD reinforced the conceptual understanding of the students, the given situations were integrated into two scenarios and the achievement gain show positive results. In general, the achievement gain for each applicable item was found to be between 7.28 – 13.91 %. Two items involving the velocity vs. time plot of a person, first, moving away, and then, moving toward the motion sensor at a constant velocity obtained 1.99 % and -1.99 % achievement gain, respectively. The achievement gain shows that the students had difficulty relating the concepts to actual scenarios.

Conclusion

In an Interactive Lecture Demonstration, collaborative learning produced a positive effect on the prediction scores of the students. The ILD with real-time measurement allowed the students to validate their prediction. However, when the given situations were incorporated to create a scenario, it posted a challenge to the students. The results of this activity identified the area where additional instruction and emphasis is necessary.

Keywords: University education, collaborative learning, ILD, conceptual understanding

Topics: Assessment & Evaluation, Learning

292.O9A

An Education Competition for Ph.D.s and postdocs working in Molecular Ultrafast Science and Technology

Anna Garry[1], Jean-Pierre Wolf[2], Vesna Markovic[2], Diego Villamaina[2], Alexander Rodenberg[3], Andrii Rogov[2], Svetlana Afonina[2], Denis Kiselev[2], Paul Donaldson[4], Marius Wehrle[5], Miroslav Sulc[5] and Aurelien Patoz[5]

[1]*Department of Physics, ETH Zürich and NCCR MUST, Switzerland*

[2]*University of Geneva, Switzerland*

[3]*University of Zurich, Switzerland*

[4]*Diamond Light Source, United Kingdom*

[5]*EPFL, Switzerland*

The Swiss Research network NCCR Molecular Ultrafast Science and Technology (NCCR MUST) brings together 17 research groups (in physics and chemistry) from 6 universities and a government research institution (PSI). Our collaborative research involves the study of molecular, atomic and electron processes using cutting edge technologies and high-level theoretical approaches. A significant factor in this collaboration is the creation of educational material to explain our fundamental scientific work to a wider audience including schools, young children and the public. We aim to create material that can excite people about our science.

This presentation describes a project that took place in 2012, where we set up an education competition for our Ph.D. students and postdocs to create pedagogical tools in forms of attractive hands-on experiments and computer simulations that could educate and engage a non-scientific audience and even younger age pupils. The aims of the education competition were threefold. The primary aim was to encourage our young university researchers to look at their science from an educational perspective, and to find ways to explain and excite a wider audience in this fundamental science. Second, they had to design and build their pedagogical experiments and demonstrate them to an audience at the Annual Scientific meeting of our Network in January 2013. The third aim was to elaborate on these experiments for creating a group of tools for NCCR MUST's educational outreach that can be developed to establish a collection of portable scientific experiments to be used in schools, exhibition spaces and science centers.

In our presentation we will outline the competition's parameters, which gave the scientists maximum flexibility in the use of technologies and laboratory material. We will then focus on the process the Ph.Ds and postdocs undertook to design and create their pedagogical tools – from initial ideas, to development, to trial and testing, to presentation of their work to a wider audience in January 2013. The entries from teams of scientists included four experimental based experiments and two computer-based learning tools, which ranged from engaging with the science of ultrafast spectroscopies to 3D models of molecular motions. Videos from two entries were also uploaded to YouTube. We outline how the competition was judged, the winners chosen, the important factors identified for engaging young science researchers with the interactive experience of educational outreach.

Keywords: University education, Ph.D.s and postdocs, lifelong learning

Topics: Experiments, Informal Physics Teaching & Learning, Learning

345.O9A

Increasing Physics Teacher Production by Replicating the UTeach Teacher Preparation Model and Awarding Noyce Scholarships

Gregory R. Hale, Ramon E. Lopez, Ann M. L. Cavallo and Erin E. Gonzales
The University of Texas at Arlington, United States

Over the last decade, secondary science and mathematics teacher production at most Texas universities has been quite small and far below the needs of schools. The production of physics teachers has been even worse. At The University of Texas at Arlington for example, the typical annual production of secondary science and mathematics teachers has been in the single digits, and the physics teacher production has averaged less than one per year. Meanwhile, the Texas Legislature passed a law requiring high school students in the state to complete four years of science and mathematics in order to graduate with a standard or advanced diploma. This 4×4 degree requirement became effective for the students entering high school in 2007. With physics being a traditional fourth science course in high school curricula, increasing the production of highly qualified physics teachers is especially important now in the state of Texas.

To address this need, we pursued two grant funding from two sources. We first obtained a National Science Foundation Robert Noyce Teacher Scholarship grant in 2008 that allows us to provide $10,000 scholarships for pre-service secondary physics, chemistry and mathematics teachers. Undergraduate physics majors can be supported in their junior and senior year as they pursue teacher certification. In addition to the scholarship, the grant also provides funds used to hire an experienced teacher that mentors the Noyce scholars when they are new classroom teachers.

With grant funds received from the National Math and Science Initiative in late 2009, the College of Science and the College of Education & Health Professions at The University of Texas at Arlington began a replication of the successful secondary science and mathematics teacher preparation program from The University of Texas at Austin, UTeach. We recruited a record number of students in our first semester, and have been consistently able to recruit well over 100 students each year since then to try teaching in a one credit-hour course with field experiences. We are on track to graduate more than 50 certified secondary mathematics and science teachers in our first graduating class, including 5 physics teachers.

The UTeach Austin website describes the origin of the UTeach program:

"Beginning in 1997, The University of Texas at Austin set out to effect long-term, systematic change in the way science and mathematics majors were being prepared for careers in secondary math or science education. The Dean of the College of Natural Sciences, Mary Ann Rankin, brought together a group of experienced secondary teachers and administrators and charged them to design an innovative teacher preparation program based on national standards, educational research, and their years of experience in the K-12 setting. As part of a substantially revised approach to teacher education called UTeach, the College of Natural Sciences employs several of the best high school science and math teachers in the state to lead the introductory UTeach courses and coordinate a range of on-going field-based experiences. To reinforce the value of such a career choice for students, the College of Natural Sciences offers a rebate for these introductory courses.

At the same time, the Dean of the College of Education, Manuel Justiz, undertook a major commitment to rebuild and strengthen the College's program in mathematics and science education. Under the leadership of Dr. Jere Confrey, mathematics and science education faculty made the decision to completely revise the professional development courses. They developed a three-course sequence that builds on research on student learning, the examination of standards-based curricula, the study of effective classroom interactions, and the development of models of teaching. Issues of technology use and effective approaches to equitable participation are embedded in all aspects of the program, culminating in students' teaching an entire unit in Project Based Instruction. In addition, the mathematics and science education faculty place students in high-need schools, where they learn firsthand of the needs, challenges and opportunities involved in these settings."

Active learning is at the heart of a UTeach program. The recruitment courses offered to first-year university students are introductions to the learning cycle, and specifically the "5E" implementation encouraged in Texas public schools. These recruitment courses are taught by experienced and expert science and math teachers referred to as "Master Teachers". These Master Teachers not only model the learning cycle during theses recruitment courses, the students also deliver three 5E-structured lessons to public school students under the guidance of the university Master Teachers and a mentor in the public school. The culmination of the 3-course sequence that UTeach students take in the College of Education and Health Professions focuses on an intensive active learning technique – project based instruction.

We, representatives of the College of Science and College of Education and Health Professions, propose to present the UTeach Arlington secondary science and mathematics teacher preparation model and explore the qualities that successful UTeach Arlington students possess.

Keywords: Teacher training, teacher preparation, university education, secondary education: upper

Topics: Teachers

Session 9B, 16:40-18:00

033.O9B

Physics during Sightseeing in London and Paris

Dorothy Sebestyen
Obuda University, Hungary

During the past years, one of the greatest challenges in the teaching of physics has undoubtedly been: how to make it more attractive for our students. The history of physics can contribute to deepening the students' understanding of physics, and on the other hand it provides an opportunity for wide-ranging cultural educational lectures.

At our university The Cultural History of Physics is an optional course for the students of electrical engineering, following the compulsory, two-semester Physics course.

According to my personal experiences I can say that during a foreign journey we can discover a lot of interesting sights that can be related to physicists or the laws of physics. Buildings, bridges, churches, sundials, monuments, tombs can be found among these sights just as paintings or sculptures in the museums, or anything else that can be related to physics. According to my experience, a lot of good examples exist from London to Prague, from Copenhagen to Florence.

The above mentioned sights and attractions can be used as illustrations when we lecture on the history of physics as well as when we would like to make our physics classes more interesting.

This presentation intends to show some of the sights mentioned above, this time from London and Paris, for example: the Imperial Standards of Length (Trafalgar Square), the sundials on the St Margaret's church, or the Foucault pendulum in the Pantheon. It aims to arouse the colleagues' interests to apply such ideas in teaching process, whereby we are able to increase the students' interest towards physics. On the other hand I would like to call their attention that using such examples we can inspire our students that during their foreign or national journeys, they should consider these possible attractions when they go sightseeing.

Keywords: University education, history of physics, sundial, art

Topics: Teaching

088.O9B

Checkpoint Leonardo - combining informal science and art education to primary and science teacher education

Anssi Lindell, Marjo Autio-Hiltunen, Anna-Leena Kahkonen and Antti Lokka
University of Jyvaskyla, Finland

Both artists and scientists want to make the invisible world visible. As artists want to express their sensory perceptions filtered by their emotions and aesthetic visions, scientists try to represent their observations and results of experiments in scientific models. In both cases the final images and their interpretation are beyond the premises and results of human intuition and creativity. This apparent similarity suggests benefits in teaching these two fundamental ways of knowing a world together. The similar feature is that a scientific model is not a copy of reality, just as a painting, for example, is not a strict copy of its object. The difference is that a piece of art represents an aesthetic (a subjective) impression, while a scientific model represents an empirical objective construction to predict and explain perceptions.

Checkpoint Leonardo is a project for teaching and learning the art and science ways to gain knowledge of the world in informal museum and school education simultaneously. It consists of a series of art exhibitions and workshops based on the scientific and artistic perspectives of the exhibit artworks . The first four workshops were designed and instructed for the conceptual level of 6th grade pupils by interdisciplinary groups of physics student teachers and primary school student teachers. This project was a part of their pedagogical studies covering courses of pedagogy of arts and science and it was co-instructed by lecturers of pedagogy of science, art and museum pedagogics at the University of Jyväskylä and Jyväskylä Art museum, and the regional artist group Live Herring. Also, a series of lectures in the theme of different ways of perceiving the world was included in the Checkpoint Leonardo project.

The pupils from Jyväskylä region were invited to visit the exhibition during 15. 3. – 28. 4. 2013 and inquire the essence of a piece of art of their choice in a workshop. The works of art and the workshops were based on different ways of perceiving (related to new cubism), infrared imaging, oxidation as a source of color, and acid-base indicators. The basis for all workshops was to use the techniques and represent the results in an aesthetically pleasing manner. As the work continues and accumulates, the representations combine into an artistic project as well as a scientific body of results.

During the project we have acquired and analyzed essays and interviews on students' ideas of aesthetic and empirical ways of knowing world and their development in informal pedagogy. We shall show preliminary results on these.

Keywords: Science and art, informal science teaching, Museum pedagogy, scientific model, science teacher education

Topics: Informal Physics Teaching & Learning, Socio-cultural Issues, Teachers

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307.O9B

Physics in the Museum

Marmon Pagunsan
Southeast Asian Ministers of Education Organisation Regional Centre for Education in Science and Mathematics, Malaysia

Students' learning is not limited to the four corners of classroom. Students' learn science informally in other educational institutions which are not necessarily established for such purpose. This paper will share an innovative physics learning intervention in a museum of history and culture. This is dubbed as an innovative physics learning intervention considering it explored the potentials of informal physics learning in a museum of history and culture. It will present the steps of development of physics learning activity guide in the museum. The said museum physics learning guide is intended for upper secondary students which could serve as diagnostic assessment or summative assessment. Physics teachers' experiences, views and ideas on the use and potential of the learning activity guide will be presented as well. The presentation will conclude on the potentials and implications of informal physics learning in quest for scientifically literate citizenry. Finally this endeavour seeks to bring about meaningful learning not only to students but to general public seeing the application and relevance of physics in ones history, culture and life in general.

Keywords: Secondary education: upper, informal physics learning, lifelong learning, museum, learning activity development

Topics: Informal Physics Teaching & Learning, Socio-cultural Issues, Teachers

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342.O9B

In-Service Teachers' Training Creative Physics Workshops at the National Polytechnic Institute in Mexico

Alexander Kazachkov[1] and Abraham Salinas Castellanos[2]
[1]*Karazin Kharkov National University, Ukraine*
[2]*CECyT 10 CVM National Polytechnic Institute, Mexico*

Some authors believe that the decline of student´s interest in scientific careers is occurring only in developed countries, however, there is strong quantitative evidence that this phenomenon is also occurring in developing countries. As an immediate consequence, the number of students enrolling in scientific careers has declined substantially worldwide.

Many possible reasons have been proposed to explain the fall of popularity of science among students. A common and most probable explanation is the lack of qualified science teachers. Most science teachers have no scientific background. In most cases, teachers who choose to teach science are often those who did not study, or did not like science themselves in school. These teachers are unable to convey the fascination of science to their students.

Therefore, there is a substantial need of in-service teachers´ training workshops for science teachers at the basic education levels. In this work we report our experience on a series of strongly contents-oriented workshops for physics teachers at the National Polytechnic Institute (IPN) led by the authors. We consider that pedagogical workshops are indeed important, but it is more important that teachers learn more science in order to attract students´ interest in scientific subjects.

Our main goal is to implement these workshops among science teachers on a regular basis at the IPN, not only for physics, but also for chemistry, mathematics and biology.

Some of the trainees' suggestions are presented in the report as the involving live demonstrations.

Keywords: Science teachers, popularity of science, contents-oriented workshops

Topics: Teachers

Session 9C, 16:40-18:00

052.O9C

ICT-Based Active Learning Approaches on Mechanics in Blowgun-Darts Systems of Tapioka-Straws and in 2-Body-Collision-Systems of Pendulums

Akizo Kobayashi and Fumiko Okiharu
Faculty of Education, Niigata University, Japan

We are developing various innovative modules of active learning in physics education to overcome students' misconceptions by use of ICT, i.e. video analysis of ultra-high-speed digital movies, or real time analysis by motion detector, force sensors, current and voltage probes, temperature sensors etc.

We present our special effort to promote active learning approaches by using ICT tools having milliseconds resolution, e.g. interactive video analysis of rapid blowgun movements and also those of rapid collisions phenomena, where rapidly movements are difficult before to observe with naked eyes, but now those are clearly analyzed by using high speed movies camera as Casio EX-ZR300 (with 120-1000fps).

It will be shown that we can realize suitable conditions for activity-based learning on "Force and Motion" in almost frictionless world by using blowgun darts through effective usage of Tapioca-Straws, where we can investigate Newton's laws of blowgun systems by changing length and also pressures of Tapioca-Straws-pipe systems. We can also develop active learning approaches on laws of terminal velocity in frictional world by use of suitable blowgun pipes and darts by changing the size and pressures of those. We show various modules for deeper understanding on the mass concept in 2-body-collision systems of pendulums using interactive video analysis of high speed movies of collision.

We also discuss on the effectiveness of these curricula, in elementary school, junior high school and university by using personal response systems (clickers) and interactive video analysis.

ACKNOWLEDGMENT

The authors are supported by Grant-in-Aid for Scientific Research No.23650503

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Keywords: ICT-based active learning, blowgun-darts, tapioka-straws, 2-body collision, interactive video analysis, high speed movies camera, force and motion, clickers

Topics: Assessment & Evaluation, Curriculum, Experiments, ICT, Learning, Teaching

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171.O9C

Investigating connections between thermal energy, electric currents and magnetism in the laboratory setting

Muhammad Sabieh Anwar
Lahore University of Management Sciences (LUMS), Pakistan

We describe three experiments that we have successfully employed in the thermal physics laboratory at the undergraduate university level. These experiments bring home the connection between thermodynamics, heat exchange, magnetism and electrical currents. They involve sophisticated concepts that can be elegantly executed in the thermal physics modules of a laboratory course, tailored to suit the needs of beginning or advanced university students.

In the first experiment, we resistively heat a ferromagnetic wire that snaps away from an assembly of permanent magnets as it reaches its Curie temperature. Students are required to formulate an energy balance equation involving electrical and thermal terms. The equation subsequently enables them to measure the Curie point. The calculation also returns the instantaneous temperature. Finally, the temperature dependent magnetic susceptibility of the ferromagnetic wire is also determined.

The second experiment is an adaptation of an earlier experiment for measuring the latent heat of vaporization of nitrogen as its evaporation is differentially monitored by the switching on of an electric heater.

Third, we investigate the behavior of thermal energy as it diffuses out of a pulsating heat source. With the help of our computer controlled setup, the harmonic content and the differential damping of harmonics can be observed in the thermal domain, thus providing a valuable extension to the standard Fourier analysis of electric circuits.

All of these experiments have been performed by students in four-hour long or day-long experiments in our Department of Physics. Interactive laboratory manuals based on Socratic dialogs have also been written to assist students performing these experiments. The snapping away of a ferromagnetic wire at its Curie point also qualifies as neat classroom demonstration of a phase transition in a magnetic material.

Keywords: University education, heat exchange, temperature dependence of magnetic effects, specific heat capacity, diffusive waves, Fourier analysis, mathematical phenomena

Topics: Experiments

306.O9C

Informal Teaching and Learning of Special Theory of Relativity

Jan Novotný, Jana Jurmanová and Jindřiška Svobodová
Masaryk University, Czech Republic

Einstein's Special Theory of Relativity is important for our understanding of time, space, matter and energy. It represents an example of creative and analytical thought. When the Special Theory of Relativity is taught in schools, it is not possible to carry out real experiments. We have prepared several multimedia activities giving a brief overview of relativity. Short animations are complemented by various questions and tasks and presented to students.

Although some of the consequences of the basic ideas may seem intuitive, there are various pitfalls no only for beginners. The aim of our study was to help an understanding starting points of the theory of relativity.

In the present study we explore the comprehension levels of relativity theory in prospective science teachers who take the introduction to physics lesson at the Faculty of Education. The effect of it for learning on their achievement is researched. In the research, a control group pre-test post-test quasi-experimental research model was used. Research data were obtained by using open-ended questions prepared by the researcher.

Keywords: Physics teaching, meaningful learning, theory of relativity, research model

Topics: Informal Physics Teaching & Learning

325.O9C

Active Learning in higher-level courses: Thermal and Statistical Physics

Jonathan Keartland
University of the Witwatersrand, South Africa

Reports on the employment of Active Learning (AL) strategies at university level have largely focussed on their application in first year Physics courses at universities. This trend is slowly changing, evidenced by the number of recent studies appearing in the literature. AL methods have been used for the last five years in teaching the second and third year Thermal and Statistical Physics modules in the School of Physics at the University of the Witwatersrand in South Africa. AL strategies employed include regular minute papers, detailed responses to material that has been identified as unclear by the students in minute papers, active and co-operative lecture activities, active problem-solving sessions, and active and co-operative revision sessions. The intervention has been monitored using numerous student surveys over the years. The results of these surveys provide strong evidence that the students have embraced the introduction of AL, and that they have been successful in increasing student confidence and active participation in lectures. More importantly, the performance of the students in examinations and tests have shown a marked improvement. This paper will provide details of the AL strategies used, the results of student surveys, and evidence for general improvement in results. The students in the mid-range of ability appear to be affected most positively by the AL methods utilised. It is strongly suggested that experienced Physics instructors responsible for higher-level tertiary courses should consider adopting AL strategies.

Keywords: Active learning, thermal and statistical physics, higher-level courses

Topics: Assessment & Evaluation, Learning, Teaching

Session 9D, 16:40-18:00

065.O9D

Theory-Practice Gap: The relevance of students' conceptions for teaching geometrical optics in practice

Claudia Haagen-Schuetzenhoefer
University of Vienna, AECCP, Austria

Physics educational research of the last decades has put a major emphasis on research on students' conceptions in different fields of physics (Duit, 2009). Constructivist approaches have emphasised the importance of considering students' conceptions as a starting point for the design of teaching/learning interventions in order to trigger conceptual change (Duit & Treagust, 2003; Posner, Strike, Hewson, & Gertzog, 1982). Though that has been known for years it is assumed that these ideas have not yet reached conventional classroom practice. One fundamental key concept which is known to be central for successful learning of many facets of geometrical optics for example is the concept of vision (Guesne, 1985; Langley, Ronen, & Eylon, 1997). When students do not get the opportunity to acquire the idea that we only can perceive objects when light from these objects enters our eyes, they tend to hold a number of well-known misconceptions (Guesne, 1985) which interfere with other key concepts of geometrical optics (visibility of objects, colour vision, image formation, …). In the course of our Geometric Optic project (Author), where research based teaching materials for year-8 students and a test instrument for evaluation are developed, we also analysed schoolbooks and asked teachers (N > 50) for the importance of certain key ideas for learning geometrical optics. This contribution presents the results of the school book analysis and the teacher questionnaires. To sum it up, key ideas like the process of vision do not play a role of high importance in the instruction of the teachers we asked. A similar status can be found in schoolbooks. The results of a concept test on geometrical optics (Author) mirrors this situation as it shows that the majority of students cannot solve test items on the sender-receiver model or the visibility of objects.

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Keywords: Theory-practice gaps, geometrical optics, students' misconceptions

Topics: Learning, Teachers

067.O9D

Students' conceptions on the nature of white light

Claudia Haagen-Schuetzenhoefer
University of Vienna, AECCP, Austria

Although optical phenomena are part of teenagers' everyday lives, it is often very difficult for them to explain such phenomena using correct physics concepts. Physics Education Research of the last decades has investigated a vast number of students' alternative concepts in different fields of physics (Duit, 2009) which influence learning process. In the field of geometrical optics for example, students' conceptions and resulting learning difficulties are well known (Andersson & Kärrqvist, 1983; Driver, Guesne, & Tiberghien, 1985; Jung, 1982; Fetherstonhaugh & Treagust, 1992). Currently we are developing student material for geometrical optic in lower secondary (year-8) based on research on students conceptions in this field. To empirically test the quality of the material developed we investigate the learning processes and outputs with the help of teaching experiments (Komorek & Duit, 2004). There, single students or pairs of students are interviewed in a kind of micro-teaching session based on our material developed (Author). In the course of our teaching experiments on colour phenomena, we encountered an alternative conception we have not found discussed thoroughly in literature. Students' utterances showed that their idea about white light conflicts in many cases with the scientific concept of white light being a collection of all primary colours, so to speak the presence of all the frequencies of visible light. In conventional instruction light sources like the sun, light bulbs and so on are used as sources of white light. Students, however, regard the light of these sources frequently as yellow, even after instruction. Students' problems with the concept of white light seem to cause further learning difficulties with dispersion and colour subtraction and addition. This contribution presents students' conceptions on white light as well as intervention strategies helping to bridge these difficulties.

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Keywords: Colour addition, students' conceptions of white light, teaching colour phenomena

Topics: Learning, Teaching

090.O9D

The "LuNa" Project: experimental modules to teach optics in Primary and Secondary Schools

Maria Bondani[1], Alessia Allevi[2], Luca Nardo[3] and Fabrizio Favale[2]
[1]*Consiglio Nazionale delle Ricerche - Istituto di Fotonica e Nanotecnologie, Italy*
[2]*Università degli Studi dell'Insubria - Dipartimento di Scienza e Alta Tecnologia, Italy*
[3]*Università degli Studi di Milano Bicocca - Dipartimento di Scienze della Salute, Italy*

The "LuNa" (La natura della Luce nella luce della Natura – The nature of Light in the light of Nature) Project is devoted to the experimental teaching of optics in the different school grades.

The Project has been financed by both private and public sponsors in the years 2009 and 2010 that supported the acquisition of the experimental equipment.

The basic idea of the Project is that the history of optics and the debate about the nature of light are a meaningful example of how science proceeds in the development of a physical model. Moreover optical phenomena can be presented at different levels of complexity in order to be accessible to students of different age.

The core of the Project are several portable setups that support experimental and partially interactive lessons that cover all the aspects of optical phenomena, from geometrical optics to single-photon interference passing through atmospheric optics, spectroscopy, holography and theory of perception. When possible, the setups are realized with simple materials easy to find and to reproduce for teachers and students. For more complicated setups research materials are used.

Teachers ask for the modules most suitable to be included in the curricula of their classes and the level of the presentation is tailored on the specific requests.

The Project has involved about 200 classes (more than 4000 students) since 2009.

Website of the Project: http://luna.dfm.uninsubria.it/

Keywords: Optics, experimental demonstrations, portable setups

Topics: Experiments, Learning, Teaching

190.O9D

Effective use of interactive whiteboards – a design based research approach

Bor Gregorcic[1], Eugenia Etkina[2] and Gorazd Planinsic[1]
[1]*University of Ljubljana, Faculty for mathematics and physics, Slovenia*
[2]*Rutgers University, Graduate school of education, United States*

In the talk we will discus how Interactive Whiteboards are used in a high school physics class. IWB use has already been studied from a general perspective but very few studies have addressed the specifics of their use for teaching physics. We investigate effective ways of using IWB in instruction and curriculum design in high school physics. The framework for our study is based on the Design Based Research approach. It is a cyclical process of designing, implementing, evaluating and redesigning of a learning unit. As the cycle is repeated, the result is an improved unit and emergence of principles for IWB use and curriculum material design. We put special emphasis on using the interactive surface of the board, as this is one of the main advantages of the IWB over a standard computer-projector setup. The surface, when used in combination with dynamic interaction software like Algodoo, for example, makes possible a personal, creative, graphical and even kinesthetic input from the students.

Keywords: Interactive whiteboard, IWB, design-based research, Algodoo, effective use, highschool physics, learning unit, kinesthetic input

Topics: ICT, Learning, Teaching

Session 9E – workshop, 16:40-18:00

014.W9E

Interactive Laboratory Experience (ILE) – A Hands-On and Minds-On Approach to Effective Physics Teaching

Mark Greenman
Boston University, United States

The target audience for this workshop is undergraduate college and university physics instructors and secondary school physics teachers. The Interactive Laboratory Experience (ILE) is a derivative of the Interactive Lecture Demonstration (ILD) pedagogy originally developed by Dr. Ronald Thornton of Tufts University, Malden, MA, USA and Dr. David Sokoloff of University of Oregon, Oregon, USA. The ILE/ILD pedagogy can be effectively used as a demonstration technique within large lecture halls, within more intimate student centered laboratory settings (e.g. a high school classroom and/or University "studio" classroom) and/or as a tool for professional development for secondary school physics teachers. The ILE/ILD provides a tool that is shown to markedly improve concept learning of stubbornly held misconceptions.

This 8-step pedagogy intellectually and actively engages students in learning concepts in physics. The Interactive Laboratory Experience moves students through a learning cycle from soliciting student pre-conceptions, to engaging in animated scientific peer debate, to leaning from nature, confronting initial conceptions with experimental observations and making connections to the student's world outside the classroom and laboratory.

Participants will leave with an annotated 8-step ILE/ILD "how to" along with a rubric to self assess how well they are utilizing this pedagogy. In this workshop participants will be fully immersed in experiencing first hand the use of the Interactive Laboratory Experience/Interactive Lecture Demonstration techniques. Participants will also use the ILE/ILD self-assessment rubric to evaluate the fidelity of the presenter to the pedagogy.

In addition to the 8-step "how to" and the self-assessment rubric, participants will leave with three full ILEs and a link to a WEB page containing an additional 30 activities using ILEs to support pre-college and college level courses on mechanics, electricity & magnetism and waves.

Keywords: Secondary education upper (ages 15-19), university education, teaching strategies, professional development, experiments, teaching methods, teacher training, concept learning, studio physics, concept development

Topics: Experiments, Learning, Teachers, Teaching

Friday

9. 8. 2013

»»Session 10A, 8:30-9:50««

076.O10A

Principles of Constructing Network Instruments for Active Learning

Konstantin Rogozin and Irina Rogozina
Altay State Technological University, Russian Federation

In classrooms active technologies of learning are always used in teaching physics

- from the simple "Socratic Dialoging" whereby the teachers ask students to make their thinking clear in the days of Aristotle
- to modern "Technology enabled active learning" (TEAL), which was integrating lectures, problem solving and hands on laboratory activities in one studio (Dori & Belcher,2005).

Advanced networking capabilities allow teachers to organize active learning physics processes for students in places of their actual location 24 hours a day, 7 days a week and 52 weeks a year. In this case, in our opinion, following the principles of their creation should be used:

I. Providing access to the instruments of learning to mobile devices. "Active learning is based on two assumptions: (1) that learning is by nature an active endeavor and (2) that different people learn in different ways" (Meyers & Jones,1993). This means that each student should have his own educational trajectory (a student-centred approach to teaching) in which they will be allowed access to the course content. That content will be specially organized, structured and presented in a way that is easier for the students to understand and focus on what students do in relation

- to their efforts to activate students‘ existing conceptions
- and at the same time
- to encourage them to construct their own knowledge (Hernández, 2010) and skills for decision making.

II. Taking into account the physiological features of the students. Effective teaching tools are determined primarily by how well they use the laws of cognitive psychology. Redish (2003) said that "to understand learning, we must understand memory - how information is stored in the brain".

- First of all, the mental system has a limited capacity. The brain can not actively connect more than seven items at once (Miller, 1956) and important feature is the ability of the brain to forget (Ebbinghaus, 1887).
- The second one is a control mechanism that is required to oversee the encoding, transformation, processing, storage, retrieval and utilization of information (Huitt, 2003).
- The third is a two-way flow of information as we try to make sense of the world around us (eyes and ears) (Miller, 2010) and one output channel (muscles).
- Finally, the human organism has been genetically prepared to process and organize information in specific ways (Huitt, 2003).

III. Using of various techniques of teaching. Physics curriculum can be visualized on the basis of the five types of presentation physics content: 1) Conceptual Technique is implemented in a verbal way in forms of definitions, rules, physical laws, which are generally accepted; 2) Symbolic Technique (apparatus of symbolic links) of formal relations between physics parameters; 3) Technique of Theoretical Problems Solutions is formed on the basis of ownership of the Technique of Concepts, Symbolic Technique of formal relations and elements of other code systems, such as graphs, charts, figures and tables; 4) Technique of Computer Simulation can represent dynamic models of physics phenomena; 5) Technique of Real Physics Experiments. In our opinion (Rogozin et al. 2012), the physics skills for decision making should be formed out in each of the directions separately because according to the laws of cognitive psychology “Skills are formed within the framework of activities that are directed to reach the goal”.

IV. Specially organizing the process of physics teaching. Wells, Hestenes and Swackhamer (1995) proposed a new method of organizing the process of physics teaching. This method can be regarded as a way to teach systematic scientific inquiry. They coined the term “modeling cycle” for the integration of systematic modeling into the learning cycle. The central idea in the modeling approach is that you understand a phenomenon by creating or adapting a model to describe it. This method of teaching physics requires three successive stages: 1) Representation of the system and its variables; 2) Specifying relations among the variables and how they change; 3) Validity of the model is established by comparing it with empirical data on how the system behaves.
On the basis of these principles we have created the network resources for learning physics, which have been successfully used in 3 universities of our country.

Keywords: University education, active learning physics, instruments of learning, construction of network instruments, mobile devices

Topics: ICT, Learning, Teaching

223.O10A

Learn from the history: Lessons from old Japanese physics experimental textbooks published during 1880s

Hiroshi Takahashi[1], Akira Akabane[2], Jun Shozawa[3] and Toyomi Tamaki[4]
[1]*Gunma University, Japan*
[2]*Saitama Medical University, Japan*
[3]*Tokyo Future University, Japan*
[4]*Mathematical Assist Design Laboratory, Japan*

When the modern school system of Japan started in 1872, coinciding with the establishment of the Monbusho (the Ministry of Education), the subject of “Physics” was also introduced in the school curriculum. Many leaders of the Meiji Government in Japan recognized that the introducing of science and technology is indispensable for the modernization. At higher education level, mainly foreign teachers hired by the Japanese government taught physics during 1870-1880s. The early physics lessons at primary or secondary education levels were performed by using Japanese textbooks translated from foreign languages. It is believed that physics experiments were seldom performed in the primary or secondary schools at this time. Some teachers was, however, aware the importance of performing experiments in teaching physics. At 1882, the Monbusho published a small book titled “Rika-Shoshi”. The textbook is the first physics experiment textbook written in Japanese, and was translated from “Easy Experiments in Physical Science” written by Le Roy C. Cooley, published in 1870. The translator and editor were Ten Naomura and Junichi Udagawa, respectively. In the Japanese textbook, there are several additional notes that are not seen in the original textbook. The notes are mainly proposals to replace laboratory instruments by daily materials. At the time, it was extremely difficult to get some laboratory instruments. At 1884, Junichi Udagawa wrote a textbook titled “Kani-Shiken-ho”. In the book, he proposed various physics experiments that can be easily performed by using daily materials, such like drinking glass, coins, etc. Some other Japanese teachers also published physics experiment textbooks during 1880s. They also proposed many simple handmade experiments that can be performed using daily materials in their books. Japanese pioneers had devised several unique handmade physics experiments. We will discuss how we learn from the ingenuity of pioneers of about 130 years ago.

Keywords: Handmade physics experiments, school textbook, history of physics education in Japan

Topics: Experiments, Socio-cultural Issues

318.O10A

Does Self regulation in Hypermedia Trigger Conceptual Change in Nature of Science?

Mehmet Fatih Tasar and Nagihan İmer Çetin
Gazi Üniversitesi, Turkey

Teachers’ sophisticated understanding of the nature of science (NOS) is an essential and crucial factor for achieving progress in students’ scientific literacy. This study sought to investigate how pre-service science teachers’ concepts about NOS develop and change by using self regulation within Hypermedia Learning Environment (HLE). A mixed methods research design was used in this study. Quantitative data regarding participants’ views about NOS were collected by using the "Views on Science-Technology-Society" (VOSTS) instrument before and after the instructional intervention. On the other hand, qualitative data were collected through concept maps regarding participants’ NOS understandings. The findings of the study indicated that at the end of the instructional period pre-service science teachers’ conceptual understandings about NOS shifted from naive to informed. This study provided evidence supporting the importance of using self regulation in hypermedia when learning NOS.

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Keywords: Self regulation, hypermedia, nature of science, science education

Topics: ICT, Learning

322.O10A

Climate change education for physics teachers

Tomáš Miléř, Jan Hollan and Jindřiška Svobodová
Masaryk University, Czech Republic

Climate change science is a multidisciplinary field. Many important functions of the climate system are domain of “climate physics”. We claim, that physics teachers should have good understanding of basic principles of climate physics, e.g. greenhouse effect and causes of sea level rise, in order to transmit the knowledge towards their pupils. Dozens of studies have shown that people (mostly students or pupils) confuse greenhouse effect with ozone hole. To investigate the roots of this confusion we interviewed students at Masaryk University, Faculty of Education, who suppose to become physics teachers. The findings of our study were utilized to design an university course based on laboratory and outdoor experiments and measurements. We provide recommendations for improvement of teaching physics at universities. Our first draft of a textbook, available (in Czech) as klima.pdf at http://amper.ped.muni.cz/gw/activities, is being further developed using the research we've done.

Keywords: University education, physics, climate change, greenhouse effect

Topics: Curriculum, Experiments, Socio-cultural Issues, Teachers, Teaching

Session 10D, 8:30-9:50

123.O10D

The explicative power of the vector potential in superconductivity: a path for high school students

Sara Barbieri[1], Marco Giliberti[2] and Claudio Fazio[1]
[1]*Università degli Studi di Palermo, Italy*
[2]*Università degli Studi di Milano, Italy*

In the classroom practice, teachers dealing with electromagnetism always spend a lot of time trying to familiarize their students with the concept of electrostatic scalar potential and its physical meaning is treated in detail with many examples taken also from the everyday life. On the contrary the notion of magnetic vector potential is never introduced, both because it is not contained in textbooks and because teachers usually associate this concept with complex topics they dealt with in their university courses. In our experience we found that the introduction of the magnetic vector potential can be of great help in treating electromagnetism and modern physics topics at high school.

In this presentation we will show how the use of the vector potential allows a phenomenological and consistent explanation of superconductivity at a level suitable for high school students. We will deal with the two main aspects of the phenomenon: the resistivity of the superconductor that drops to zero at the critical temperaure and the expulsion of the magnetic field from the superconductor (Meissner effect). Using the vector potential, students can have a phenomenological interpretation of the superconductivity, remaining in the frame of electromagnetism and avoiding the use of too complicated mathematical tools that the explanation of the microscopic mechanism would require (i.e. quantum mechanics and Cooper pairs).

Keywords: Secondary education: upper, magnetic vector potential, superconductivity

Topics: Teachers, Teaching

143.O10D

Exploration of students' ideas on superconductivity

Marisa Michelini[1], Alberto Stefanel[1] and Antonio Vanacore[2]
[1]*University of Udine, Italy*
[2]*University of Salerno, Italy*

Superconductivity is an important context in order to be brought in the high school because involving relevant applications under various technological aspects, both in the medical and research [1-3], and it can be interpreted on different levels [4-5]. Therefore it can be integrated in ordinary electromagnetism programs in high schools in order to renew the school curricula expanding areas of physics of the twentieth century and rethinking the ordinary curriculum seen in a new perspective.

Several simples apparatuses were designed for example to show the magnetic levitation in a didactic laboratory [6-9] . Few studies have been done about pupils 'learning in this area and for several years has been developing a project for the teaching and learning of superconductivity in high school that led us to design and test educational courses that integrate the superconductivity in' electromagnetism [10-12]. In the context of the Italian collaboration of the Supercomet family European projects, educational paths were designed, implementing superconductivity in the electromagnetism curriculum of upper secondary school [13-14]. Several research experiments have been conducted [15-16]. In these studies proposing an approach to superconductivity centered on the magnetic properties it was seen that the students using especially the representation of the field lines are able to give account consistently Meissner effect. In parallel they recognize through measurements of resistivity [17] that a superconductor is an ideal conductor resistivity. Moreover it emerged that they need to achieve a dynamic view of the process of electromagnetic induction that in a perspective semiclassical realizes cancellation of the magnetic field inside the superconductor to tie together the peculiar characteristics of the superconducting state ie $B = 0$ and □ = 0 [15]. Reversing the approach, the magnetic properties of superconductors have been proposed as a consequence of those of ideal conductors. Research experiments were done with 43 students (18 years old) of 3 classes in two different schools of Friuli in 10 hours of laboratory activities conducted using Inquiry Based Stimuli Worksheets and a questionnaire used as pre and post tests and have been identified how which students have enabled a dynamic view of the process of magnetic levitation and activated the link between electrical and magnetic properties of superconductors.

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Keywords: Upper secondary education, superconductivity, learning

Topics: Learning

159.O10D

Evaluation of Liquid Crystals Display Course for Secondary School Students

Jerneja Pavlin[1], Marko Rožič[2], Vitomir Babič[3], Nataša Vaupotič[4] and Mojca Čepič[1]
[1]*University of Ljubljana, Faculty of Education, Slovenia*
[2]*Srednja šola Črnomelj, Slovenia*
[3]*Šolski center Celje, Gimnazija Lava, Slovenia*
[4]*University of Maribor, Faculty of Natural Sciences and Mathematics, Slovenia*

School physics should link the innovations and applications as well as present a physical correctly information about the new developments linked to physics. Liquid crystals are used in several devices and a topic of current scientific research. It seems that liquid crystals are a good candidate for satisfying the above mentioned recommendations and therefore motivational topic for student to learn physics.

The teaching module (LCD course) about liquid crystals was designed. The main aim of the module was to explain to students how LCD works. Experiments used within the course are presented at the workshop [1]. The module was tested among 75 secondary school students (age 17.5). Students gained the knowledge about liquid crystals since they achieved on average 68.8 % of the possible points on the test immediately after the lessons. It was found that generally students liked the LCD course. This can be confirmed with the students' reports about LCD course since only 2 students out of 75 did not write positive assessment of it. An interesting negative assessment of the LCD course written by a student was: “I will not be able to watch the screen normally anymore. I will want to see pixels."

In the contribution we briefly present the content of LCD course. Students’ achievements on pre-test and test will be presented and they will be underpinned by data collected by semi-structured interviews with students and teachers. Based on these we will elaborate on weak and strong points of LCD course and will discuss future improvements of the course.

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Keywords: Liquid crystals, experiments, course, evaluation

Topics: Assessment & Evaluation, Experiments

Session 10E, 8:30-9:50

122.O10E

Car's braking distance

Peter Horváth
Comenius University in Bratislava, Faculty of Mathematics, Physics and Informatics, Slovakia

The motivation for our contribution was the finding that the majority of our students (16 -19 years) have a misconception about the car stopping distances. Their idea of stopping distance tends to be significantly undervalued. The performances show pupil activities, measuring braking distances from videos using Tracker. With the activities we can build a realistic idea of stopping distances and, in addition, we can develop the ability of students to work with charts.

Keywords: Videomeasurement, breaking distance, graph, read from the graph

Topics: Curriculum, ICT, Teachers, Teaching

167.O10E

Using Online Interactive Physics - based Video Analysis Exercises to Enhance Learning

Priscilla Laws
Dickinson College, United States

As part of our new digital video age, physics students throughout the world can now use smart phones, video cameras, computers and tablets to produce videos of physical phenomena [1] and analyze them using software such as Logger Pro, Tracker or Coach. For the past several years the LivePhoto Physics Group [2] has been creating short videos of physical phenomena and related curricular materials that can be educationally effective when students generate and/or analyze frame-by-frame data using a digital computer or tablet. [3,4]

In this talk a new LivePhoto Physics project involving the creation and testing of a series of 24 Interactive Video Vignettes (IVVs) [5] will be described. These IVVs are short ungraded web-based assignments that take a student between five and ten minutes to complete. Each vignette is designed to incorporate a video of a phenomenon, the student's predictions about it, and the completion of on-line video analysis that allows the student user to compare findings to his or her initial prediction. The vignettes designed for web delivery as ungraded exercises to supplement textbook reading, or to serve as pre-lecture or pre-laboratory activities that span a number of topics normally introduced in introductory physics courses. Sample Vignettes will be shown, and the outcome of preliminary research on the impact of Vignettes on motivation, learning and attitudes of students using the Vignettes will be discussed.

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[5] Rochester Institute of Technology and Dickinson College (NSF DUE 1122828 & 1123118). A sample IVV can be found at <http://ivv.rit.edu/>.

Keywords: ICT, video analysis, ungraded interactive web assignments

Topics: Assessment & Evaluation, ICT, Learning, Teaching

150.O10E

Problem-Based Learning and Video Analysis as Strategies in Learning Concepts of Force and Motion

Manuel Eusebio
Higher Colleges of Technology – ADMC, United Arab Emirates

Two groups of 20 students each from the Bachelor in Engineering Technology Program of the Abu Dhabi Men's College, Higher Colleges of Technology, who are currently enrolled in Physics I in Spring 2012-2013, will serve as respondents in this study. The groups will alternately be exposed to problem-based learning and video analysis instruction strategies. A pretest and a posttest utilizing selected items from Forced Concept Inventory and researcher- constructed items in force and motion together with a perceptions inventory related to the use of the two strategies will be administered to the respondents. Mean achievement in each topic will be investigated and students' reactions regarding the use of the two strategies, specifically students' attitude, motivation and enjoyment afforded by the two strategies in understanding the lessons will be extracted from the data.

Keywords: Problem-based learning, video analysis, instructional strategies

Topics: Teaching

272.O10E

Students´ Video Production as a Formative Assessment

Eduardo Gama[1] and Marta Barroso[2]
[1]*Colégio Pedro II, Brazil*
[2]*Universidade Federal do Rio de Janeiro, Brazil*

Learning assessment is a subject very discussed and treated by teachers and education researchers, in both theoretical and practical approaches. Obtaining a measurement, qualitative or quantitative, of learning in physics in the high school is a process in which must to be possible to identify not only the contents and concepts that the students failed to achieve, but also the reasons why the learning was not properly achieved. Students' video productions offer teachers the possibility of developing an assessment process which assists in obtaining the previously mentioned measurements. As a diagnostic evaluation, it mainly concerns in producing information that allows to understand the points where the learning process has succeeded or failed, and to know the learning quality of each student. It must allow identifying, individually or in the whole class, the deficiencies and errors related to the concepts and its interpretations. As it works also as a performance assessment allows the verification of other student skills, as the ability to carry a project and to work in a group, beyond others.

In the present work we describe a way in which short video productions by students at the end of a worked and discussed physics topic in a classroom, can be used as an assessment resource that produces information not only about the learning quality of the students, individually or as a class, but also helps to reorient the classroom work as it reveals some aspects of the students´ difficulties that normally don´t appear in formal assessments as tests and questionnaires. The method allows discussion, interaction with contents and supportive learning, and indicates, in the end, alternatives to conduct the classroom work. At the end of this work some correlations are presented, indicating strong relation between the quality of the student production and the quality of his learning, revealing also its active aspect. Another interesting aspect of the work observed is that students don´t choose only easy forms of video producing, but forms that require careful preparation that reflect directly in the quality of their learning.

Keywords: Learning assessment, video production, formative assessment

Topics: Assessment & Evaluation, Learning, Teaching

Session 10F, 8:30-9:50

002.O10F

Students' understanding of angular speed

Graham Rankin
Kwantlen Polytechnic University, Canada

A significant amount of research has been done in the field of physics education in investigating students' conceptualizations of physical concepts as: heat, gravity, electricity, sound, and light. This study extends this field of research in physics education to the domain of angular kinematics.

First and second year university students all of whom had prior instruction in the concept of angular speed were interviewed about this concept as part of the study. The interviews were designed around four tasks which required the student to answer questions from differing observer perspectives about the motion of one or more objects moving in a given path.

Students were found to hold a variety of conceptualizations and ways of reasoning about angular speed that depended upon the context of the questions being asked during the interviews. Some of these conceptualizations and reasoning given in response to questions during the tasks revealed a misunderstanding of the angular speed concept. Furthermore, the study found that some of the misunderstanding could be traced to textbook examples which were designed to illustrate this kinematic concept.

Keywords: Angular speed, kinematics, conception, textbook, reasoning

Topics: Learning

026.O10F

Fluency to Link Newton's 1st and 2nd Laws: High school students' performance in Taiwan

Wheijen Chang
National Changhua University of Education, Taiwan

This study investigated students' fluency in connecting Newton's 1st and 2nd Laws of Motion. The 1st law states that at the conditions of nil resultant force ($F = 0$) and observing at inertial frames of reference, objects keep rest or motion with constant velocity ($a = 0$), i.e., the state of equilibrium. The 2nd law states that the equation of $F = ma$ is valid only when observed at inertial frames. Three research questions were investigated in this study. 1) How well can students adopt inertial frames when reasoning $F = ma$? 2) How well can students adopt the state of equilibrium to reason $F = ma$? 3) How well did the students achieve after a brief intervention teaching was implemented? More than 300 high school students in Taiwan participated in this study. The data were collected via contextualized open-form questions, diagnosis interview, and multiple choice questions. The results

showed that when reasoning *F = ma*, most students tend to observe at “notable” (but non-inertial) reference frames and overlook inertial frames. Besides, many students failed to determine the condition of equilibrium, i.e., *F = 0* and *a = 0*, which in turn hindered the ability to reason *F = ma*. The insufficient fluency in connecting the 1st and the 2nd laws were found to be more significant than the widely addressed misconceptions by the literature regarding "force and motion". Moreover, this study found that the students’ proficiency of adopting inertial frames and the state of equilibrium, improved considerably after the intervention teaching. The findings suggest that explicit and thorough instruction by teachers is crucial to connect the 1st and 2nd Laws, in order to facilitate learning proficiency in Newtonian Mechanics.

Keywords: Inertial frames of reference, state of equilibrium, Newton's first Law, Newton's second Law, fluency of reasoning Newton's Laws

Topics: Learning

091.O10F

Underwater laboratory: Teaching physics with diving practice

Fabrizio Favale[1] and Maria Bondani[2]
[1]Università dell'Insubria, Dipartimento di Scienza e Alta Tecnologia, Italy
[2]Consiglio Nazionale delle Ricerche - Istituto di Fotonica e Nanotecnologie, Italy

The interest in sport-related examples in teaching elementary physics is well known. Very often, a simple physical example taken from sports can be a great help in particle dynamics, fluid mechanics and thermodynamics lectures. This may be the case of diving. Diving education and diving science and technology may be useful instrument in teaching physics both in scientifically and non-scientifically oriented High School course. In our presentation, we describe an activity that puts together some simple theoretical aspects of fluid statics, fluid dynamics and gas behavior under pressure, with the diving experience, where the a swimming pool and the sea are used as a laboratory. A pure experimental approach to these topics was made also in a school laboratory but some experiments, requiring the complete immersion in the water, became more attractive and more meaningful as the students experienced them directly on their bodies in water.

The activity was done with about one hundred students of High School classes in Italy in three different situations and it can be considered an example of an active learning approach to teaching physics.

Keywords: Secondary schools, teaching methods and strategies, hydrostatics, physics of games and sports, diving

Topics: Experiments, Teaching

233.O10F

The Conceptual Difficulties Held by High School Students in Mechanics

Stephan Paraffin Mchunu and Sitwala Namwinji Imenda
University of Zululand, South Africa

The main purpose of this study was to identify and document conceptual difficulties experienced by high school students with regard to mechanics.The literature and classroom experience pointed to some concepts in mechanics which many learners experience serious difficulties with. These included work and energy, motion on the inclined surfaces and force.So, what exactly was it about these concepts that posed conceptual stumbling blocks for the learners? That was what this study set out to investigate.The study made use of a researcher-designed test: the Test in Basic Mechanics (TBM) to collect the required information. The TBM comprised two sections, consisting both structured and open-ended items. The first section was used to obtain biographical information and determine the familiarity of learners with some mechanics concepts (projectile motion, forces, Newton's laws, work and energy). The second section consisted of multiple choice questions – each of which was followed by an open-ended question asking the learner to motivate his/her answer.The questions were based on targeted conceptual difficulties identified from the literature, those identified from the pilot study, as well as conceptual difficulties which had emerged from learners' responses and problematic notions, from the researchers' experiences as physical science educators. Accordingly, there was a deliberate attempt to focus not only on the learners' ability to obtain the correct answer but, more importantly, on their underlying conceptual understanding of the concepts. The TBM was validated by one science education expert and two physics lecturers– all three from the University of Zululand, as well as one physical science subject advisor from the Empangeni Education District. The instrument was also cross-validated by two physical science educators (both Heads of Science Departments) from two schools that were not selected for participation in the study. The linguistic complexity of the text was also investigated to make sure it was not beyond the understanding of the grade 12 learners. In addition, the test, as a whole, was then proof-read by two colleagues before the pilot study was undertaken. This process was done in order to establish content and face validity, as well as to clear out misunderstandings or misleading and ambiguous texts.The feedback received from these experts was used to fine-tune the instrument. The research sample comprised 140 grade 12 learners from four high schools in the Empangeni school district, KwaZulu Natal, South Africa. Non-probability, convenience sampling (Leedy&Ormrod, 2005:206) was used to select participating schools. The selected schools were geographically convenient to reach by the first author who carried out the field research. Thus, no claim is made in this study that the selected schools were representative of the wider, high school population in the province. The data source to be analysed was mainly qualitative in nature, as the main purpose of the study was to get to the learners' reasoning about the physics problems they were given to solve, and not so much on getting the right answer. The results revealed that the learners experienced conceptual difficulties with regard to (a) resolving components of the weight of an object; (b) understanding 'work' in terms of its scientific definition; (c) applying the work-energy theorem; (d) understanding 'kinetic energy' in terms of its scientific definition; and (e) applying the principle of conservation of mechanical energy. These findings are discussed, and recommendations made.

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Keywords: Conceptual difficulties, high school students, physics, mechanics, work, energy, motion, force

Topics: Curriculum

⋙Session 11A, 10:10-11:30⋘

048.O11A

Searching for models and guideline for effective TL: using investigation, and peer-education in "From flint to renewable energies"

Susanna Occhipinti
Regione autonoma Valle d'Aosta, Italy

It is presented the experience of the Expo Laboratory, an engaging and effective method developed and perfected over the last 10 years, that allows to approach students coming from all levels of education of the Aosta Valley, to contents of physics and to involve them in laboratory activities. It is a pathway of about 30 exhibits, which this year deals with the theme "Exploring Energy and its transformations: from flint to renewable energies" as the Italian Ministry of Education requires at the end of compulsory education to certificate the students skill "to analyze qualitatively and quantitatively phenomena related to the transformation of energy from the experience.

The Expo Laboratory presents the different types of energy, mechanical, chemical, thermal, biological and nuclear, renewable energy, using gadgets and everyday objects or models specially built, that students need to distinguish and recognize. Then, it shows the different properties of energy: transformations, conservation and energy savings, through traditional physics experiments, as Wan der Graaf Generator, Wimshurt discs, Newton's cradle or simple demonstrations in which they must recognize the different transformations. In the workshops are proposed problem-situations and cases to solve, even using simple connections of cause and effect, with the aim to promote the investigation. Each activity is presented by secondary school students to visiting classes with peer education approach: then they must know the contents, organize the laboratory and the case to solve using correct scientific language suitable to the target to which they are addressed. The goal is to build a shared knowledge among all students, promote practical workshops, recovering old instruments or proposing new, simple and easy to use, and finally stimulate the passion and the students' interest in physics, target fully achieved, as evidenced by evaluation questionnaires administered to each class at the end of the visit.

Keywords: Investigation, expo laboratory, peer education, case analysis

Topics: Experiments, Learning

089.O11A

Making pre-work popular in physics

Christine Lindstrøm
Oslo and Akershus University College, Norway

Motivating students to complete pre-work prior to class is a familiar challenge in physics, as well as in other subjects. Norwegian institutions offering teacher education are no exceptions. These institutions have also been relatively unfamiliar with teaching methods developed by Physics Education Research (PER). In 2012, flipped classroom, just-in-time teaching and Peer Instruction were introduced in the first of two physics modules of the science course for future science teachers (at grade levels 5-10). The students undertake the equivalent of one whole year of science, where physics constitutes 20 %. The first physics module, comprising eight three-hour sessions, lasted three weeks covering thermodynamics, gravity and buoyancy, sound, light, kinematics, forces, and energy, with a focus on conceptual understanding. Prior to each session, students were required to read the relevant sections of the textbook, watch a few short videos and do an online test, which included three multiple choice questions and a request to inform the lecturer of the two things the student had found the most challenging in the material. The first half of the session used just-in-time teaching and Peer Instruction based on the online feedback. The second half of the session focused on experiments and some problem solving.

The results of the implementation was that voluntary course attendance was very high (94 %, N = 23), as was student satisfaction with the course (4.7 out of 5). In the course evaluation, students were asked how helpful twelve different elements of the course had been for their own learning. The five highest rated (out of 5) were reading the text book prior to class (4.8), Peer Instruction (4.6), watching short videos prior to class (4.4), the just-in-time teaching lectures (4.3) and the online test (4.1). Thus, all three pre-work elements were considered very valuable. Students self-reported doing the pre-work 83 % of the time, whereas completion of the online test was at 71 %. Short answer questions revealed that students were unfamiliar with pre-work from their other courses, but that it, together with Peer Instruction, was an aspect of the course that had worked particularly well. Students' short answer responses pointed to the reasons for the popularity and high compliance with the pre-work: the clear structure of the course, the expectation of pre-work completion, the role of student feedback in forming the lecture, and the importance of being prepared to follow the lecture. Thus, the key to making pre-work popular was to provide a clear course structure explicating what was expected of the students at different times, respect their feedback on what they needed help with, and make them realize that in the lecture, they would not only benefit from having done the pre-work – there were negative consequences of not coming prepared.

Keywords: Flipped classroom, pre-work, just-in-time teaching, teacher training

Topics: Learning, Teachers, Teaching

092.O11A

Transforming Engineering Physics Tutorials with Cooperative Learning and Learning Assistants: A First-Hand Experience

Sheh Lit Chang, Leiju Qiu and Nidhi Sharma
National University of Singapore, Singapore

Our engineering physics course (Physics IE) on mechanics and thermodynamics is the first calculus-based physics course which most engineering students will enroll in. It is offered in both semesters and the contact sessions are lecture, tutorial and laboratory. In this article, we focus on changing the way we conduct the tutorial sessions, from the traditional lecturing style to cooperative learning with undergraduate learning assistants. The objectives of this transformation are to promote active learning among the students and provide a more effective instruction for our students.

In order to improve students' problem solving performance, we adopted Heller's suggestions (Heller et al, 1992) and groups of 3 students are formed, resulting in having 6-8 groups in each tutorial class. We also adopted the learning assistant model from University of Colorado, Boulder in our course (Otero et al, 2010) by recruiting our 2nd year and 3rd year undergraduate physics students as learning assistants (without prior training) in our tutorial class, to assist the teaching assistant to handle the student groups more effectively. One tutorial was conducted in the traditional lecturing style for the sake of comparison between two modes of tutorials.

The purpose of this paper is to share our first-hand experience in implementing cooperative learning and role of learning assistant in our course. Mid semester assessment on effectiveness showed that around 60% of students surveyed felt that cooperative learning style is effective to their learning on a 4-point Likert scale. However, most of them still felt that traditional lecturing style was effective and efficient in the end-of-semester survey. Students' performance in final examination will also be used to assess our instruction.

Our personal experience with this mode of instruction will be shared and further evaluation will then be discussed. Suggestions for such implementation in other institutions will also be put up in this paper.

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Keywords: University education, cooperative learning, learning assistant

Topics: Teaching

128.O11A

Active learning in pre-service science teacher education

Vera Montalbano and Roberto Benedetti
University of Siena, Italy

Physics plays a fundamental role in science education as an accessible context for experimental design, scientific argumentation, problem solving, and the development of multi-step reasoning skills. Especially in the physics lab, students can actively develop scientific processes and habits of mind typical of physics and science in general. However, undergraduate and graduate students in higher education have few opportunities of experiences in topics meaningful for secondary education. Therefore, an unavoidable aim of a pre-service training is to improve and develop teacher skills in this direction. The most effective way seems to propose carefully design sequences of active physics learning in laboratory. Thus, teachers can have directly experience of the powerful support in comprehension of physical concepts and laws that can derive from active learning. In the same time, they can test in laboratory some experiment relevant for their teaching in secondary school.

We report the difficulties and the results obtained in a course on teaching in physics lab for teachers enrolled in Formative Active Training, which actually allows to obtain the teacher qualification in Italy. Two different type of teachers attended to the course, a small group, with physics or mathematics degree, for teacher qualification in secondary school of second grade (age 14-19) and a more numerous group for qualification in secondary school of first grade (age 11-13), usually with a different science degree such as biology, environmental sciences and so on.

Some introductory topics was performed by all teachers such as introduction to physics lab and measurement, evaluation of uncertainties in measurements, measures of some basic physical quantities. Other topics were focused on experimental situation that can be easily achievable and suitable for student of different ages, and in this case the two groups faced different experiments.

We compare this training in physics lab with other experiences we performed in previous years in pre-service education and updating courses for teachers in-service.

Keywords: Lifelong learning, secondary education: lower (ages 11-15), physics laboratory

Topics: Experiments, Teachers

Session 11D, 10:10-11:30

082.O11D

The Inter-University Teaching and Research Resource Center «Modern Physics»

Konstantin Rogozin[1], Denis Yanyshev[2], Sergey Kuznetsov[3], Diana Kondrashova[4] and Ulyana Pshenova[1]
[1]*Altay State Technological University, Russian Federation*
[2]*Moscow State University, Russian Federation*
[3]*Tomsk National Research Polytechnic University, Russian Federation*
[4]*Altay State Technological University, Uzbekistan*

Modern informational, intellectually saturated with interactive learning instruments and educational technology requires a work of the specialized creative professional teams both at the stages of their creation and the operation. This challenge is not possible even in the framework of some the best Universities, which have their own traditions and experience in education. Historically in Russia, there are a limited number of possibilities, where university professors could show created pilot learning tools to their colleagues.

In the universities of Russia we have three different levels of programs recommended for teaching physics: minimal, basic and advanced. It is important to place content and learning tools of various levels on the same information resource for teacher to review (to discuss) and for the students to use in the educational process or real life.

Moscow State University, Altay State Technological University and Tomsk National Research Polytechnic University (ones of the largest teaching and research universities in Russia) had entered into the agreement on the formation of the Inter-University Teaching and Research Resource Center «Modern Physics».

In that agreement it is written that the main activities are:

- Carrying out the research on the development and implementation of modern information interactive technologies with media saturation in the educational process of university and schools;
- Accumulation, standardization and adaptation to MID devices in a single resource center for the best development of teachers;
- Ensuring access of students and schoolchildren to information resources placed in the center, as well as the best world information resources with the support of the Russian-language interface;
- Rendering methodical assistance to teachers;
- Promotion of the achievements of modern Physics.

Universities have accepted the terms and the plan of actions to be implemented by each of the parties. The working operation of the resource will begin in September 2013. This online resource will be open for physics teachers and students.

This project is aimed to develop high-quality distant education in the country (e-learning) and may be it will be adopted as the prototype of a Unified distant educational system of Russia.

Keywords: University education, secondary education: upper (ages about 15-19), Teaching and Research Resource Center, interactive learning instruments, educational technology, specialized creative professional teams

Topics: ICT, Learning, Teachers, Teaching

157.O11D

Impact of Project Based Learning Of Physics in Technical Institutions, Karachi

Syed Ali[1], Syed Naseem Hussain Shah[2] and Aziz Hasnain[3]

[1]*Aligarh Institute Of Technology, Karachi, Pakistan*

[2]*Federal Urdu University of Arts, Sciences & Technology, Karachi, Pakistan*

[3]*Centre For Physics Education, Karachi, Pakistan*

"Tell me and I'll forget
Show me and I may remember
Involve me and I'll understand"

Chinese Proverb

Project-based learning is a comprehensive approach of teaching and learning strategy that engages students in investigation of their authentic problems. Projects have the potential to help the students in learning. In traditional teaching methodology the students can not think about what they are doing rather they are interested on getting it done. In Project-based learning our goal is to involve in activities that develop creativity and critical thinking by engaging them in substantial opportunities. Once students find such opportunities their ability to understand the physical phenomena is also increased. Projects organize the activities of the students, share their knowledge, conduct research, solve different types of problems, and synthesize information.

Usually the students of technical Institutions are matriculates and majority of them are average and below average. It is very difficult for the teachers to make their concepts of physics clear through the traditional lecture method only. Moreover the syllabus designed for the students of Technical Institutions contains 60% practicals and 40% theory. The project-based method adopted in our Institute plays a vital role in removing the misconceptions of the students about physics and developing a solid in-depth understanding of the physics involved in their curriculum. We introduce the way of teaching in which teachers divide the course contents into small tasks, use modelling, making of small projects in the class leading to mega projects. One of such project was the “Distance And Angle Detector”, in which we calculate the distance of an obstacle and its relative position with respect to the magnetic north and getting the display on LCD as well as on Computer. We calculate the distance by transmitting ultrasonic waves and receiving back after reflection from the obstacle. Some other projects were Solar mobile charger (conversion of solar energy into electrical energy), Solar cooker (conversion of solar energy into heat energy), optical voice communication system (Transmission of sound energy on light), Conversion of mechanical energy into electrical energy (using bicycle).

The aims of this approach are

1. To engage the students full time in their studies, infusing higher order thinking skills, guiding students in life choices, and providing them experiences, motivating them, providing core knowledge of the subject, integrating the concepts from a number of disciplines or fields of study, and providing opportunities for solving real problems.

2. The students will be able to understand the fundamental principles and concepts of physics use these to solve problems in practical situations/technological courses and understand concepts to learn advance physics/technical courses by applying this comprehensive approach of learning.

3. To provoke students to encounter the central concepts and principles of a discipline.

In Project-based learning performance is assessed on an individual basis although the projects have done by the students in groups. Variety of assessment tools have been used to evaluate the performance including the exhibitions of their projects. We assessed the students on the basis of multiple choice questionnaire, viva voce, and the final projects judges evaluation from the relevant field. Multiple assessors have been invited from different fields to improve the quality of work as well as to provide them an exposure to the world outside the classroom.

The result of such an approach of teaching in our Institute is that the students are motivated. They improve their test scores as well as their final results, more regular, fewer disciplinary problems, debating ideas, designing plans, drawing conclusions and creating artifacts. Our last few years results shows that our students have better understanding of physics then the other Institute's students due to the implementation of project based learning.

Keywords: Project based learning, syllabus designed, technical institutions, modelling, distance and angle detector, LCD

Topics: Learning

188.O11D

Computer modelling in some Czech Physics Olympiad problems and Easy Java Simulations

Lukas Richterek, Zdeněk Pucholt, František Látal and Jan Říha
Palacký University Olomouc, Czech Republic

The Physics Olympiad is a well known annual physics competition for high school students. Its aim is also to systematically develop the skills of the participants through a more complex problems that sometimes require more self-study endeavour and – namely in the case of the first school run – also simple computational dynamical modelling. The equations derived from dynamic laws often do not have an analytical solution for the monitored physical quantities and their dependency on time

(especially at the high school level), which quite naturally helps to introduce the principles and usage of dynamical models at an appropriate basic level.

Certainly, there is a lot of software products for building mathematical models and animations based on them. In our case Easy Java Simulations package has been chosen as a free available modelling and authoring tool that allows easy creation of interactive graphical simulations in Java for non-expert programmers with a broad international community support. We would like to present a set of simulations based on the Czech Physics Olympiad problems and self-study texts. The models cover various parts of high-school physics (especially mechanics and electromagnetism) and are also used for short training workshops during our annual summer school for high schools students. This topic is also used as a additional modul in our university courses for future teachers.

Keywords: Secondary education: upper (ages about 15 - 19), university education, dynamic modelling, Physics Olympiad, Easy Java Simulations

Topics: ICT

285.O11D

The messy transition from wrong to right: improvements but persistent inconsistencies on conceptually-equivalent questions after Interactive Lecture Demonstrations

Scott Daniel and Alexander Mazzolini
Swinburne University of Technology, Australia

Background

Traditional lecture instruction often only leads to minimal improvement in students' conceptual understanding. Use of active learning strategies, such as Interactive Lecture Demonstrations (ILDs), can help. ILDs have been used since 2010 in teaching about alternating current (AC) resonance in a large-enrolment introductory electronics course.

Learning improvements after such educational interventions are typically measured using the average normalised gain (*g*). This is calculated by comparing total scores on the pre-test and post-test to generate a number between 0 and 1. It will be argued that this aggregate measure is too general, and that better insights can be gained into students' conceptual change through analysis of individuals' responses to sets of questions that ask about a particular concept in different ways (so called 'expert-equivalent' questions).

Research question

How can expert-equivalent questions be used to better describe conceptual change in pre- and post-testing?

Method

Learning gains were assessed by testing the conceptual understanding of students after 8 hours of traditional instruction but before the ILD intervention (via a multiple-choice pre-test), and again after an additional 2 hours of ILD instruction (via an identical post-test). The responses of individual students were matched across the different sessions using anonymous but unique student-generated codes.

Data were collected in 2010, 2011, and 2012. The tests consisted of multiple-choice conceptual questions that did not require quantitative calculations but instead were designed to assess students' qualitative understanding of various complex concepts associated with resonance in AC circuits. The tests given in each year were slightly different however in each case there was a pair of questions that asked about the same concept in two different ways – graphically and in words. The multiple-choice responses to these pairs of expert-equivalent questions were mapped to one another, and students' responses examined for consistency.

Results

The average normalised gain in test scores for students who participated in all active learning ILD activities was statistically significant.

However, the analysis of responses to pairs of expert-equivalent questions revealed a much more complex pattern. Most students answered inconsistently in both the pre- and post-tests, that is, their response to the graphical question did not equate logically to their response to the written question, and vice versa.

Nevertheless there was a general shift towards more students answering at least one, and sometimes both, of the questions correctly, and so aligning their understanding with the expert view.

Conclusions

The comparison of aggregated scores in pre- and post-tests is a coarse assessment instrument that hides some unexpected facets of student learning. In the transition from novice to expert, it seems that learners may understand a complex concept in one context but not in another, even though an expert would consider the two as equivalent. There is not a binary switch from confusion to clarity, but instead an extended intermediate phase of partial or contextualised understanding.

Keywords: University education, Interactive Lecture Demonstrations, electronics, learning

Topics: Learning

Session 11E, 10:10-11:30

006.O11E

Intelligent Tutoring System applied to teach optics in a b-learning scenario to high-school students

Daniel Sanchez-Guzman[1], Cesar Mora[1], Ricardo García-Salcedo[1,2] and Irma Miguel[2]
[1]*Instituto Politécnico Nacional, Mexico*
[2]*CICATA-Legaria, Mexico*

Present work shows the implementation of an Intelligent Tutoring System (ITS) based on the Cognitive Tutor Authoring Tool (CTAT) software; the use of this kind of software have reported a better comprehension of certain topics learning, they have been implemented in a broadly manner with Mathematics and Language Learning; the implementations using Physics topics have been rarely or null. CTAT is a software developed at the Human-Computer Interaction Institute (HCII) at Carnegie Mellon University (CMU) for research learning applications; this software offers an innovative way to build ITS in an easy way for teachers. The teacher only needs to focus on the specific topic to be covered and define where the ITS will be implemented designing a sequence. There are two kinds of ITS. Example-Tracing Tutors and Cognitive Tutors, in this research we used Example–Tracing Tutors. We selected the Snell’s law topic to design the ITS and we applied with High-School students (Secondary education: upper). The didactic sequence is composed of: a) a lecture-based presentation of the concepts, b) an ITS student-training with different examples and behaviors, c) a student work with ITS covering the Snell’s law topic, d) lecture-based review of concepts, e) student evaluation and f) student feedback. To have a quantitative evaluation of the sequence it was applied the Light and Optics Conceptual Evaluation (questions 6 to 10) as a pre- and post-test. Also it was obtained a qualitative evaluation using a personalized test about the experience with the use of the tutor. It was applied to a twenty-student group and compared with a thirty-student group that received only lecture-based with some exercises. Results with the use of an ITS shown a significant gain (Hake) compared with the results of only lecture-based instruction. Despite of the limited number of students, the next step is to repeat the experiment with a bigger number of students to probe the effectiveness of the ITS in Optics learning, specifically Snell’s law.

Keywords: Secondary education: upper, intelligent tutoring system, optic tutor, ICT applied to physics teaching, HCI design for physics education

Topics: ICT, Learning, Teachers, Teaching

028.O11E

An Ultrasonic Black Box

Sorasak Danworaphong[1] and Wandee Thaisiam[2]
[1]*Walailak University, Thailand*
[2]*Kasetsart University, Thailand*

In this work, we propose the use of ultrasonic waves to image an unknown object in a black acrylic box. The box has the dimension of 30×30×30 cm^3. The top surface of the box is dually punctuated in square-grid-like fashion for the insertion of two 1 cm diameter ultrasonic transducers with 2 cm apart centering at each cross point of the grid. One of the transducer acts as an ultrasonic wave emitter and ultrasonic echoes are then received by the other transducer. From the time of flight measurement on an oscilloscope, it is possible to construct the image of the unknown object based on ultrasonic reflection or echoes. The image reveals the unknown object which in this case we use a sizable letter "A" as our object. Such experiment presents the basic concept of echosonography that should be useful for students in various fields.

Keywords: Echosonography, proximity sensors, ultrasonic imaging

Topics: Experiments

149.O11E

Compact Mobile Five-in-One Demonstration Experimental Stand for Teaching Fluid Mechanics

Ervin Racz and Imre Fejes
Obuda University, Hungary

Classes Physics and Modeling Distributed or Transmission Line Networks are two important ground courses for the students studying electrical engineering at master (M.Sc. or MA) qualification level at the Kandó Kálmán Faculty of Engineering at the Óbuda University. Visiting the Physics courses students can study the theoretical bases of the technical physics such as mechanics, electro dynamics, thermodynamics, quantum mechanics and solid state physics. The class Modeling Distributed or Transmission Line Networks gives insight to the modeling possibilities of the different transmission line networks such as water transmission lines, gas transmission lines, canalization, electrical transmission lines, routes and traffic systems, etc. Fluid mechanics is educated in both classes from different viewpoints using very much different aspects of this field. The efficiency of the education can be improved by showing experiments in live on the university classes. Direct experience, direct observation can help to memorize the cucciculum. Using this thesis of the methodology meeting the requirements of both classes mentioned above a compact mobile five-in-one demonstration experimental stand was designed and built at the Power System Department at the Kandó Kálmán Faculty of Electrical Engineering at the Óbuda University. The experimental stand will be introduced in this publication.

Actually, the experimental stand is a closed loop tube system using absolutely unique special glass tubes especially designed for this application and commercial copper tubes generally used for water systems. Connections between glass–glass and glass–copper tubes are solved by transparent silicon pipes. The stand has five different experimental positions measuring or demonstrating five different effects in fluid mechanics. Before and after all experimental positions one-one special glass valves are installed. Opening or even closing the valves the experimental places can be separated from each other. It is possible to use only one experimental place and do not use the other ones. The closed loop tube system is filled with lightly colored distilled water. Using distilled water there is no scales in the system and the quality and the clarity of the system can be saved. The colorized water improves the visibility of the effects. A commercial water pump is used to circulate the water in the system. During the experiments the variability of the flow rate of the used fluid is a critical parameter. In order to modify the flow rate in the main loop a bypass loop with a precisely variable valve was built around the water pump. Opening or closing the valve the circulation flow rate of the liquid can be adjustable continuously. Providing of the monitoring of the flow rate a rotameter especially designed and built for this application is installed in the system. The stand is easily movable because it is fitted with wheels.

Using the experimental stand numerous ground effects for examples laminar or turbulent flows, turbulences, swirl-free flows, some pressure effects in fluids flowing, some dilatation and narrowing effects (confusor, diffusor), meaning of equation of continuity and Bernoulli’s principle, operation of a Pitot-pipe, Prandtl-pipe and Pitot-Prandtl-pipe can be demonstrated. Due to the mobility of the whole system it is easy to move it in or out to a university class and demonstrate some fluid effects in live. Students like the possibility to experience these effects with their own eyes in the classroom.

Authors say thank you for the funding for the Óbuda University and Power System Department. Authors also say special thanks to the Hungarian Csonka Glass Ltd. Csonka Glass Ltd. readily helped us at designing and making ready all special glass parts for the compact mobile five-in-one demonstration experimental stand which useful at teaching fluid mechanics.

Keywords: Fluid mechanics, demonstration experiment, equipment development, education

Topics: Experiments, Teaching

158.O11E

From sellotape and polarizers to conoscopy in the classroom

Maja Pecar and Mojca Cepic
Faculty of Education, University of Ljubljana, Slovenia

The optical properties of anisotropic materials are not easy to understand, because of the lack of students' experiences about birefringence in everyday life. Birefringence at University level is mostly explained by derivation of Maxwell's equation for light passing through anisotropic materials. Consequently, students who study optical properties of anisotropic materials using the conoscopy – the common optical method to measure those properties, can have problems in understanding the physics background of the method because of the lack of practical experiences.

There are many properties that influence the conoscopic figure formation which are dependent on each other, but there are also experiments, that can show the influences of those properties separately. In this case the student can learn about the conoscopic figure formation through a step-by-step experimental sequence, using simple and non expensive materials.

The experiments have been effectively used with undergraduate students within a teaching sequence. The results of the qualitative research on the teaching sequence based on the experimental sequence set-up will be presented.

Keywords: Anisotropic materials, conoscopy, simple experiments, teaching sequence

Topics: Experiments, Teaching

Session 11F, 10:10-11:30

040.O11F

Department-Level Reform: Implementing Active-Learning Techniques in Introductory Physics and Astronomy Courses

Raluca Teodorescu, Gerald Feldman, Larry Medsker and Mark Reeves
The George Washington University, United States

Motivated by studies and various reports released by the U.S. National Academies and the U.S. National Research Council [1-4] in the last 10 years, as well as U.S. employers-related surveys [5] which highlight the importance of training the students with active learning techniques, the Department of Physics at the George Washington University is in the process of implementing student-centered active-learning instructional strategies in all the introductory physics and astronomy courses. These courses are taught by about 15 faculty assisted by 11 graduate teaching assistants, and they accommodate around 600 students per semester. We will present the current framework for our teaching reform which includes a revised Course Scheduling Protocol, a newly created Faculty Manual, a Graduate Teaching Assistants Training Program, and faculty training that covers theoretical and practical aspects of our approach. We will show how this framework was designed to serve our teaching needs and to improve the quality of our teaching.

We are implementing several assessments – student-related, course-related, and faculty-related. The course-related assessments are usually applied after the course is developed, but before it is delivered to the students. Their purpose is to ensure that the course is properly designed. Some student-related assessments are administered as pre- and post-tests, and also throughout the semester. Their purpose is to assess students' conceptual understanding, their problem-solving skills and their attitudes towards learning physics. Faculty-related assessments are administered during the semester and also when the course is finished. Their purpose is to make faculty reflect on their teaching approaches and identify the areas for improvement. We will present these assessments and will discuss our preliminary results.

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[2] Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, (2007), http://www.nap.edu/catalog.php?record_id=11463.

[3] National Research Council, How People Learn: Brain, Mind, Experience and School, (2000), http://www.nap.edu/catalog/9853.html

[4] National Association of Colleges and Employers publishes yearly "Job Outlook" booklets that list the skills that the employers want from their future employees. http://www.naceweb.org/Research/Job_Outlook/Job_Outlook.aspx

[5] Holdren, J. P. and Lander, E., "Engage to Excel: Producing One Million Additional College Graduates with Degrees in STEM", report of the President's Council of Advisors on Science and Technology (PCAST), February 2012.

Keywords: Curiculuum development, faculty training, teaching assistants training

Topics: Assessment & Evaluation, Curriculum, Teaching

278.O11F

Inference generation during problem solving in physics

María E. Pereyra[1], Zulma Gangoso[1] and Isabel Brincones Calvo[2]
[1]*FaMAF, Universidad Nacional de Córdoba, Argentina*
[2]*Departamento de Física, Universidad de Alcalá de Henares, Spain*

Solving a physics problem is a complex cognitive task that involves the comprehension of physical situations and the search of physical models that explain the events considered in the problem statement. These processes of comprehension and search require the construction of mental representations of different levels of abstraction, as described in the Model of Comprehension in Physics Problem Solving proposed by Truyol et. al [1]. In this framework it is plausible to assume that the generation of inferences plays an important part in the process of elaborating a model of the problem, due to the need to combine information given in the problem statement with previous knowledge of the solver (this includes general knowledge of the world, knowledge about physics and knowledge acquired through problem solving) to go from a natural language (in which the statement is written) to a more formal, abstract and specific language (in wich the mathematical equations that express the physics laws and principles are expressed). Identifying and justifying those inferences contributes to a deeper understanding of the process of solving a physics problem and adds to the refinement of the Comprehension Model. In turn, the development of a model of the problem solving process allows the design of teaching strategies and learning environments that help improve the performance of students in this task.

In this sense, we present an exploratory case study that aims to indentify the types of inferences generated by different solvers when solving physics problems, as well as the moment in the solving process that the inference was generated. The sample of subjects considered in this study includes university professors, graduate students and high school teachers. The problems presented to the subjects are the sort of problems given to undergraduate students in physics courses at the university. We analyze the transcription of the audio of individual interviews during which each subject solved a physics problem, orally and written. The instrument used in the analysis [2] is based on two different views on inference generation, logic and text comprehension, and includes two different sets of categories of inference corresponding to each view. This instrument also includes a definition of inference that allows the construction of a set of operations that lead to the identification and categorization of inferences.

The results show that the method of analysis is useful to study inference generation in physics problem solving. It was observed that all types of inferences considered were generated and no clear patterns appeared. The results also show that teaching experience greatly influences the efficient use of inference generation. For subjects without teaching experience it was necessary to construct a greater number of inferences, and this did not guarantee the success in finding of a solution to the problem. As for the moment in the resolution process in which the inferences occurred, the subjects generated most inferences to build or improve the physical conceptual model and in the case of those who found difficulties in the resolution, they generated more inferences to build a physical model consistent with their understanding of the situation.

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Keywords: University education, problem solving, inference generation, comprehension, problem representation

Topics: Learning, Teaching

283.O11F

The Preparation of Physics Teachers and the Next Generation Science Standards

Ramon Lopez[1], Greg Hale[2] and Ann Cavallo[3]
[1]Department of Physics, Univ. of TX at Arlington, United States
[2]College of Science, Univ. of TX at Arlington, United States
[3]Department of Curriculum and Instruction, Univ. of TX at Arlington, United States

In the United States, individual states establish their own state science standards that guide school instruction. In March of 2013, the Next Generation Science Standards (NGSS) were released after more than two years of development with the participation of several states. In all, twenty-six states have indicated that they will adopt these standards as their state standards. Such a wide-scale adoption of a common set of science education objectives will be a major milestone in US science education. It will also have an enormous impact on US physics education, models for teacher preparation that are being replicated around the country, such as UTeach and PhysTEC, and sources that fund STEM teacher preparation and research, such as the National Science Foundation Noyce Program. In this presentation we will discuss the structure of the NGSS and examine a variety of issues that have significant implications for the preparation of future physics teachers. Among the issues are the inclusion of scientific and engineering practices, crosscutting concepts, engineering as a discipline within the NGSS, and the possible inclusion of significant amounts of Earth and Space Science content in physics courses. The inclusion of these elements in the preparation of physics teachers may provide valuable lessons to participants from other countries contemplating a more holistic view of science education.

Keywords: Physics teacher preparation, science standards, curriculum

Topics: Curriculum, Teachers, Teaching

321.O11F

Active Learning and Problem Solving

Douglas Clerk and Deena Naidoo
University of the Witwatersrand, Johannesburg, South Africa

Instructors will generally agree that what really matters is what you make your students do – as opposed to what you (the instructor) might do - this is the basis of active learning. However, perhaps we need to look more carefully at precisely what we make the students do – they can be expected to learn what they practice doing, but is that necessarily what we want them to learn? In 2012 some changes were made to the way tutorial sessions were conducted in the physics course for first year engineering students at our university. The 'traditional' tutorial had for some decades been conducted as a 45 minute session starting with 30 minutes of free student-tutor interaction, where students were expected to work on their "prepared" tutorial exercises and request assistance from tutors when in difficulty. The balance of the session was devoted to either a "spot test" or a "discussion question" which contributed to their continuous assessment mark. The majority of students have been frequently observed simply to waste their time during the first 30 minutes of a session, and then to apply their minds diligently in the last 15. The pass rate for the mid-year examination in 2012 was extremely poor, which resulted in a simple intervention - which was to increase the time to 30 minutes, spent on compulsory, mark-bearing tasks performed by the students during a tutorial session. This change was implemented for the second semester. At the end of the year the examination pass rate improved dramatically, which could be attributed at least partially to this intervention. This intervention shows that "active learning" need not be complex or inconvenient – the intervention consisted in a simple quantitative change: only the duration and quantity - not the type - of learning activity was changed. The improvement in the pass rate would seem to indicate that the intervention was successful and that active learning even at this simple level does work. The students were certainly better at answering their examination questions, but what exactly did their examination questions ask them to do? The examination questions – both at mid-year and in November – were examined according to a typology which we have been developing in which there are four basic types of physics questions, based on what the student would have to be doing when answering the question. The question types we have identified are: "bookwork", "Intuitive/Interpretive", "Routine Operation" and "Novel Problem". The analysis revealed that the bulk of the questions were "Routine Operations", requiring students to use known algorithms. The students' ability to perform this type of assessment task had undoubtedly improved, but we can unfortunately say little or nothing of the effects of the intervention on any other type of question. The reason for this is that these other question types were somewhat rare in these examinations. The implications of this are the subject of an on-going study.

Keywords: Active learning, problem solving, question type

Topics: Assessment & Evaluation, Learning, Teaching

Posters

Poster session 1, Tuesday 11:00-12:00

008.P1

A fresh hands-on approach to improve students' understanding of introductory thermodynamics

Tom Lambert
PONTOn vzw, Belgium

The test and exam results from 4th year secondary school students (generally 15 years old) proved year after year a poor understanding of introductory thermodynamics topics that were taught. The results were remarkably lower than other physics topics that were covered in the same years. This poster presents a fresh hands-on approach to improve students' understanding, using an small scale research project and a visit to the local DIY (do-it-yourself) store, combined with an alternative evaluation and assessment method. This resulted in better results. A comparison and a SWOT (strength, weakness, opportunities and threats) analysis of the project will be presented.

Keywords: Secondary education: upper (ages about 15-19), introductory thermodynamics, activated learning and teaching

Topics: Assessment & Evaluation, Experiments, Informal Physics Teaching & Learning, Learning, Teaching

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011.P1

Electrical circuits in high school students using comic-based on Active Learning in Mexico

Ricardo García[1], Tame Gonzalez[2]-Cruz and Daniel Sánchez[3]
[1]*CICATA-Legaria and Instituto Politécnico Nacional, Mexico*
[2]*Universidad de Guanajuato, Mexico*
[3]*CICATA-Legaria, Mexico*

Present work shows a didactic strategy based on Active Learning, it has been structured to promote a better learning in high school students with the use of a comic book that shows various concepts of electricity. In the experiment we use the first part of the book that was used to show the concepts of electric resistance, electric current and electric potential difference. The book was complemented with other activities like low-cost experiments, discussions in the classroom and lectures, oriented to clarify the concepts previously mentioned and define some related themes like the Ohm's law. This didactic sequence was applied to an experimental group of students that course the second semester at high school level and the results were compared with a control group of students with similar characteristics and the methodology applied to the control group was the use of lectures. The evaluation of this proposal was using some questions from the Electric Circuits Concept Evaluation

(ECCE) designed by Sokoloff and results where analyzed with Hake's normalized gain. We found that the methodology was better effective than only the use of lectures, these results cannot be generalized and we will continue to apply the same experiment with more students to validate these results.

Keywords: Comics, Active learning, High school level

Topics: Learning, Teaching

012.P1

Teaching physics and information flow in didactic structure of physics knowledge

Eizo Ohno
Faculty of Education, Hokkaido University, Japan

Physics knowledge and its structure have to be transformed to didactic ones for fitting to acts of teaching. In this presentation, a methodology to represent a didactic structure of physics knowledge is proposed. Relationships between acts of teaching and the didactic structure of physics knowledge represented by this method are investigated. In the previous researches, characteristic features of physics knowledge are represented as concept networks (e.g., Koponen et al., 2010). In this research, the didactic structure of physics knowledge is diagramed using the logic of distributed system. The connected distributed system consists of separated parts. These parts are related to activities and demonstrations in physics lessons. Sets of physics knowledge are used to classify the events and objects which students experience in physics lessons. The notions of classification are introduced and information flow between classifications is expressed based on the concept of channels by Barwise-Seligman's Channel Theory (Barwise and Seligman, 1997). The classification is a basic structure in Channel Theory. An activity (an experiment) in physics lessons is represented by the classification. A key activity (experiment) is considered as the core of channels. The core drives indirectly information flow between two separate classifications. The didactic structure of physics knowledge obtained in this research reflects transforming from scholarly knowledge of physics to the physics knowledge to be taught.

References:

Barwise, J. and Seligman, J. (1997), Information flow: the logic of distributed systems, Cambridge, New York: Cambridge University Press.

Koponen, I. T. and Pehkonen, M. (2010), Coherent Knowledge Structures of Physics Represented as Concept Networks in Teacher Education, Science & Education, 19(3), 259-282.

Keywords: Upper secondary education, diagram, concept network, structure of knowledge, classroom discourse, didactic transposition

Topics: Curriculum, Learning, Teaching

019.P1

Traditional Culture Permeation in Thermo-physics Teaching

Xi Xia Liang
Inner Mongolia University, China

Physics is the distillation of human civilization shaped through tens of centuries. It is extensive and profound, and possesses abundant cultural and philosophical connotations. Permeating the elements of traditional cultures into Physics classrooms of general education is instrumental to understand the basic concepts and ideas of Physics for students especially art students.

The China civilization is rich and as a long history behind it, and contributed tremendously to the progress of human civilization. In this report we present our experiences in introducing the elements of Chinese traditional culture in the thermo-physics teaching through an example, the video open course of China entitled “Excellent Reason in Heat” [1]. In this course we have permeated the traditional culture into the physics classrooms by the following ways:

(i)Introducing the Chinese ancient experiences and stories on heat [2] to help students understand the relevant thermo-physics laws and concepts, and to imply the physics teaching in history.

(ii)Quoting essays and poems of the ancients and personalities in masterpieces to describe physical phenomena as well as give some philosophical ideas and to help students breezily learn Physics with literary appreciation.

(iii)Inditing classical poems explaining the physics contents in classrooms to waken students learning interest and help them easily remember Physics laws.

In summary our teaching practices indicate that introducing the traditional culture into the thermo-physics courses may promote the blend between the art and science, resolve the abstracts and puzzles of physics concepts at a certain extent. Moreover, it develops and expands the nationality tradition, and helps to inspire youths’ innovating spirits and to enhance the general quality of students.

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[2] There are many descriptions related to the thermo-physics in ancient books, for example, Yingxing Sung, Tian Gong Kai Wu, 1637, Ming Dynasty.

Keywords: University education, thermophysics, traditional culture,classrooms

Topics: Teaching

021.P1

Development of the Interest toward the Study of the Optics in Children of the Basic Level

Juan Carlos Ruiz Mendoza[1] and Cesar Mora Ley[2]
[1]*Universidad Autónoma de Nuevo León, Mexico*
[2]*Instituto Politécnico Nacional, Mexico*

This study is preceded by the results of a survey to 200 teachers from 100 schools in the state of Nuevo Leon, México. We have found that even though Optics as a subject matter is part of the course syllabus, 90 % of the professors are unaware of the topic, and consequently it is not thought. We proposed to investigate the expertise of professors in this area and parallel this report is developed, which is oriented to increase interest in optics. Our first approach has been Geometrical Optics experiments. We developed a software that allows to know how the laws of reflection and light propagation through a lens permit the establishment of optical images. We constructed optical instruments (Telescopes, Microscopes, and Periscopes) with inexpensive materials that can be armed and disarmed by children between 10 and 12 years old. The software intends to foster a learning environment where children can explore, observe, test ideas, remake the activities several times, ask and discover, on the premise that the best way to learn science is through a hands on activity. Two events were celebrated in 2012 as part of the "Science Week", at the Faculty of Physics and Mathematics, Autonomous University of Nuevo Leon, México. During the events, 1600 6th grade children participated from the schools where the surveys were initially conducted. We observed positive results regarding the interest of the children in the study of optics, such as: some children say when they grow up would build a big telescope to see the stars, this as a consequence that they had fun with telescopes they armed looking at other children's faces and relatively distant objects because they were unaware of the true operation of the telescope. Like this there are many other positive comments regarding the activities of the children, according to the positive results of this research and the children's interest in learning more about the Science of Optics, we will increases the number of events for 2013.

Keywords: Teaching, geometrical optics, natural sciences

Topics: Teaching

031.P1

Toulmin's model as learning tools of the electric field for engineering students

Gema Alejandra Carreto-Arámburo[1,2], Cesar Mora[2] and Mario López-Lopéz[1]
[1]*Benemérita Universidad Autónoma de Puebla, Mexico*
[2]*Instituto Politécnico Nacional, Mexico*

We present the results of research conducted on understanding about the concept of electric field, electric field lines, the direction and intensity of electric field and the relationship between it and the

electric charge, with students of Chemical Engineering. We shown a teaching proposal based on the application of Toulmin's argumentative model in order to improve understanding of these concepts in students. We pretend to achieve the goal of proper understanding, through the construction of argumentative schemes under specific categories of analysis. Also, we discuss the advantages of applying this reasoning in an experimental student group, who were observed with a greater understanding of the concepts, and a slight increase in the average responses of the post-test compared with the results of control group.

Keywords: Toulmin argumentative model, specific analysis categories, electric field

Topics: Teaching

035.P1

Computational modeling with AVM diagram and its contribution for a meaningful learning of physics concepts and development of a critical view of science

Sonia López[1], Eliane Veit[2] and Ives Araujo[2]
[1]*Universidad de Antioquia, Colombia*
[2]*Universidade Federal Rio Grande do Sul, Brazil*

A comprehensive training of science teachers involves not only proficiency in their disciplinary field, but also a critical conception of science and its teaching. Although in recent decades there has been a greater emphasis on inclusion of epistemological contents in training courses for science teachers, very often their image of science is far from current philosophical conceptions of the nature of science. Reflections on this issue led us to design and implement a teaching proposal, based on the principles of Moreira's Critical Meaningful Learning Theory (CMLT) and key elements of scientific modeling, especially through the use of computational models and the AVM diagram (Adaptation of Gowin's V to Computational Modeling). The main goal was to promote a critical meaningful learning of physics concepts with a better understanding about the production of scientific knowledge. During the application of this proposal, we attempted to answer the following research question: How does the implementation of the principles of CMLT in the classroom - through computational modeling activities with AVM diagram - contribute to the disciplinary, epistemological and didactical training for pre-service physics teachers? A collective case study was designed to answer this question. The case was constituted by seven physics major students attending a course titled "Didactics for physicists" at the University of Antioquia, Colombia. We investigated the progress of these students regarding the nine principles of CMLT during the development of computational activities with the AVM diagram. The most important result was the improvement in the student's ability to formulate good questions in physics class. In general, we found that the integration of scientific modeling elements and principles of CMLT was succeed in improve the student's conceptual domain about Newtonian dynamics. The use of scientific models - as partial and not exclusive representations of the reality - allied to discussions about the scientific modeling process, favored the construction of

epistemological views compatible with the currently accepted by the scientific community. In addition, the construction of computational models and the design of learning materials allowed the pre-service teachers to reflect about the challenges to promote a meaningful learning of physics through innovative methods still underrepresented in schools today. These findings lead us to believe that the use of this didactical proposal in pre-service and in-service training courses for physics teachers, could be appropriate to foster a comprehensive training, which necessarily involves addressing disciplinary contents, as well as epistemological and didactical issues.

Keywords: Computational modeling, AVM diagram, meaningful learning of physics concepts

Topics: Teaching

036.P1

The use of smartphones in class to improve physics learning

David Méndez Coca
Centro Universitario Villanueva, Spain

Physics professors have difficulties to assess the learning of the class every day. But now, with internet and the smartphone it is possible to do it. Most of the students have a smartphone with internet. These technologies promote a motivation for the students. The familiarity of the students with the electronic devices can be a great help in the field of education because they do not need any previous training to use them. The students answer with the smartphone some questions and the professor can assess the results immediately. By this way, the professor knows the learning of each student and can promote the cooperative learning joining students who have different answers. This experience took place with preservice elementary teachers. The contents were about mechanics and the learning was measured by a pretest and a posttest. The gain of learning was good and this experience increased the motivation.

Keywords: Smartphones, cooperative learning, preservice elementary teachers

Topics: ICT

041.P1

Promotion of activity based learning in physics for the Students & Teachers of Remote Areas of Pakistan

Syed Naseem Hussain Shah[1], Syed Ali[2] and Aquila Islam[3]
[1]*Federal Urdu University of Arts, Sciences & Technology, Karachi, Pakistan*
[2]*Aligarh Institute of Information & Technology, Karachi, Pakistan*
[3]*Karakoram International University, Pakistan*

For the promotion of activity based teaching and learning in science, we at the Centre for physics Education initiated a program in 2009 to arrange a science excel camp in rural areas and involve local students in science activities that are relevant to their environment. First of its activity was organized in October 2009 in Quetta in collaboration with USAID funded organization "Edlink". In this presentation, we are going to describe the activities held in Quetta, Pakistan. The Baluchistan is the largest province of Pakistan and Quetta is its capital. Baluchistan has the least number of educational institutions, the lowest literacy rate among both males and females, the lowest ranking in the Gender Parity Index (GPI) and the smallest presence of private educational institutes in the country, according to the recently issued National Economic Survey (NES). In this camp the groups of teachers and students of secondary schools from the remote areas were involved for active learning in School Physics. A teacher's approach towards teaching is traditional in Pakistan and is a means to transfer book knowledge only. Mostly all the teachers follow the talk and chalk way of delivering their lectures in which students of school level are not attracted and get bored. The student's posses some wrong ideas impinged in their minds due to poor teaching / learning methods in schools. Parallel to the old method of teaching, here we intimate them that Hands-on activities and other interactive approaches, when integrated in teaching, lead to an increase in student's understanding of the subject. Our tool of investigation was the questions based on force, work, energy, electricity, communication, and light and optics conceptual evaluation.

The aims of this educational camp are:

1. To train teachers how to include activies in their lessons plan.

2. To introduce actives relevant to their surrounding.

3. To realize them that even with little efforts they can perform many experiments of physics.

4. To involve the students in activities that help them understand physics concepts and their surroundings

5. To remove their misconceptions about many phenomenon of physics.

To better understand physics, it is broken up into smaller fields like mechanics, heat, light etc. Keeping in view this fact we provide the students different houses and each house represent the activities from one of those fields. The performance of the students were carefully examined and recorded by giving them different tasks in these houses. The beauty of these houses was that they all were carrying low cost physics experiments, instruments, physics apparatus and equipments. The students showed their keen interest during this camp that based on different experiments. These experiments were on force, work, energy, electricity, communication, light and optics. Moreover, pre and post designed questionnaire of conceptual physics was given to the students and results were analysed.

The detailed analysis from the answers of pre and post designed questionnaire reveals that the students lack in applying simple concepts to real situation. It is observed that after completing the science camp's activities their concepts were improved and their interest of studying physics was increased.

Keywords: Understanding school physics, science camp experiments, interactive approaches, hands on activities

Topics: Learning, Teaching

057.P1

Mobile Lab Classes

Guillaume Schiltz and Andreas Vaterlaus
Swiss Federal Institute of Technology, Switzerland

In 2009 the Physics Education Group at ETH Zurich started a project on mobile lab classes, which consists of a half-day course on scanning tunnelling microscopy (STM). Scanning tunnelling microscopy has been developed in 1982 by Binnig and Rohrer as an imaging technique. It is a real space, high-resolution imaging method exploiting quantum-mechanical electron tunnelling between a sharp tip and the sample whose surface is imaged. The tip is raster scanned over the surface and a topographic image is obtained. STMs are rather expensive devices that schools usually cannot afford.

Our STM-lab class can be booked at no charge by middle schools (upper secondary education). By appointment a faculty member from our group, equipped with 6 mobile STMs (Nanosurf easyScan 2), visits the school. After a short presentation on electron tunnelling effects, piezo motion and atomic structure, students are guided to operate the microscopes by themselves with different samples.

The main goals of these lab classes are:

- to introduce students to modern physics topics that usually are not part of the standard curriculum;
- to allow students to perform hands-on experiments with high quality equipment;
- to engage students in physics and raise their interest in science;
- to support physics teacher.

In this presentation we report on the feedback from teachers and students that we have received so far. We discuss the benefits and the drawbacks of mobile school labs and share our experiences on mobile lab classes.

Keywords: Mobile labs, scanning tunnelling microscopy, hands-on experiments

Topics: Experiments, Teaching

058.P1

"Is noise just as bad as they say? Try to reduce it": project-based learning in physics

Erica Macho-Stadler and Jesus Elejalde-Garcia
Universidad del Pais Vasco, Spain

Noise is an environmental problem that produces an increase in the number of complaints from European citizens. Noise reduction requires the development of regulation by Governments, the research and development of new control methods, as well as information and education campaigns. Citizens should be aware of the serious effects of noise pollution on health. If we want young people to contribute actively in the reduction of noise, they have to know how it affects their health or their environment. In this sense, the inclusion of content over noise at any educational level could be an effective action to change their attitude on this issue.

This paper proposes a project for high school students or college undergraduates. The study focuses on the noise level of some of the daily activities of young people and their possible consequences. The project is based on the experimental study of real life, and its main objective is to involve students in noise reduction. During the project, students have to work with the contents of the "Physics of sound" (the nature and characteristics of sound waves, propagation of sound in open and closed spaces) and also with other disciplines (health, the human ear). The project includes the following activities: sound level measurement using a Sound Level Meter, survey of hearing health, hearing test and survey of noise annoyance. All these activities can be developed in different contexts: at home, at school or during leisure activities. At the end of the experience, students prepare a final report including the description of the identified problems and recommendations to reduce noise and to avoid acoustic injury. Finally they present their work in a public mini-conference.

Keywords: Secondary education: upper (ages about 15-19) and university education, physics of sound, noise, project-based learning

Topics: Learning, Teaching

059.P1

Science Interval Project: We Can Teach and Learn Physics During the Leisure

Eloneid Nobre[1], Francisco Adeil Araújo[2] and Meirivani Oliveira[3]

[1]*Federal university of Ceara-program of professional master in teaching of sciences and mathematics, Brazil*

[2]*Federal university of Ceara/secretariat of education of the state of Ceará, Brazil*

[3]*Secretariat of education of the state of Ceará, Brazil*

The break between classes is a moment that, in recent years, has been reason of concern to the school community, it is still seen as an unproductive space. The Science Interval Project aims to combine the science education with leisure time during the interval school, attracting the students for a time of learning and discovery. Specifically, the project aims to provoke and instigate the student so he discovers, builds and gives new meaning to knowledge and submits to the school community the work developed in the classroom by the teacher and his students. The project began in May 2012, in a public school for basic education, located in a poor neighborhood in Fortaleza, capital of Ceará, in the Northeast of Brazil. The neighborhood is known for high rates of violence and the school has experienced the loss of a few students due to fights between gangs and use of drugs. This violence came to the school environment, for example, by aggressive jokes and fights during the interval of the classes. Searching a solution to this situation, we developed this project in school seeking to involve the students in activities that awake their interest and can be performed in a cooperative way. On last Friday or Wednesday of each month, the projects and experiments developed by teachers and students in the classroom and in the science laboratory are presented in the schoolyard. The presentation is made by the students who were chosen by their teachers, or those who have expressed an interest in participating. The use of low cost experiments is prioritized, because the school does not have a suitable science laboratory. Recent studies show that the method in which the student performs the experiments by himself and he himself presents them to his colleagues, results in a more meaningful learning, accumulating experiences that reach 90 % of the contents of apprehension. Therefore, it is important to orientate the student to be more active in the process of teaching and learning. We conducted a survey with 204 students to verify if the objectives of the project were being met. The results are shown below that 91 % of the students can learn science in a fun way during the Science Interval. When they were inquired if they participate of moments of the Science Interval, visiting the tables and performing the experiments, 60 % said yes and 28 % said sometimes. The answer to the question if the project has contributed to do an improvement in their performance in Physics classes, 75 % answered very much, 22 % said somewhat and only 3 % said that it did not contribute. The project has been changing the school routine. The whole school community is committed towards continuing the project, making it a routine. Teachers, students, all school community begin to understand that so important than only improving school performance, with good grades, is to make the student be able to construct their own knowledge and also changing his attitude in the society.

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Keywords: Secondary education: upper (ages about 15-19), method and strategies of teaching, low cost experiments, teaching and learning of physics

Topics: Experiments, Teachers, Teaching

064.P1

Analogies and metaphors in the teaching of Physics: an example around the thematic of fields.

Maria De Fátima Da Silva Verdeaux and Janice Anita Bomfim Goulart
University of Brasilia, Brazil

The exact role played by analogy in science teaching is a much discussed topic.Even though a general consensus has not yet been reached, those discussions have arguably contributed to provide guiding elements in the use of analogy as a teaching tool.

This work aims at rethinking the role of analogy in science teaching by considering and highlighting its participation in very structure of scientific thinking and thus arguing its necessity to the building of scientific literacy and culture. We then propose a new didactic and pedagogical strategy based upon the use of analogy as a tool to explicitly address the conceptual aspects of Physics, contrasting with the teaching based on merely mechanical resolutions of mathematical exercises.

Keywords: Secondary education: upper, physics teaching, analogy, conceptual physics, modeling

Topics: Learning, Teaching

066.P1

A hands-on to teach colour perception: The Colour Vision Tube

Claudia Haagen-Schuetzenhoefer
University of Vienna, Austria

Colour phenomena are usually fascinating. However, it is frequently quite challenging for students to explain such phenomena based on adequate scientific concepts. Our contribution focuses on body colour phenomena. From physics education research we know quite a number of learning difficulties related to this field (Andersson & Kärrqvist, 1983; Driver et al., 1985; Fetherstonhaugh & Treagust, 1992; Viennot & de Hosson, 2012). After instruction of geometric optics, students still believe the colour impression they get from an object is a fixed property of this object. Although they are mostly able to reproduce the laws of colour mixing, they can hardly account for colour impressions produced by objects lit with other than white light sources. We developed a hands-on experiment which can be easily used in class to demonstrate such colour effects. The hands-on is made of a tube which is closed at one end with a disc made of differently coloured segments. In the middle of the tube there is a hole just big enough to insert LEDs of different colours into the tube. The open end of the tube serves as peephole for the observer. When students look through this peephole while the tube is illuminated with differently coloured LEDs, they can experience the effect of different illumination on the "body colour" they perceive. This hands-on was tried out with secondary students before and after formal instruction in geometrical optics. We found out that both types of students face similar problems in explaining the phenomena they experience. However, after a short instructional sequence based on the Colour Vision Tube, most of them were able to apply the idea that colour impression is not a consequence of the property of objects but a consequence of the interaction between an object and the light illuminating this object.

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Keywords: Colour perception, colour subtraction, hands-on

Topics: Experiments, Teaching

069.P1

A Case Study of a Preservice Physics Teacher's Practical Knowledge about students

Cifuentes María Cristina[1] and Uribe Carlos[2]
[1]*Universidad Pedagógica Nacional, Colombia*
[2]*Universidad del Valle, Colombia*

The purpose of this study was to explore the development of a preservice physics teacher's practical knowledge over the course of a high school practicum experience. The framework of the study include the Teacher's Practical Knowledge concept, which conceptualized teacher's knowledge as an action oriented and a context dependent, that has experiential origins and emotional and moral dimensions. To capture this complex type of knowledge a qualitative case study design guided data collection, organization, and analysis. One preservice physics teacher, Alicia, participated in this study over the first year of her practicum. During the practicum she were attending to an assigned classroom to observe and provide help to her mentor during his physics class, two mornings weekly for 16 weeks, and then she took the lead in teaching fulltime, for two mornings weekly for 16 weeks. Multiple forms of data, including audiotaped interviews, written documents, field notes and videotaped teaching episodes, were collected. A qualitative analysis of data is presented with descriptive comments and reflections that shows growth and change of Alicia's practical knowledge. In particular, the growth and change of Alicia's understandings about her students, as individuals and as members of groups, as a result from interactions with them in physics class situation and her reflections about these interactions. We discuss the implications of research´s results for physics teachers´ initial training.

Keywords: Preservice physics teachers, practical knowledge, knowledge about students

Topics: Teachers

070.P1

Found Misunderstanding of Convection and Effective Experiment to Solve by Thermal Camera

Naoshi Takahashi[1], Katsumasa Yokokawa[2] and Masazumi Mori[3]
[1]*Department of Physics, Faculty of Education, Kagawa University, Japan*
[2]*Graduate School of Education, Kagawa University, Japan*
[3]*Sakaide Elementary School, Faculty of Education, Kagawa University, Japan*

We have demonstrated that in an elementary school it could be used a conventional thermal camera, not only for heating solid materials, but also for warming up fluid. We have made the first report concerning to 'show' children the motion of heating water in our last presentation in WCPE 2012. And we have found that there was a misunderstanding of convection and conduction.

In this time, we are going to show (1) more serious face of the misunderstanding that we found through questionnaire survey, and then (2) more effective use of such the camera in a class by using ICT technique. (3) We also discuss about the usual convection itself which appears gently in the lab, comparing with plume, Benard cells and so on.

Keywords: Thermal camera, convection, misunderstanding

Topics: Experiments, ICT, Learning

071.P1

Let’s use our heads to play

Jana Česáková and Michaela Křížová
University of Hradec Králové, Czech Republic

The regular activity “Let’s use our heads to play” of the Faculty of Science, University of Hradec Králové is presented. The aim of the activity during its 6 volumes has been to popularize physics and other science branches. Many experiments on a variety of physics topics are presented to the public by academic staff and students. Very popular are fire experiments, liquid nitrogen, dry ice, brain teasers, optical illusions or playing with magnets and electricity. Many participants of different ages covering preschool children as well as retired persons are coming to try presented experiments by themselves. Therefore, we would like to share our experiences with the organization of the event, attended by more than 2000 people, and show some proven experiments.

More than 50 students of our university help to prepare the happening every year. It brings them the possibility of practical testing of experiments and communication and teaching skills. Active involvement of students in the organization of similar events is indeed one of the ways how to improve the education of teachers, which is considered as the primary impetus to the improvement of education in our country.

Keywords: Pre-school education, primary education, secondary education, university education, lifelong learning, popularization of physics, experiments for children

Topics: Informal Physics Teaching & Learning

073.P1

New approach of some learning techniques in physics

Vania Covlea, Emil Barna, Marius Calin, Oana Ristea, Tiberiu Esanu, Catalin Ristea and Alexandru Jipa
University of Bucharest, Romania

This work discusses a few techniques applicable to the learning and teaching, including, in physics: the interactive heuristic lecture, the collective interview, the collective experiment, the interactive software.

The general theoretical aspects of the lecture, which will be dealt with, are provided by a professor to students before the course. In the lesson, professor introduces the subject, presents the main problems, with theoretical and experimental details and the possible consequences of the analyzed situation. Professor tempers the moderating discussion. In the end he makes the conclusions. Lesson is video-recorded.

Although it is a technique well-known, the experiment is continuously re-evaluated and upgraded. Professor's creativity is decisive. According to its authors, the classroom experiment built by students - under rigorous guidance of professor - has a maximum impact.

A collective interview refers to interactive assessment of the progresses in learning of the students, as well as the stabilizing their knowledge. The interview may be carried out by dedicated questionnaires, but also by spontaneous questions generated by collective interactions student-student and professor-student.

As interactive software can be used a course-lab in electronic format. For each topic, the student has at its disposal a breviary text and an application made in a friendly programming environment. The application code is shown for each topic, allowing students who are interested to develop the proposed applications in a personal manner.

Illustrative examples are in the field of Physics.

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Keywords: Learning techniques, interactive interview, video lessons, IT applications

Topics: ICT, Teaching

078.P1

Teaching Newton's law of cooling in „hands-on measurement” approaches

Csilla Fulop and Tibor Medvegy
ELTE, Hungary

Teaching methods practiced in science alter in how much focus is put on each of these means: quantities, notions, interdependence, understanding, solving problems, explanation, calculation, applications, planning or evaluating experiments, etc. Doing „hands-on measurement” projects is a very complex method of teaching and learning. We will analyse this method in terms of these means. We also take a closer look at the activeness of this method using the „learning pyramid model” of pedagogy.

For a specific study we will take an experimental law - the well known Newton’s law of cooling - as an example. According to Newton's Law of Cooling the rate of change in temperature of an object is proportional to the difference between its own and the ambient temperature. It means that the relation between the temperature of the object and time is exponential.

We will discuss four possibilities used in our everyday practice as students' activities in physics laboratories. So we will examine projects for 4 different levels. These levels can be dedicated to certain age or school system: primary school level, secondary school level, mentor level and academy level. The academic goal of our projects are different, but not so the goal and means of education.

At primary school level developing the relation between sense and measured quantities is the focus. At secondary school level we disqualify the concept of a steady change in this phenomenon. The mentor level is a special course for the gifted students, in our project we highlight the numerical methods of demonstrating an exponential nexus. We present alternative solutions planned for our students. At academy level the emphasis is on the proper and punctual use of engineering skills, also introducing calibration, as well as developing accuracy by using tempered vacuum chamber and applied apparatus.

Keywords: Newton's law of cooling, hands-on measurements, from primary to university education

Topics: Experiments, Learning, Teaching

085.P1

Concept Cartoons as a Teaching and Learning Strategy at Basic Schools in the Czech Republic

Eva Hejnova
J. E. Purkinje University, Faculty of Science, Czech Republic

The contribution deals with tasks that are called „concept cartoons“. The concept cartoons consist of cartoon-style drawings showing everyday or some interesting situations. The cartoon characters (usually three or four children) put forward alternative viewpoints about the science involved in the situation, and the format of the task invites pupils to join in debate with the cartoon characters. Typically a concept cartoon is used as the focus for a group discussion, which can then lead on to investigations to decide which of the viewpoints put forward is the most acceptable.

At Czech schools this type of tasks isn´t too known but their potential is large, mainly in respect to the possibility of the concrete application of constructivist theory in the classroom. Concept cartoons namely provide a stimulus for discussion and argument, challenge and develope the learners´ ideas, promote thinking and reasoning, help learners to ask their own questions, provide starting points for scientific investigation and enquiry etc. This approach is defended by numerous researchers as not only better representation of the character of science but as challenging of critical thinking and developing of conceptual thinking.

A set of seventeen concept cartoons for the topic „Motion and force“ was created by the author of this contribution in the forms of slides in PDF format (it is possible to use them for interactive whiteboard too). The tasks are designed for learners at the age of 13 to 15 (i. e. the pupils basic schools in the Czech Republic). These concept cartoons were developed according to FCI (Force Concept Inventory) test and some other tasks from book „Concept cartoons in scienece education“ by S. Naylor and B. Keogh, but they were formulated for the needs of learners at basic schools.

Concept cartoons can be used at the start of the topic „Motion and force“ to provide a stimulus for discussion and raise questins about what needs to be done to find out more, or at the end of the topic, where the emphasis might be on reviewing or consolidating learning.

The set of the concept cartoons was given to appr. ten Czech teachers in 2012 and 2013, who used them during their teaching. Some of these teachers provided the feedback. They often stated the concept cartoons plaid a useful role in the development of the teacher´s own subject knowledge and understanding and they appreciated that their pupils were more involved in and motivated towards science. However, it has not been carried out any systematic or more extensive research into this problematics in the Czech Republic.

Keywords: Secondary education: lower (ages about 13-15), concept cartoons, teaching and learning strategy, critical thinking

Topics: Learning, Teaching

086.P1

Monitoring the level of the basic elements of students' scientific literacy developed by research-oriented activities

Mária Nováková and Marián Kireš
Faculty of Science, Pavol Jozef Safarik University in Kosice, Slovakia

The term scientific literacy is defined by Arons (Held, 2011) as the effective application of scientific knowledge and skills to solving problems and making decisions in personal, social and professional life. In meeting the needs of the labor market in knowledge-based economy, the importance of scientific literacy increases. Ability to apply scientific forms of thinking in order to obtain and then use the new information requires students' developing of the components of their scientific literacy. Several experts, eg. Colville and Pattie (2002), Beau-mont and Soybo Walters (2001) agree on division of capabilities of the scientific work to basic (used to organizing and description of the subjects and phenomena) and integrated (through which we are able to solve problems and do experiments). Basic capabilities are: observing, judging, assuming, classifying and measuring.

In paper is presented the methodology of the prepared didactic experiment aimed at detecting the level of students' basic skills in scientific work. It consists of graduated system of physics observations and laboratory measurements, tools for collecting and analysing data. Selected measurements (eg. Gauss gun) are prepared for the different levels of research-oriented learning activities (Ibsen – Inquiry-based science education).

The training Gauss cannon is specified as follows: A sequence of identical steel balls includes a strong magnet and lies in a nonmagnetic channel. Another steel ball is rolled towards them and collides with the ball end. The ball at the opposite end of the sequence is Ejected at a surprisingly high velocity. Optimize the magnet's position for the greatest effect. Activity is presented in form of instructional material for teachers using the method of interactive demonstration and a worksheet for students who carry out the method of controlled research.

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Keywords: Secondary education: upper (ages about 15-19), university education, inquiry-based science education, inquiry-based skills, scientific literacy, Gauss cannon

Topics: Experiments

087.P1

Computer-aided activities for inquiry-based skills development

Veronika Timková and ZuzanaJešková
Faculty of Science, Pavol Jozef Šafárik University in Košice, Slovakia

The development of scientific literacy through active students' engagement in their process of learning has become a main trend of science education today [1]. The strong attention in the current curriculum is paid to the development of inquiry-based skills and abilities while students work as real scientists. These involve fundamental abilities that are necessary to do scientific inquiry that differ in relation to the degree of sophistication of the inquiry-oriented intellectual processes [2]. Among the basic inquiry-based skills for upper secondary schools students there are emphasized the abilities to design and conduct scientific investigations as well as developing appropriate models enhanced by digital technologies. The contribution presents examples of activities designed for different levels of inquiry with the help of datalogging, videoanalysis and modelling computer tools (COACH6 environment [3]). The activity on falling objects is aimed at students´ simple investigation of falls of different objects (heavy and styrofoam balls, plates and cups) in order to discover the difference and the influence of the drag force. The experiments can be complemented with the modelling activity when students analyse the already existing model or create their own one eventually, depending on their intellectual level. The activity on the behaviour of balloons is based on the motivational problem of two inflated balloons and their discrepant behaviour when they are interconnected. This problem should lead students to designing and planning their own experiment to explain and reason in order to draw conclusions. The activity on the effect of Magnus force well-known and widely used by sportsmen (tennis, football, volleyball players) can be an attractive problem for students to analyse. They could design and conduct an experiment in a lab and with the help of videoanalysis tools they can collect data about the motion. The model based on dynamical modelling can be studied and analysed in detail in order to compare the results with the theory to show the correspondence.

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[1] ESTABLISH project, available on <www.establish-fp7.eu>

[2] Wenning, C. J. 2005. Levels of Inquiry: Hierarchies of pedagogical practices and inquiry processes. In: Journal of Physics Teacher Education Online, 2(3), 3-11.

[3] Software COACH 6, available on <http://cma-science.nl/>

Keywords: secondary education: upper (ages about 15-19), university education, inquiry-based science education, inquiry-based skills, Magnus force, pressure of inflated balloon, drag force

Topics: Teaching

093.P1

A simple experiment set for demonstrating optical communication with LEDs as light transmitting and receiving components

Makoto Hasegawa
Chitose Institute of Science and Technology, Japan

A light emitting diode (LED) can also act as a light receiving component when irradiated with light beams. By employing this aspect, a simple experiment set for demonstrating optical communication has been provided in which LEDs are employed, not only as a light transmitting component, but also as a light receiving component. In this set, intensity of light to be emitted from an LED as a light transmitting component is modulated in accordance with audio signals such as music from a CD. The light from that LED is then transmitted via air or an optical fiber to another LED which acts as a light receiving component. By sending signals from the LED as the light receiving component to a loudspeaker, the transmitted audio signals such as music can be reproduced. Thus, optical communication can be easily demonstrated. This experiment set has been effectively used in various situations of science experiment demonstration at primary schools, secondary schools, high schools, and even for universities.

As advantages of using an LED as a light receiving component, LEDs are in general much cheaper than photodiodes. Thus, a large number of the sets can be prepared at low cost and simultaneously used. Moreover, in some conditions, much clearer music can be reproduced with an LED than with a photodiode as a light receiving component. This is because output signal levels from an LED are not likely to be saturated, unlike signals form photodiodes.

Furthermore, LEDs with different colors can be employed as each of the light transmitting and receiving components. In such a case, audio signals can be or can not be communicated in accordance with combination of colors. This aspect can be useful for easily demonstrating relationship between colors of light and their energy levels.

Keywords: Primary to university education, LED, optical communication, science experiment demonstration

Topics: Experiments

095.P1

Concept Survey of Wave of High School and Undergraduate Students

Hisashi Kogetsu[1] and Kazunari Taniguchi[2]
[1]*Kyoto University of Education, Doshisha High School, Japan*
[2] *Kyoto University of Education, Japan*

We investigated students' conceptual understanding of wave physics in Japan. In order to the survey, we developed the Concept Inventory Test which consists of 7 qualitative questions in a free response (FR) format and/or a multiple-choice (MC) format. The main contents of questions are as follows:

1. Superposition of two wavepulses closer to each other at a same speed (FR)

2. Spatiotemporal behavior of a phase of a periodic wave (FR, MC)

3. Physical quantities related to the speed of a sound wave (MC)

The candidate for the survey is 128 students (16-17 yrs) in the second grade of senior high school, and 45 undergraduate students in the introductory physics class which learned physics by a traditional instruction.

As the results of the survey, about a superposition of two wavepulses, it was confirmed that not a few students have understanding which can be explained by the mental model of mechanical waves (Wittmann, 1998). Moreover, about a spatiotemporal behavior of a traveling periodic wave, it was revealed that the understanding of a time variation of an oscillation at an arbitrary point on the wave was more difficult for almost all students than that of a space variation of the wave.

Keywords: Wave, concept survey, high school

Topics: Assessment & Evaluation, Learning

106.P1

Open Inquiry based learning experiences to understand the Nature of Science

Nicola Pizzolato, Claudio Fazio, Rosa Maria Sperandeo-Mineo and Dominique Persano Adorno
University of Palermo, Italy

In the last decades, many researchers have focused their studies on the efficacy of inquiry based activities to teach fundamental aspects of NoS. Explicit pedagogical approaches, in which specific instruction on the topic of NoS is provided in addition to engaging in scientific inquiry, are generally considered more effective with respect to the implicit method, where NoS conceptions are expected to develop as a natural consequence of inquiry learning experiences alone.

In our study, we further explore the connections between scientific inquiry and development of NoS conceptions, by investigating the efficacy of different kinds of inquiry approaches. In particular, we have first analysed the outcomes from a pre-post activity questionnaire administered to a large sample of high school students, involved in Guided Inquiry (GI) learning paths on thermal physics, within the context of “Establish”, a FP7 European project aimed at promoting and developing inquiry based science education in European secondary schools. We have found that students engaged in GI-based experiences, without any specific instruction on NoS, do not significantly change their views.

Furthermore, we have investigated the efficacy of an Open Inquiry (OI) based learning environment to implicitly develop contemporary NoS conceptions in first level university students. A sample of 30 mechanical engineering undergraduates was involved in a challenging learning environment, starting from the problem of projecting a thermodynamically efficient space base on Mars, and performed a 6-week long research-like experiences regarding the topic of thermal energy exchange by conduction, convection and radiation. All students activities – formulate questions, plan experiments, collect and analyse data, construct explanations, share results – were recorded and analysed by applying the methods of statistical implicative analysis. We have found that a highly motivating OI-based learning environment, stimulating autonomous reasoning and problem solving abilities, may constitute an efficient teaching/learning approach both to consolidate tough physics concepts and, at the same time, to clarify important aspects of NoS. Implications for the design of Inquiry based teaching/learning environments are discussed.

Keywords: Upper secondary education, university education, inquiry based science education

Topics: Learning, Teaching

115.P1

Training physicists for Measurement in Society

Leslie Pendrill
SP Measuring Technology, Sweden

Many physicists who follow careers outside of academia use their skills in the context of measurement. What are those skills, what kind of impact do they provide in early 21st society and, above all, how do we best train these skills throughout careers?

Three particular skills that physicists are good at and which come to use in measurement are:

- Relating measurement of different quantities made by different people through metrological traceability (“Meeting future needs for Metrological Traceability – A physicist’s view” L R Pendrill 2005 “Accreditation and Quality Assurance” – Journal for Quality, Reliability and Comparability in Chemical Measurement,10, 133-9). Important for international trade, communication, efficient industrial production – in fact anywhere products/systems composed of diverse parts made at various places need to be put together. As Petley once put it: 'Physics from the Nobel Prize winner to the Man in the Street'.

- Systematic analysis of measurement systems ("Metrology: time for a new look at the physics of traceable measurement?", L R Pendrill 2006 Europhysics News 37, 22-5). The experimental skills learnt by physicists in the lab can be applied in many walks of life.
- Applying statistics to measurements and decision-making in society, for instance accounting for risks of incorrect decisions about product conformity (L R Pendrill 2010 "Optimised uncertainty and cost operating characteristics: new tools for conformity assessment. Application to geometrical product control in automobile industry", Int. J. Metrol. Qual. Eng.1, 105-110, DOI: http://dx.doi.org/10.1051/ijmqe/2010020)

Experiences of teaching metrology at the university, to industry and through websites ("Applications of statistical methods in Measurement & Testing", http://metrology.wordpress.com) will be shared in this presentation.

The author is Chair of ISO TC12 'Quantities & Units' standardisation technical committee; member of the Metre Convention's Joint Committee on Guides in Metrology; Board member of the newly created 'Physics & Society' division of the Swedish Physical Society (http://www.fysikersamfundet.se/fs/om_sektionen_eng.html). He has formerly been Chair of EURAMET, the European Association of National Metrology Institutes and Chair of Commission 2 SUNAMCO of the International Union of Pure & Applied Physics.

Keywords: Measurement, society, training

Topics: Teaching

117.P1

The learning of quantum mechanics in secondary school using the Stern-Gerlach experiment

Carlos Raphael Rocha[1], Victoria Elnecave Herscovitz[2] and Marco Antonio Moreira[2]
[1]*UDESC, Brazil*
[2]*UFRGS, Brazil*

In a course of 25 class-hours of Quantum Mechanics (QM) for secondary school, we analysed the potential use of the Stern-Gerlach (S-G) experiment as a problem situation for learning some principles of QM, considering the concept of linear superposition as a subsumer. Five classes (two first year and three third year secondary school classes) were studied. The concept of intrinsic angular momentum (spin) of the electron was approached using a computer simulation of the S-G experiment. In addition, the concepts of state of a quantum system, eigenvalues as possible values of measurements, probability of obtaining eigenvalues, and collapse of the state vector were also taught. Students took a quizz (one single question at the end of a class) and an evaluation test (including seven questions at the end of the course), both with a question about the S-G experiment, and other topics. A total of 143 students responded to the quizz and 147 to the evaluation test. In the quizz, 61 % of the students answered correctly the proposed question, while 13 % of the students presented an incorrect answer. In the evaluation test, 47 % of the students answered the question

correctly while only 9 % did it incorrectly. We still had 21 % of the students who answered almost correctly the question in the quizz, while 12 % answered almost correctly in the evaluation test. It might be possible to say that more than half of the students had, at least, quite an acceptable performance regarding their answers in both tests. Considering that this was a short-term course, findings suggest that some learning has occurred, which can eventually develop towards meaningful learning if more time is devoted in mastering this conceptual field. We then suggest the use of this problem situation in secondary school together with others related to linear superposition, such as quantum entanglement and quantum cryptography both to update the secondary school curriculum of physics education, as well as to motivate the students to learn physics in a way that is closer to the scientific and technological evolution that already invades their daily lives.

Keywords: Quantum mechanics, Stern-Gerlach experiment, secondary school

Topics: Learning, Teaching

126.P1

Teaching Lunar Movement using an Ancient Earthwork in a 2D game

Michelle Aubrecht
Ohio State University, United States

Even though video games have been around for over 40 years, employing them as viable learning environments is relatively new. In the last few years,many people have begun researching games and learning: how to make them, use them, and assess what is happening when learners use them.

With support from the National Endowment for the Humanities, we utilized a consulting collaborative approach, created a Native American Advisory Board, made a prototype, 2D mini-game that focuses on the Newark Earthworks in Ohio, USA as a lunar observatory, and obtained additional funding to create an affinity space (Gee, 2012). This poster presents the 2D mini games that will be part of a larger game that demonstrates the moon's monthly cycle as it is observed at the Newark Earthworks, a world heritage nominated site. We will explain our learning objectives, design process, and how games teach.

The Earthworks spans several kilometers. The Earthworks Octagon precisely tracks the northernmost moonrise; Building something that is seemingly focused on an event that occurs only every 18.6 years is striking! In addition, that’s just one section of the Earthworks. What were they doing every 18.6 years that would lead them to construct such an enormous structure?

We think that exploring this structure and the culture of ancient Native Americans, learners will be inspired to learn more about astronomy and begin observing the moon themselves.

Keywords: Video game, Earthworks, moon, lunar, Native Americans, Indigenous Science, astronomy

Topics: ICT, Informal Physics Teaching & Learning, Learning

132.P1

Database of selected papers of Physics Teachers' Inventions Fair

Zdeňka Koupilová[1], Leoš Dvořák[1] and Jan Koupil[2]
[1]*Charles University in Prague, Czech Republic*
[2]*Gymnázium, Pardubice, Dašická, Czech Republic*

The Physics Teachers' Inventions Fair [1] is an annual conference of physics teachers of all levels – from basic school teachers to university professors. They share ideas about new demonstration and laboratory experiments, long-term projects and how to make their lessons more attractive. There are about 100-150 participants and approximately 40 papers presented each year. It has long tradition. In September 2012 the 17th Fair took place in Prague and this year's conference will be in Hradec Králové. Even though the impact of the conference is mostly national, every year there are more than ten participants from foreign countries who are also inspired. [2]

Papers from the conference are a very good source of teaching ideas because they are mostly ready to be used in the classroom. But as they were published in paper proceedings, they have been badly accessible for people who didn't attend the specific conference. The idea of building the database of selected papers arrived and at the occasion of the 10th conference in 2005 the first version was presented – on CD and online as well. Selection criteria (not all papers are in the database) dealt not only with quality of the paper content, but papers have to be oriented on experiments, specially the experiments with simple stuff and easily accessible equipment, or present ideas how make learning more attractive and active. According to the number of connections to online version of the database and the survey of opinions of the conference attendance done in 2008, the database was considered as a very useful and often used source of ideas for physics teachers of all levels of schools. [3] That's why the papers from further conferences have been added and in 2012 the implementation of the whole database has been changed to reflect new technologies used on internet. The database still remains freely accessible for public.

New database contains more than 400 articles (original papers from the conference) in Czech. It is possible to search the papers not only according to their titles or authors names, but also according to their topics and an extensive structured index is implemented here as well. Entire database is in Czech and about 10 % of the most interesting papers are translated into English [4], making it internationally usable.

The poster will present used technology, details about database content and how the database is used.

References:

[1] Home page of the conference Physics Teachers' Inventions Fair: http://vnuf.cz/

[2] Teslamania 2010 Physics Teachers' Innovation Fair, http://teslamania2010.eventbrite.com/

[3] Database of selected contribution: Inventions Fair for Physics Education http://vnuf.cz/sbornik/

[4] Selected papers of Physics Teachers' Inventions Fair in English: http://vnuf.cz/papers/

Keywords: Secondary education: lower and upper, university education, teaching ideas, simple experiments, database

Topics: Experiments, ICT, Teachers, Teaching

135.P1

How geographically uniform is Earth's temperature rise?

Gordon Aubrecht
Ohio State University at Marion, United States

One consequence of human use of energy is emission of greenhouse gases. Many nonscientists (as well as a few real scientists) do not think that climate change could be caused by human actions. Reasons range from doubt that tiny humans could affect an entire planet to belief that human life on Earth will soon end. Science is about experimental data, reasoning from those data, and theoretical perspectives supported by the data. Svante Arrhenius provided (in 1896) the first theoretical (and compelling) reasons that carbon dioxide could influence Earth’s energy budget. Multiple sources of modern data underlie the belief of virtually all climate scientists that humans are changing our climate. Earth’s temperature is rising. Is the rise distributed uniformly around the world? We compare the three world temperature records (Hadley-Climate Research Unit database of 162 years, and the National Oceanic and Atmospheric Administration and the Goddard Institute of Space Sciences databases of 132 years) to the US (National Climate Data Center database of 118 years) and Australian (Australian Government Bureau of Meteorology database 103 years), a small part of the US (National Climate Data Center database of 118 years), and other records to see what the temperature data show about geographic variation.

Keywords: Climate change, temperature records, anthropomorphic effects on climate, geographic variation

Topics: Informal Physics Teaching & Learning, Socio-cultural Issues

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136.P1

Stick-slip oscillations: teaching friction by using Tracker

Maria Bondani[1] and Fabrizio Favale[2]
[1]Consiglio Nazionale delle Ricerche – Istituto di Fotonica e Nanotecnologie, Italy
[2]Università degli Studi dell'Insubria – Dipartimento di Scienza e Alta Tecnologia, Italy

The stick-slip model describes several different physical phenomena, such as for instance the squeal and squeak of brakes, of chalk on board and of shoes on floor or the motion of earth crust that causes earthquakes.

We built a simple setup to display and study stick-slip oscillations. The system is made by a small block with flat bottom laying on a rough surface. The block is connected to a spring whose free end is pulled at constant speed by a rotating electric motor: the resulting motion of the system is characterized by an intermittent behavior, in which a static phase is followed by a moving phase. The motion of the block is recorded by a compact digital photo-camera and the movie is analyzed with the free software Tracker Video Analysis and Modeling Tool that allows both the recovery of the experimental motion and to elaborate mathematical models and simulations.

Although the physical system is not simple, the analytic description of the motion can be obtained with the mathematical tools available to high-school students. From the analysis of the tracks, both static and dynamic friction coefficients can be evaluated, together with the equations of motion.

The experiment was performed with third-year High-School students, as a way to introduce and discuss friction from a comprehensive point of view, and with second-year University Physics students, to explore all the quantitative details of the effect.

Keywords: Friction, movie analysis, mathematical simulations

Topics: Experiments, Teaching

138.P1

A pilot experience in physics laboratory in a professional school

Vera Montalbano, Maria De Nicola, Simone Di Renzone and Serena Frati
University of Siena, Italy

The reform of the upper secondary school in Italy has recently introduced physicsin the curricula of professional schools, in realities where it was previously absent. Many teachers, often with a temporary position, are obliged to teaching physics in schools where the absence of the laboratory is added to the lack of interest of students who feel this matter as very far from their personal interests and from the preparation for the work which could expect from a professional school.

We report a leaning path for introducing students to the measurement of simple physical quantities, which continued with the study of some properties of matter (volume, mass, density) and ending with some elements of thermodynamics. Educational materials designed in order to involve students in an active learning, actions performed for improving the quality of laboratory experience and difficulties encountered are presented. Finally, we compare the active engagement of these students with a similar experience performed in a very different vocational school.

Keywords: Secondary education: lower (ages 11-15), vocational education, physics laboratory

Topics: Experiments, Socio-cultural Issues

139.P1

Research based discussions on optics with teachers to integrate professional development with everyday school work

Francesca Leto, Marisa Michelini and Mossenta Alessandra
University of Udine, italy

The issue of the integration of content knowledge (CK) on subject matter with that producing the competence in creating an educational environment is a multidimensional problem in teacher education (TE). The lack of scientific preparation of primary and kindergarten teachers and of adequate educational tools are pivotal elements in this problem, as the need of a qualified in-service TE aimed at professional development. Traditional education is focused on narrative information and on scientific activities, whose priority is on description of systems, phenomena and functions. The change of the teachers' way of thinking needed to engage the children in activities concerning the eliciting of ideas, children's hypothesis and interpretation of phenomena is difficult in this framework. Building bridges between scientific perspective and common sense ideas and everyday experience is more evoked than acted, even when the teachers state to put children learning at the center of their work.

An Experiential Model for TE on the personal involvement of the teachers in carrying out the same activities planned for the children favorites the integration of content knowledge (CK), with teaching strategies knowledge (PK), but it doesn't guarantee the activation of a practice based on intellectually active children. Among the many reasons claimed by the teachers prevails the lack of self-confidence on the conceptual discussion and on the organization of the experimental explorative activities.
Within the Italian project on innovation in teaching/learning (IDIFO4), research based labs have been carried out, focused on the analysis and the discussion of tested educational paths both on the conceptual, subject matter content and educational planes. Different kinds of discussion concerning students' ideas and learning processes were carried out by the community of researchers and teachers. Action oriented contents and methods emerge as teaching learning proposals based on the children learning processes research and they melt in coherent paths as an outcome of the experienced modules of formative intervention.

Optics lab offers an example of this kind of integration between educational research and teacher professional development.

The lab dealt with three different aspects of optical processes: sources, propagation phenomena and light-matter interaction. From these perspectives physics education researchers and teachers addressed student ideas on the models of vision; they discussed pupils spontaneous statements concerning the word 'light' and light-phenomena, light sources and vision models, collected in teachers classes. They discussed in cooperative way emerging ideas of children in classroom activities. Modalities of work and of data analysis, their results and teachers' opinions on the role of carried out activities for their professional development are significant for in-service teachers education and for the ways for an integration between research and education.

Keywords: Primary school and kindergarten teacher education, research based lab, optics

Topics: Experiments

208.P1

Popularization of Physics by Using an Interactive Show

Petr Kácovský, Věra Koudelková and Marie Snětinová
Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic

Nowadays, physics is one of the less favourite subjects for secondary school students (age of 15–19), although it is one of the key branches for development of human civilization. For this reason, our main goal – as physics teachers – is to improve students´ perception of physics, to make physics more attractive and involve students into experimental work. In addition, we want to support the perception of physics education study and make it interesting (not only) for future graduates.

Our contribution describes two long-term projects and activities organized by the Department of Physics Education (Faculty of Mathematics and Physics in Prague) for secondary school students. The activities are called "Physics Through All Senses" and "Magical Physics" and they have much in common – in both cases we have prepared a 90 minutes-long set of experiments performed not as a lecture with exact theoretical background, but as an interactive show engaging students into it.

The project "Physics Through All Senses" has started in autumn 2012 and the homonymous show contains almost thirty experiments divided into groups according to human senses.

The project "Magical Physics" has started in spring 2010 and it is focused on physical measurements with dataloggers. The experiments are joined in a story "The Voyage to Mars" and we emphasize here the inter-disciplinary relations mainly into biomechanics, biology and chemistry.

Our performances have seen more than 3 000 students till now. In our poster presentation we will present some of performed experiments and our experience with such type of informal learning.

Keywords: Interactive show, experiments, secondary school, informal teaching

Topics: Experiments, ICT, Informal Physics Teaching & Learning, Teaching

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210.P1

Laboratory workshop on the elective module "Autonomous Processes in Electronics"

Akmaral Imanbayeva[1], Sergei Manakov[1], Bekbolat Medetov[1], Amirkhan Temirbayev[1], Aisha Naurzbayeva[1] and Saule Baimuldina[2]
[1]*Al Farabi Kazakh National University, Kazakhstan*
[2]*Institute Experimental and Theoretical Physics, Kazakhstan*

Design and development of any up-to-date radio electronic device is accompanied by physical or mathematical modeling. Preliminary computer simulation of wireless devices enables us to analyse physical processes in the concrete device without major material expenditures and to reveal fundamental features of its performance. After step-by-step simulation, further development of the concrete electronic device becomes much simpler. University students must have some general knowledge about computer models, numerical methods of studying of various objects of knowledge, and freely enough orientate in the up-to-date software products. The important level of mastering methods of calculus mathematics and physics is the ability of a student to write computer programs independently, without tutor's guidance. Creating similar computer models "from scratch", working with the source code of the program, the student better understands specific methods of processing information. We have developed new laboratory practical works on the elective course "Autonomous Processes in Electronics". The workshop consists of four labs:

- Generator with inertial nonlinearity.
- Studying of dynamics of Chua generator.
- Studying of bifurcation modes of the ring oscillator.
- Studying of dynamics of the generator of dynamic chaos with phase control.

The basis of all the works are modern achievements of world science [1, 2], and our original design [3] in physics of dynamical systems and dynamical chaos. All lab works are based on the same technology:

1. Building of a computer model of the scheme.
2. Setting of initial conditions, starting-up of the circuit and measurement of its characteristics.
3. Automatic loading of measured physical values into files.
4. Processing of experimental data and visualization of the results of processing using specialized software.

For computer simulation we use software "MultiSim 11", which is the most popular program for constructing, projection and modeling of radio electronic schemes. Setting the initial conditions, start-up circuit and measurement of the main characteristics of the assembled model made built-in virtual instruments. Such processing of the experimental data and visualization of the results will be realized by the programs developed in Matlab.

Such labs for the system of modern education will significantly change the way of development and assimilation of information in the learning process of physical and engineering disciplines. These workshops provide new possibilities for integration of various actions, and thereby promote achievement of goals in education socially significant and relevant in the modern period of social development. The results indicate improvements in some areas as well as areas for further improvement.

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[2] Yamapi R., N. Nbendjo B.R., Enjieu K.H.G. // International Journal of Bifurcation and Chaos.(2007). Vol.17, No 4. P.1343-1354.

[3] Temirbayev A., Zhanabaev Z., at al.//Phys. Rev. E.(2012),Vol.85.P.015204.

Keywords: Laboratory workshop, computer simulation, dynamical chaos

Topics: Experiments

231.P1

A WebLab for teaching physics

Eduardo Kojy Takahashi[1], Dayane Carvalho Cardoso[1], Rubens Gedraite[1], Hermes Gustavo Neri[1], Rener Martins Moura[1] and Adilmar Coelho Dantas[2]

[1]*Universidade Federal de Uberlândia, Brazil*

[2]*Instituto Federal de Educação, Ciência e Tecnologia do Triângulo Mineiro, Brazil*

This work presents the implementation of a remote access laboratory, a WebLab, consisting of equipments and real systems that can be controlled remotely using internet. It is based on a control system that is applied to remotely manipulate an experimental apparatus and determine the specific charge of the electron (e/m) from the path of an electron beam in crossed electric and magnetic fields of variable intensity. Considering the developed website the user can observe the experiment and act on stepper motors that are coupled to three potentiometers of two power supplies: one, to adjust both the accelerating voltage and the focus potential of the electron beam, and other to control the magnetic field strength that deflects this beam. The data acquisition system operates in real time and the charge-to-mass ratio of the electron can be determined from the accelerating voltage, the magnetic field intensity and the radius of the electron orbit. The interaction between user and experiment is based on a Man Machine Interface, configuring in this way a hands-on laboratory. In the version that we have developed, there is no difficulty for the user running the application. It is very friendly and can be accessed from any web browser with support for Flash Player or a cellular device with Android system. Thus, it is not necessary to install any plug-in or external third-party framework. To minimize the WebLab mounting cost we used an open-source electronics prototyping platform (Arduino Uno) to connect a PC to the automation and control system of the experiment. The hardware developed so far allows the user to send command logical signals written into the serial port of a PC interconnected with the Arduino board and converted into electrical impulses that act on the power supplies potentiometers by adjusting the voltages applied

to the experimental device. The remote labs represent a major evolution in the concept of digital inclusion, once they allow safely access students, teachers and researchers, regardless of their economic status to complex and relatively expensive equipments that are installed in laboratories of several educational or research institutions. Furthermore, a WebLab allows to carry out autonomous laboratory experiments anytime and anywhere, stimulating the meaningful experiences provided by a discovery learning which is considered by some researches in Science teaching as the most higher learning dimension. The remote experiment provided can be used both in the classroom teaching as in distance learning by teachers and students of secondary or university education. The access environment to the remote experiment is also presented in this paper. To ensure the use of WebLab consistent with the cognitive level of the learner and to reorient the experimental practices for developing investigative activities we developed a instructional design to provide a virtual learning environment based on Leontiev´s Activity Theory, containing various teaching resources to subsidize definitions of goals, needs, actions and operations that can assign meaning and significance to the proposed experimental activity. This instructional design is a complementary work, also submitted to this congress.

Acknowledgements: We thank FAPEMIG (Brazil) and UFU (Brazil) for financial support.

Keywords: Secondary education: upper, university education, remote experimentation, Thonson´s experiment

Topics: Experiments

248.P1

The influence of career choice of graduates in physics at a public university in the teacher shortage

Sergio Kussuda and Roberto Nardi
UNESP/FC, Brazil

This research is part of a broader study, carried out in the Science Teaching Research Group. Some of the researches in this group seek to study how happens the initial education of physics teachers in order to subsidize, for example, restructuring curriculum and implementation of new pedagogical projects. This research aims to analyze the careers' choice of students that finished the Physics Teachers Education Program at UNESP, Bauru Campus, in the last two decades. We used online questionnaires as a methodology to collect data, applied to physics teachers graduated from 1991 to 2008. Among the list of 377 students that completed the Physics Teachers Education degree during this period, we could contact 273 and 52 of them responded the questionnaire. The questionnaires analyzed allowed us to verify that 40 of them worked as physics teachers or professors after graduation; 7 of them exclusively in colleges and 32 of them worked as teachers in basic education sometime in their career. The data also showed that teachers' dropout rate is significant: from 40 of those that have taught, 13 abandoned the career, 10 of them worked only in Basic Education and 3 of them in Higher Education level. One of the main conclusions of this study is that the lack of physics teachers in this region, and possibly in the country, is not just because the small number of physics teachers graduated, but is greatly aggravated by the exodus of these teachers to other fields, mainly because the dissatisfaction essentially with this level of teaching salaries, working conditions in basic education and the difficulty of transposing the knowledge accumulated in the University for Basic Education.

Keywords: Physics education, physics teaching, initial education of physics teachers, lack of physics teachers

Topics: Socio-cultural Issues

358.P1

Representations as tools of appropriation, creating meaning through activities

Roberto Cruz-Hastenreiter and Cristiano Mattos
IFRJ / USP, Brazil
USP, Brazil

Based on some constructs of the Activity Theory (Leontiev, 1978), we point to the need to develop activities that reveal the meaning of representations. We examine use of representations in teaching and propose some suggestions.

Shaaron Ainsworth (1999) asserted that, in order to learn from engaging with multiple representations of scientific concepts, students need to be able to (a) understand the codes and signifiers in a representation, (b) understand the links between the representation and the target concept or process, (c) translate key features of the concept across representations and (d) know which features to emphasize in designing their own representations.

Let us initially take the item (a), which proposes that students need to understand the codes and meanings of a representation in order to relate it to the Activity Theory. To achieve this goal we propose an "action" that we call "unzip" , namely to bring to the conscious level subconscious operations and thus make evident their relationships and meanings.

In this sense, we advocate activities that focus the awareness of the teacher on the representations used by him so that he can consciously, if necessary, propose other forms of representation that are consistent with his goals. Items (b) and (c) indicate the need to recognize the concepts involved in representation as well as understand the relationship between representation and conceptual objectives. This is in agreement with the Activity Theory in which knowledge is highlighted as the result of a social and historical process. Above all we recognize that representations are a result of the development of humanity, not as symbols that "freeze" only one meaning, but assist in the communication process. Above all, they carry with them the traces of their development, their history, and their limitations and contradictions.

Still from the perspective of collaborating in the training of a teacher who is aware of his actions, the recognition of the characteristics of the representations mentioned above responds to the intention of making their actions less and less alienated and enables the sharing of meaning with students.

The item (d) suggest that the teacher should be author not only of his actions but also of instruments of mediation whose proposed activities provoke an awareness of the level of consciousness of the educator.

In all these items the understanding, recognition, and choice in the elaboration of representations geared to teaching reinforce the ideas of the appropriation of instruments in the Activity Theory.

Keywords: Lifelong learning, representation, activity theory, mediational tools

Topics: Learning, Teaching

369.P1

First Polish finale of the Chain Experiment

Justyna Nowak and Daniel Dziob
Jagiellonian University, Institute of Physics, Krakow, Poland

Chain Experiment is the first competition in Poland that combines physics teaching, abstract thinking and do-it-yourself (DIY) skills. It is organized by the Institute of Physics, Jagiellonian University in collaboration with University of Ljubljana, where such competition has been organized since 2005. The principal idea of Chain Experiment is to promote the science (especially physics) among students at different stages of education.

The main task for the participants is to build a machine that will move the metal ball employing as many interesting physical phenomena as possible. Chain Experiment consists of several stages. At the first stage, which usually takes several months, participants submit their applications and design their devices. During this period the organizers visit schools and present them the so-called "mini-chain" demo version. The most important part of the competition is the grand finale, during which all devices are connected to each other to form a one long chain. Each team is assessed in three categories: applied physical phenomena and the ability to explain them, the reliability of the device and the aesthetics of the device.

In 2013, the Chain Experiment involved 221 teams from all across Poland. Participants were divided into five different age group categories and there was also a ‘family category’. Demo version of the chain experiment was presented in about 50 schools and also at various events organized by the Jagiellonian University.

Keywords: Chain experiment, competition, informal education, physics in context

Topics: Informal Physics Teaching & Learning

373.P1

Online Tutorials in Physics and Engineering

Markus Kuehn, Michael Lakatos, Simone Grimmig, Manuel Stach, Janina Marquis, Frank Kalka and Marios Karapanos
University of Applied Sciences, Kaiserslautern, Germany

Online tutorials meanwhile have developed into a mainstream format of E-Learning. We present a collection of virtual modules for physics and engineering which we developed using professional software and multiple programming tools. In addition to the technical aspects, the virtual units considerably contribute to each student´s digital competence. In this context, digital competence not only encompasses information and communication technology (ICT) literacy, Internet literacy, media literacy, and information literacy, but even goes beyond the sum of these components [1].

For the extra-occupational degree programme in automation engineering we develop webcasts based on blended learning concepts in electrical engineering and digital electronics. Respectively, we produced exercises on electrostatics, electrical circuits and network analysis as well as exercises on Boolean algebra, combinational and sequential circuits and logic families. In addition to basic video interaction features we can increase interactivity by using flash hotspot callouts that allow linking to any web page which contains, for example, interactive HTML5 and Java Script elements. The external links may also lead to web pages which contain java simulations [2].

With Easy Java Simulations (EJS) we have a free authoring tool for building interactive Java simulations using the actual mathematical model of the physical problem. We created virtual laboratories for our blended-learning courses in physics, e. g. the double-slit experiment with microwaves. In addition to the laboratory experiment students can run additional simulations varying the number, size and spacing of the slits as well as the wavelength of the electromagnetic waves. The aim is to experimentally learn how the diffraction patterns depend on different parameters.

Based on HTML5 and Java Script using the jQuery framework we developed an interactive virtual laboratory tool to perform a titration experiment. A solution of unknown concentration is analysed by adding a solution of predefined concentration. Our example shows an acid-base titration of HCl and NaOH. The end point of the titration is indicated by the colour change of the solution from transparent to pink which is illustrated in the simulation. Finally, students can determine the molarity of the acid solution by the used volume of the base.

For the mechanical engineering department we also created an online tutorial for tensile testing using HTML5 and Java Script. In a computer animation developed in Cinema 4D the students learn how tensile specimens made of steel expand when stress is applied until finally the rupture of the specimen is reached. In the real experiment the students measure the behavior of two different steel samples recording the stress-strain curve.

Finally, the virtual units are embedded in the university´s learning management system. Both virtual units and students´performances will be evaluated. The results of these evaluations will have an impact on the development of the upcoming physics and engineering tutorials.

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Keywords: University education, physics laboratories, engineering, e-learning

Topics: Experiments, ICT, Learning

Poster session 2, Wednesday, 11:00-12:00

009.P2

PONTOn vzw - promotion and support for MST teachers (non-profit organization)

Tom Lambert
PONTOn vzw, Belgium

PONTOn vzw is a Dutch abbreviation for (translated into English) promotion and support for MST teachers. (The vzw part means PONTOn vzw is a non-profit organization). PONTOn vzw organizes in-service training for primary and secondary school MST teachers. All participants experience our contextual approach and perform all experiments with day-to-day materials. Since its first in-service training in 2008, it has organized in-service trainings for the following physics topics: optics, sound, heath, general integrated science for 12 year-old students in the new Flemish curriculum and electromagnetism. Also chemistry in-service trainings were organized: introductory chemistry for 14 year-old students and a chromatography workshop. Each participant gave evaluative feedback by means of a questionnaire, in order to improve our approach.

This poster presents the PONTOn vzw approach and the reception of the initiatives by the MST teachers who participated in our initiatives.

Keywords: Lifelong learning, primary education (ages about 6 – 10), secondary education: lower (ages about 11-15), secondary education: upper (ages about 15-19)

Topics: Experiments, Teachers, Teaching

027.P2

Physics of alternative energies a proposal for exploration didactic of physics concepts around of solar water heater

Jonas Torres-Montealbán[1] and Leonardo Gonzalez Coghlan[2]
[1]*Chapingo Autonomous University, Mexico*
[2]*Freelance designer, Mexico*

As a teaching-learning approach, a solar water heater was studied in the alternative energies course with Pre-college level students in the Chapingo Autonomous University, that is, those students completing the requirement course in order to be admitted at the college level. This study will show how the construction of a solar heater improves the learning process linked to physics concepts through the worksheets. The growing interest in clean energy requires understanding the functioning of the alternative energy systems like termosolar energy. The exploration didactic improved the learning process linked to the physics concepts, when worksheets are used in the physics lab and a mutimedia system. Each worksheet contain six elements: 1) Problem, 2) Situation, 3) Prediction, 4)

Experiment, 5) Comparison, and 6) Conclusion. The multimedia allows the teaching of physics concepts in order to be incorporating pictures, videos, texts and computing animations. This approach has been designed in four stages. The first stage defines the theoretical framework of the proposal called "exploration didactic". The second describes the didactic model, which consists of three kinds of worksheets: conceptual, phenomenological and experimental formal. The third stage includes the discussion about the information collected and how the construction of a solar heater improve the Physics learning process among Pre-college students. Finally, the evaluations into worksheets are assessment tools for this multimedia, and the resources will be validated between physics teachers in order to know their usefully.

Keywords: Physics of alternative energies, explorative didactic, pre-college education (ages about 19), multimedia

Topics: ICT

060.P2

Syllabuses Evaluation of Mechanics in Distance Degree in Physics

Marcello Ferreira[1] and Maria Verdeaux[2]
[1]*CAPES, Brazil*
[2]*Universidade de Brasília, Brazil*

This work aims to present the methodology and preliminary results of an analysis of syllabuses disciplines of General Mechanics in distance courses degree in Physics offered by public institutions of higher education in Brazil in 2010. The desired approach is supported to one evidence and two assumptions: the evidence is the rapid growth of distance education in Brazil, recognized its irreversibility in the current educational context and its potential for training and qualification; the first assumption is that the research in science education and the application of its results are catalysts for improving Brazilian education, and, second, that the General Mechanics sets the conceptual structuring axis of a scientifically critical and reflective thinking, put in the service of qualified higher education in Physics. Established these principles, there is the following problem: how to configure the degree courses in physics in distance mode in the fabric of General Mechanics? To what extent the educational projects of these courses and their curricula are positioned opposite a conventional curriculum Mechanics General requirements established in the Brazilian educational system? The search for answers to these questions implies a contrast between the educational projects of undergraduate courses in Physics and measuring the distance of his approach to a conventional curriculum of General Mechanics, academic and legally defined. Preliminary results of the research presented here point to the fact that the curricula of the courses studied approach, on average, approximately 70 % of conventional content considered minimal by the methodology of this study. These results raise a thorough discussion of the causes and consequences of this phenomenon for the sake of qualification training in these courses.

Keywords: Curriculum, teacher training in physics, distance education, general mechanics, distance degree in Physics

Topics: Curriculum, Teachers

114.P2

Understanding the electric field inside the material

Rodolfo Espíndola[1], Gabriela Del Valle[2] and Guadalupe Hernández[2]
[1]*UAM/UAEMEX, Mexico*
[2]*UAM, Mexico*

In elementary college physics courses are reviewed basics of electrostatics, such as Electric Field, the electrostatic conductive materials, etc. Explain to students that in conditions in which the conductor is isolated and the static charges, the Electric Field inside the conductor is zero. The explanation in the literature for this problem induces to students to make mistakes and to confuse the use of the above conditions, when dealing with charge densities for the electric field inside a conductive material. In this paper we review the most important concepts, discusses the most common learning problems with these concepts, we propose a help to address these issues.

Keywords: Electrostatic, electric field, teaching

Topics: Teaching

130.P2

Inquiring 5 years old pupils on MST perceive

Marisa Michelini, Lorenzo Santi and Stefano Vercellati
Research Unit in Physics Education, University of Udine, Italy

Curriculum analysis is based on different perspective in literature (Beauchamp, 1986; Walker, 2003) with significant distinctions between attributed curriculum meaning (Clements, 2007). To have a global vision of the curriculum, the analysis of the documents is not enough, but the investigation of the acted end perceived curriculum had to be done.

Is it therefore necessary to developed instruments and methods, mainly based on questionnaires and interviews, to investigate the main aspect of the curriculum at the level of teachers and students (Kuiper et al, 2011). Following the metallization of the curriculum proposed by Van den Akker (2003), who proposed to represent curriculum as spider-web in which the main subjects and aspects of the curriculum and the curricular research take place at different levels (rational, aims and objective, content, learning activities, teacher role, materials and resources, grouping, location, time, assessment).

In the framework of the pilot study of the EU SECURE project, the scientific curricular perception of 5 year old pupils was investigated in two classes by means oral interviews, analysis of the class-context, and the submission of a questionnaire using two different strategies.

The two strategies adopted for the questionnaire were developed In the context of a university-school cooperation: iconographical representations and the use of replying strategies that transform the filling task in a enjoyable activity for children but, that, at the same time, guarantee the quality of the collected avoiding at least the mutual influences between the pupils.

The two strategies adopted will be described and the data collected, their significance for the two adopted strategies, the contribution that those data give in the investigation of the pupils perception of the curricular will be discussed.

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Keywords: Pre-school education, kindergarten, math science tech curriculum

Topics: Curriculum

145.P2

A didactic strategy centered three-dimensional models and their impact on the understanding of Gauss's law in differential form

Angel Antonio Rojas Garcia[1], Cesar Eduardo Mora Ley[2] and Sonia Janeth Lopez Rios[3]
[1]*UCC, Colombia*
[2]*IPN, Mexico*
[3]*UdeA, Colombia*

It's not a secret the complexity that many physics concepts represent for students of basic, middle, and even college level; added to this, the poor mathematical training of most of them, which turn into students having frequent failure of college physics basic courses, and even more, into students dropping out.

All of the above allows us to think of the prevailing necessity of proposing strategies of teaching and learning that provide students and teachers tools, which turn physics into a science more accessible to everyone, in such way that promote students active learning, and on teacher the opportunity of making the physics class a more dynamic and participative place.

Our proposal is framed on the implementation of a didactic strategy based on three-dimensional computer models with AutoCAD to support the teaching-learning process in the subject of Electricity and Magnetism in the engineering programs of Cooperative University of Colombia, located in Ibague; National Polytechnic Institute (Mexico), and University of Antioquia, Colombia. We are presenting to you this research work where is articulated in an interactive and integrated way: text, model, and a group of a variety of virtual activities in order to facilitate the comprehension of the abstract aspects that the study of Gauss Law in its differential form implies, in which the essential function is to improve the classroom environment, harmonizing it with a collaborative setting and generating an independent and positive attitude on students, toward the mathematical models that come from it.

The theoretical framework that oriented this study attends to the main concepts of the Active Learning Theory (Sokoloff) and the Mental Models Theory by Johnson Laird. As of this, a quantitative type study of a quasi-experimental kind is formulated, having a control group and two experimental groups.

The results obtained permit infer that the Physics students who the didactic proposal focused on the tridimensional model was implemented with got a conceptual, procedural, and attitudinal contents learning, as well as a cognitive skills development, that were reflected in their academic performance.

Keywords: Three-dimensional model, Gauss law, active methodologies, AutoCAD

Topics: ICT

153.P2

Introducing students to experimental research work: astrophysical jet visualization with fluids

Andrea Muñoz Gutierrez, Estela Margarita Puente Leos and Marcos Ley Koo
Departamento de Física, Facultad de Ciencias, Universidad Nacional Autónoma de México, Mexico

This project is part of a series of experiments designed and carried out by students to fulfill the requirements of an elective course in the undergraduate physics curriculum of the Universidad Nacional Autónoma de México. The aim of this course is, among others, challenge students to study experimentally a problem of their interest, motivated either by their own curiosity or an existing research problem. The students must propose a experiment, which shows their knowledge and creativity. They must consider that they should use easy to find and affordable material as well as the availabilty of laboratory facilities. The teacher plays only a guiding role.

The experimental problem, in this project, is a current research problem in Astrophysics: namely, the simulation and study of plasma jets ejected by different celestial objects (such as young stellar bodies, radio galaxies, black holes and X-ray binary systems). In order to understand this complex phenomena, several studies have been performed with observations, theoretical models and numerical simulations. Recently, laboratory experiments with high-energy density plasmas made possible to get supersonic magnetized jets similar to astrophysical jets. Hypersonic jets have also allowed to visualize similar jets and to analyze their time evolution. Motivated by these experiments we were able to visualize shock waves produced by air jets.

In this project, jets at supersonic speeds were produced by using compressed air, syringe needles (for medical, veterinary and gastronomical purposes), a laser pointer and a common lens from a standard optics laboratory, which allowed us to observe well defined shock waves. These jets can be a visual aid for Relativity, Astrophysics and Fluids courses (depending on its approach) for undergraduate students.

The course's design relies on and enhances the students' capabilities, since they must do a bibliographical research, look for the material, equipment and facilities before writing the proposal, do the experimental work and write the final report, to realize if the original goal was accomplished and to what extent. By doing this, they will have a better idea of how research life really is. In this particular case, the jet project's originality rests on the student's ability to solve the experimental problem using syringe needles, laser pointers, common optical lenses and the University compressed air's facility, instead of high energy plasmas or electromagnetic pulses, specially made mirrors and nozzles, and high intensity lasers.

The presentation of the work includes the experimental set up, photographs of the jets obtained by the students as well as improvements and extensions of the experiment.

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Keywords: Low costs tools for teaching, experimental teaching, visualization aids, astrophysical jets

Topics: Experiments

156.P2

A Cell Phone Operated Robot

Syed Ali[1] and Syed Naseem Hussain Shah[2]
[1]*Aligarh Institute Of Technology, Karachi, Pakistan*
[2]*Federal Urdu University of Arts, Sciences & Technology, Karachi, Pakistan*

In Technical Institutes, applied physics is introduced for understanding the concepts of physics. Since the students have very little knowledge of basic concepts of electronics, we assign them small projects to enhance their learning. The themes of the projects are selected according to their social environment and needs. Cell phone Robots are the major research area of today and they are significant due to their frequency and working range which is as large as the coverage area of the service provider. Nowadays Cell phones are largely used by public and students and its awareness has revolutionised the whole world. Keeping in view the use of cell phone, we have introduced some projects based on the use of cell phones. One of these projects is “Cell Phone Operated Robot”. In this project the robot is controlled by a cell phone that makes a call to the cell phone attached to the robot. During a call by pressing any button, a tone corresponding to that button is heard at the other end of the call. This is called dual tone multiple frequency (DTMF) tone. The robot perceives this tone with the help of phone stacked in the robot. The received tone is processed by the microcontroller AT tiny 2313 with the help of DTMF decoder IC CM8870 and output is given to motor driver IC L293D which drives the two DC motors.

The aims of this project are:

1. To explore different uses of cell phones.
2. Involve the students into research based activity
3. To overcome the limitations of working range, frequency and control.

While assigning the project, it is ensured that the components are easily available, their cost is low and within the access of students. We divide the students into groups of 5 students. One of the best among the 5 students is selected as the group leader to maintain the discipline and standard. This group is supervised by a teacher who looks after day to day matters about the project and helps the students in every aspect.

At the end of the project, we also collect data on students’ performance during working on the project and assess by taking interview and giving them a pre and post-test. It has been observed that students learned a wide range of knowledge, for example; from the use of breadboard to the PCB, from tracing of circuit to the trouble shooting, from reading the values of resistors to the pin configuration of the ICs, and from hardware to software.

In this presentation, we will exhibit the details of our project in the poster as well as the working model of the project

The applications of such robots are very useful in our social context, especially in remote areas where the service provider exists. We can use these types of robots in these areas by placing some sensors like temperature sensor, water level sensor etc. in them to monitor these quantities without reaching there. We can also fix a camera to them to record videos and images of such places where we cannot go or where we have security problems.

Keywords: Robot, trouble shooting, social context, temperature sensor

Topics: ICT

160.P2

SCLPX – A New Approach to Experiments in Physics at School

Čeněk Kodejška, Roman Kubínek and Jan Říha
Palacký University Olomouc, Czech Republic

Conducting experiments in physics by usage of modern measuring techniques, particularly computers are much often more attractive to students than conventional ways of experiments. SCLPX - Sound Card Laser Pointer eXperiments deals with experiments in physics under which such equipment as a computer sound card as a measuring device and other available physical devices such as a laser pointer, photodiode or solar cell, electrets microphone, etc. are being used. The work is mostly based on the experience with the kit ISES and presents alternative experiments in physics that can be used directly as demonstration experiments in classes of physics or as students' attempts in a laboratory work. The most important advantage of the proposed experiments is a relevant low cost of the basic equipment and the fact that all of the proposed experiments could be repeatedly conducted at home individually.

Detailed work procedures and laboratory protocols for individual experiments will be published step by step on http://www.sclpx.eu.

Basic informations about experiments are translated to English.

At present we have prepared and tested 20 experiments in the field of mechanics and sound waves. Another 30 experiments dealing with the properties of solids and liquids, electricity and magnetism or quantum physics are in the process of screening. All the experiments have been tested at the Nový Bydžov high school.

Keywords: Experiments in physics, laboratory works, laser pointer, solar cell, photodiode, PC microphone, Free Audio Editor, Visual Analyser, low cost of basic equipment

Topics: Experiments, ICT

164.P2

M – Learning Resource Center for Schools

Konstantin Rogozin[1], Diana Kondrashova[2], Sergey Kuznetsov[3] and Ulyana Pshenova[1]
[1]Altay State Technological University, Russian Federation
[2]Altay State Technological University, Uzbekistan
[3]Tomsk National Research Polytechnic University, Russian Federation

In the modern market the index of penetration of mobile devices (MID) is much higher than this index for personal computers. At the same time, there is a process of replacement of the traditional PCs for mobile devices. In addition, their power, multimedia and communications capabilities are increasing. That allows to use them for access and effective representation of multimedia content, as well as the basis for the creation of physics laboratory-hardware complexes, including the use of robotic devices.

In our opinion, schools alone can not make transition to mobile technologies on their own. This is due to the fact that modern information technologies require a variety of professional support in all stages: from creation to use in educational practice. Schools do not have such opportunities. In addition, teaching has a large inertia. Majority of teachers are either unwilling or unable to use the new technology. And we can to teach them.

In 2013, M – Learning Regional Resource Center for Schools is being created at the State University of Technology. The main tasks of which are:

- integrating of variety professionals in the same team: in applied mathematics, computer science, physics and physics teaching methods;
- development of software, physics laboratory-hardware complexes, content, and materials for teaching physics;
- providing training for teachers on new educational technologies;
- leasing equipment to schools.

The complexity of the project's functionality is ensured by the work carried out in four areas:

1. Software M – Learning:

Development and implementation of new tools intended for direct access to educational content and laboratory equipment with the use of MID; Development of software for support of M - Learning invariant to the basic software of the MID-devices.

2. Content-providing M – Learning:

Use (subject to copyright) of the best multimedia content and the creation of its own, which would be brought by using the LMS (for example, Moodle); Integration of educational content in a single network resource; Organization of the access to foreign information resources with the support of the native-language interface.

3. Mobile physics laboratory designers:

Construction of the laboratory-hardware complexes for physics on the principle of technical designers, which allows you to effectively resolve the contradiction between the minimization of the element base of the complex and significant increase in the number of experiments that can be conducted based on it; Writing methodological support for the use of mobile designers in physics.

4. Mobile robotics:

Layout of the composition of robotic kits, supplemented by sensors measuring physics variables; Writing methodical support of educational process with the use of robotic complexes and for the integration of robotic complexes with mobile physics designers.

Keywords: Secondary education: upper (ages about 15-19), resource center for schools, software M – Learning, content-providing M – Learning, mobile physics laboratory designers, mobile robotics

Topics: Experiments, ICT, Learning, Teachers, Teaching

168.P2

Laboratory experiments for faculty students based on the spring model

Katarina Susman[1], Daniel Dziob[2] and Mojca Cepic[1]
[1]*Faculty of Education, University of Ljubljana, Slovenia*
[2]*Jagiellonian University, Institute of Physics, Poland*

The mechanical model for phase transitions was introduced in Girep-Epec 2011 conference in the symposium on Liquid crystals. Springs were used to visualize the differences between two kinds of phase transitions – the continuous and discontinuous [1]. The »single spring« model was than further developed to »multi-spring model« with ambition to show the liquid crystalline molecules in a layer. Additional studies of the model revealed many other possibilities.

The “multi-spring model” consists of several springs vertically fixed in a plate. A second plate – movable in vertical direction – serves for changing the level of support for springs. At certain height above the supporting plate the shape of the springs changes from the straight to the bent or vice versa (this is reminiscent to the single spring model for the phase transitions). In this contribution we focus on the experiments with the straight springs. The spring model perfectly shows the oscillation of the connected system, where many parameters can be changed (adjusted). One can adjust the distance between springs, the length of the springs and the connections between springs.

The model is used to study the propagation of the waves through elastic media (series of springs), the influence of the bonds between springs on the damping of the waves, the determination of the wave velocity etc. The movement of the springs is taped with the video camera and analyzed with a Tracker (free access program).

In the contribution we present the development of the laboratory experiments for the physics and science university students. The set up of experiment and examples of the problems will be presented and discussed. Students' work and results will be followed for several years on two universities (Jagiellonian Universtity in Krakow, Poland and University of Ljubljana, Slovenia).

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Keywords: Mechanical model, laboratory work, oscillation

Topics: Experiments

174.P2

The Models and the process of Modelization on Physics Didactics

Rosa Nidia Tuay Sigua
Universidad Pedagogica Nacional, Colombia

The main scientific activity consists in the modelization of the phenomena described by physicists, chemists and biologists. This process is evident in the classroom, when after its implementation, the students adapt their thinking in a similar approach to the concepts developed by science.

If the construction of models as a key element of the scientific representations is adressed in a correct way, it will improve the teaching and learning of Physics in the initial formation of teachers by means of valuation and application of new curricular proposals.

The use and construction of models in Physics manifest the fundamental function they execute in the science and didactics, because the scientific intuition given by those models incite the teacher's epistemologic and methodlogical reflection in any scientific aspect, due to their importance linking the conceptual world with the empirical investigation objects, the models represent the study objects in front of the human reason court (Tuay, 2012). The study on the models and the process of modelization consists in understand the mechanism of construction and change of those representation forms, as well as the proposal, application and evaluation of new curicular schemes in which this teaching and learning perspective can be implemented.

Amongst the possible hypothesis that reference to the addressing of models and modelization, there are the following statements:

The models are not taken in account as simple material objects, but as representations that can be materialized in different forms.

- They present diferent evolutional stages: Some of the are more nuclear than others, that are peripheral or can be found at the frontier.
- They have been assigned different interpretations, possilbe meanings and knowledges, including those tools that are considered pure as laboratory instruments as expressed by Galison (1988).
- It is assumed that all the objects that comprise human culture have an ideal or virtual and a material dimension that is present in the texts and images. It is possible to evaluate the learning through the material dimension of the models, and it can be transfered to other tasks and contexts, to new and multiple conditions, new applications, new problems and investigation pipelines.

Throughout the investigation, the modelization of the mechanical phenomena proposed by the Universidad Pedagógica Nacional's Physics teachers in process of formation is tracked, through the therothetical ideas that the students present in form of diagrams, photography or using formal and natural laguages that are materialized in diverse paper or screen inscriptions.

Some activities, supported on experimental processes that aid on the introduction of new points of view, as well as synthesis points, that enable the confrontation of the students's models using analogies and metacognitive strategies.

The systematization of this experience and the presentation of the results of the investigation compose an essential contribution for the community that is present on the proceedings of the International Conference of Physics Education.

Colombia, as different as other countries, the Physics teacher process of formation is given throughout the first years of the undergraduate course, and as a consequence, the disciplinar and the pedagogic formation is parallelized.

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Keywords: Physics teaching and learning, scientific models, modelization, physics teachers initial formation

Topics: Teachers

175.P2

Teaching solar physics in a partnership between formal and informal education

Pedro Colombo Junior and Cibelle Silva
Universidade de São Paulo, Brazil

This research focuses on curriculum innovation and the introduction of modern physics in the Brazilian high school based on the partnership between formal and informal education. We established the construction and use of a Teaching Learning Sequence (TLS) that incorporates elements of the classroom with activities in a science center, taking into account the teaching knowledge and specificities of both institutions. The TLS elaborated translates into the idea of teaching with emphasis on the content, in this case on the teaching of modern physics using solar physics in different collaborative contexts. In a partnership between educators from science centers and school teachers, we investigated the process of didactic transposition of content from solar physics and modern physics in the context of formal and informal education. The science center concerned is the Dietrich Schiel Observatory in the University of Sao Paulo's Center for Scientific and Cultural Dissemination, Brazil. The methodology used in the construction and implementation of the TLS was developed and is entitled "cycles of reflection", understood as continuous research actions that provide, at every stage of investigation, didactic and pedagogical support for the teacher-researcher partnership.

Solar physics is an interdisciplinary subject that allows the contextualization of modern physics topics. We discussed with students the matter constitution and energy production within stars. The observation of phenomena on the solar surface, such as sunspots, allows the discussion of the nature of the Sun as a dynamic star and concepts of electromagnetism and thermodynamics. Using a spectroscope, built to observe the lines of the solar spectrum, we discussed the electromagnetic spectra, the nature of the spectral lines, atomic models, blackbody radiation. We also estimated the solar photosphere temperature using simple and low cost experiments.

The research subjects were four physics teachers. We held eight preparatory meetings with around 40 hours of contact activities. The implementation of the TLS occurred between August and October 2012, and about 30 hours of audio and video recordings were collected; ten separate, semi-structured interviews were conducted with teachers and students; records of lesson observations were made, and 127 student worksheets (support materials) were analyzed. The TLS designed, implemented and analyzed was considered satisfactory and comfortably in tune with the current physics curriculum in Brazil, proving the partnership between formal and informal science education to be viable. It also became evident that teacher preparation was essential for the successful progress of the project in the classroom and in the Observatory. This fact emerged as a fundamental issue when considering the working partnership between the school and the science center. We further conclude that it is possible to promote curricular innovation in the high school and the introduction of modern physics, using solar physics content, in the classroom when the theoretical assumptions of didactic transposition are observed.

Keywords: Formal and informal education, curriculum innovation, modern physics, teaching learning sequence, teacher of physics

Topics: Curriculum, Informal Physics Teaching & Learning, Learning, Teachers, Teaching

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184.P2

A simple kit for detecting quantitative changes in energy

Yaron Lehavi
The David Yellin Academic College of Education, Israel

Energy is often conceived as an abstract concept which can hardly have a unique measure. This view rests on the fact that the energy of a system is relative and described by different variables: height, speed, length (of a spring) etc. This might be one of the reasons for viewing energy as a collection of concepts ("energy types/forms") which are difficult to interrelate. While this is true for the concept of energy, quantitative energy change can be detected by measurement of temperature change caused by different processes: falling, stopping, contraction etc. Thus, performing such experiments in class has the potential of unifying the concept of energy and rendering it more concrete.

However, while some experiments which involve temperature change are simple and can be easily performed in class, others, mainly those that aim to reproduce Joule's experiments, involve more complicated devices.

Here we demonstrate a kit which includes a very simple, low cost, do-it-yourself device with which one can measure the heating caused by a falling weight, a contracting spring and by stopping a spinning wheel. The device is assembled from a thermometer and everyday objects such as a bottle wine cork and soft drink bottles. In addition, the kit also includes means to measure energy change via temperature change of other processes such as chemical reactions, light absorption etc.

Activities for students involving constructing this Joule-like device and means to employ it in searching for a common feature of different processes will be presented.

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Keywords: Energy concept, simple experiments, classroom activities

Topics: Experiments, Learning, Teaching

187.P2

Arduino and Processing: Introducing new technologies in classroom

Filipe Santos
IFRJ, Brazil

In this work we present some possibilities of using two free tools to help Physics teachers: arduino and processing. These two tools use the same concept of open sourcing which make them easy to use due to the great amount of examples in the Web. Another advantage of using free tools with open source is that teachers can modify the given examples to adequate them to their reality. The low cost of arduino and the several sensors that can be connected to it, as well as the easiness of the processes related to the programming, makes this microcontroller ideal to create a great variety of experiments to be performed/used in Physics classes. This hardware is programmed through processing language, which has a friendly communication interface. We proposed the usage of those two tools to create experiments that allow teachers to deal with the increasing necessity for new technologies in classrooms.

Several possibilities of constructing experimental apparatus will be presented and discussed. The main point of this work is to present two low cost experiments: using a webcam to measure volume of balloons and the period of a pendulum; and using arduino + processing to construct a wireless workstation to monitor temperature, pressure, humidity, etc. in a classroom. Due to their compactness, those experiments can be used in Physics labs, as well as in Physics classroom. One important benefit is that the experimental apparatus that will be shown has the capability of measuring the physical observable in real time mode. Plotting acquired data in real time – using a data-show – allows teachers to stimulate students to infer about the studied phenomenon. A further possibility to create an interaction between real (servo motor) and virtual (projected image captured from a camera) world will also be presented.

Keywords: Secondary education: upper (ages about 15-19), university education, Arduino, processing, low-cost, experiments, augmented reality

Topics: Experiments

189.P2

New technologies in teaching physics

Jaroslav Reichl
SPSST Panska, Prague, Czech Republic

I have been teaching for 13 years in the technical secondary school. Students have in their timetable the lessons of physics divided into two parts. They listen to the lectures, watch motivational and demonstration experiments and their knowledge is tested during the common lessons of physics. For the second type of lessons of physics students there are divided into two groups. These lessons are for laboratory classes. During these lessons students can try some experiments, solve tasks and make measurement of assigned physical quantity.

I usually want to show physics as a beautiful, logical and very practical science. For this reason I try to use some interesting way how to show to the students that physics is not boring science full of difficult formulas. I want to make my students think about problems, about method of solving the problem and about obtained solutions - if they are real or not.

That is why I use in my lessons very simple aids/tools to demonstrate basic physical principles and physical laws. I use ordinary things like small balls, bottles, cans and others. Students can repeat these experiments next lessons to consolidate their knowledge. Students also can prepare these experiments at home for their siblings or friends. This is very important for them - they improve their physics substantially.

The second type of my favourite aids is new technology. But I do not require buying any gadgets from my students! If they have them, they can use them during some type of measurement. If they do not have them, it is not a problem. They can work in groups with other students or they can do measurement with school aids. I use new gadgets (computers, mobile phones, tablets) because students usually like it. They are very good at working with these gadgets and they have a plenty of applications for measuring or display measured values. Students usually work with new measuring equipment (for example Vernier sensors). Measuring with these technologies is very easy and quick. Students have to summarize the measured values, display graph and found mistakes or data inconsistencies at the end of laboratory class.

My students measure with new measuring equipment the dependence of physical value. I describe two examples.

When students know the basic properties of semiconductors, they measure some of their parameters. I prepare the list of tasks for them. These tasks are focused on measuring the dependence of electrical resistance on temperature, volt-ampere dependence of thermistor, diode or photodiode, the dependence of threshold voltage of LED diodes on wavelength of light with maximum radiation intensity etc. These tasks are chosen to describe important the properties of semiconductors used in practise. Students can use new measuring equipment (Vernier sensors) or traditional instruments (ammeter or voltmeter). They have to measure values, do graph of these values and try to find theoretical equation of measured dependence. They cooperate with other students in the groups of four students. They can discuss the measuring methods, aids and circuit diagram. I prepare a plenty of semiconductor devices and students can choose the right of them.

The second examples concern the value of the horizontal component of magnetic induction of Earth's magnetic field. When students know coil and they are able to describe its magnetic field, I ask them a question: What is the value of the horizontal component of magnetic induction of Earth's magnetic field? I prepare some hints for students to focus them to coil and its magnetic field. For this measuring I have made a model of coil from copper wire of length about five meters and PET bottle. It is only a model but equal for solenoid which gives very good solutions. And this is great! It is very beneficial for students to know the correct description of some device (coil) and imperfect model which is usable for students measuring. Students measure electric current by Vernier sensors or traditional ammeter and then they calculate the value of magnetic induction. This measuring is interesting because of finding important parameter (with very small value) of Earth with simple aids.

Other activity of using new technologies is watching films during physics lessons. But we do not watch the whole films! I have chosen some very famous films and prepare short extracts from them. (Sometimes students prepare extracts from their favourite films.) Students try to find in these extracts physical nonsense, they can try to explain some interesting part of films and also to calculate some parameters of device from film or parameters of hero (velocity, power or force). Some of devices' or heroes' parameters are sometimes very strange and unreal. Students like this activity because they know these films and they enjoy it. But during this activity they study some more about physics. They have to discover problems without teacher or without reading text in textbooks and then they have to solve it. This activity is appropriate example how to find some mistakes and inaccuracy in newspapers, in TV news or in declaration of politicians. There are inaccuracies or lies in many cases.

I would like to show some of my activities on my poster. I usually take photos during laboratory class; my students know it and they do not have any problems with this.

Keywords: Secondary education: upper (ages about 15-19), new technologies in teaching physics, laboratory class

Topics: Experiments, ICT, Teaching

205.P2

Science toys

Katerina Lipertova
Cirkevni gymnazium, Plzen, Czech Republic

The poster presents science toys made by pupils (aged 11-14) from The Catholic Grammar School in Pilsen (CZ) and some other school projects.

Making science toys is a real crossing - border activity, it includes Physics, Mathematics and Art. Making toys is loved by kids because it's both, science and fun. Toys are made from common household materials but they demonstrate scientific principles very well.

Among the most favourite ones belong: dancing bugs with an eccentric motor, pencil-legged drawing robots, cardboard automata, marble machines, the Archimedean screw and water pumps, optical toys and illusions, balancing toys and a legless bench.

The activities such as the hot-air-balloon day, the water rocket competition, building a solar oven or Leonardo's self-supporting bridge are also very popular with students. The school has even got own Bottle Orchestra, the musicians play the beer bottles, water pipes and one-string guitars.

Keywords: Science toys, school projects, playful physics

Topics: Informal Physics Teaching & Learning, Teaching

206.P2

Influence of peer discussion on confidence in ConcepTest responses

Maykon Gonçalves Müller, Ives Solano Araujo and Eliane Angela Veit
Universidade Federal do Rio Grande do Sul, Brazil

In order to promote greater engagement among students during class time, some instructors use classroom response system (CRS). Students use the CRS (e.g. clickers) to answer questions and teachers use response feedback to make pedagogical decisions based on that feedback. We highlight one instructional method where the use of CRSs is prevalent, Peer Instruction (PI). In PI, teachers give a brief lecture on a concept that lasts no more than twenty minutes, and then deliver a ConcepTest (a short conceptual question). Students respond and if the frequency of correct responses is between 35% and 70%, teachers guide students to form small groups, preferably with peers who have chosen different responses, and discuss for about three minutes. After discussion, students vote again. Studies show that after peer discussion, the class generally converges toward the correct answer. However, it is less clear whether students are getting more (or less) convinced about the validity of their answers to these important conceptual questions. In this study, we evaluated student confidence in their ConceptTest responses, for each round of voting. We posed the following research questions: Does discussion among peers promote an increase in the degree of confidence that students have in their own response? What is the relationship between the level of confidence and the number of correct/incorrect responses? The study was conducted in a class of 34 students at a Federal Public High School, located in Porto Alegre – Brazil. The instructional sequence was related to topics of Electromagnetism, during two months over seven class meetings. On average, three ConcepTests were used per class. The study analyzed 12 ConcepTests that resulted in peer discussion. The results show that there is a statistically significant increase in the confidence level of one's own response after discussion among peers. This increase appears to be more significant when students choose the correct answer on the second round of voting. Furthermore, the results show that, after peer discussion, the higher the confidence level, the higher the percentage of correct responses. Through these results, we conclude that peer discussion, besides encouraging greater interaction in class, promotes an increase in students' confidence about their own responses. In parallel, data suggests that peer discussion increases the number of correct answer choices with high confidence.

Keywords: Secondary education: upper, Peer Instruction, confidence level, Peer discussion

Topics: Learning, Teaching

209.P2

A Summer Maths-Physics Camp

Petr Kácovský, Věra Koudelková and Marie Snětinová
Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic

Nowadays, many schools face students´ decreasing interest in physics and maths. For us, physics teachers, it may be a motivation to improve the students´ perception of these subjects but equally to care for "rare" active and enthusiastic students keen on physics (or generally on science). Our main goal is to offer these students a possibility to informally develop their science knowledge and manual skills, and also to help them find friends with similar interests and in friendly atmosphere to stimulate their personal and social development.

In our contribution we will describe The Summer Maths and Physics Camp, a two-week event for secondary school students (age of 14-19) organized by the Faculty of Mathematics and Physics in Prague for about 25 years. Of course, during this time the form of the camp went through significant changes.

Traditionally, our summer camp takes place during summer holidays in locations apart from big cities. In recent years, about 40 participants take part in this summer camp per year.

The focus of the scientific part of the programme lies not only in theoretical, but especially in practical projects. Two or three participants choose one project together, during two weeks work on it and finally present their results on the closing conference; each project has its consultant – the organizer who supervises the work. Besides projects, the scientific programme involves courses of mathematics and physics (both in three levels according to students´ knowledge and self-confidence) and since 2012 the IT course as well. In addition, every year we invite experts from our faculty and other scientific institutions who prepare interesting lectures for our participants.

The leisure programme is based on concept of experiential learning and it should lead students to cooperation and team thinking. It consists of separate afternoon and evening games connected into a coherent story, a legend, carefully elaborated and original for each year.

It is important that after their graduation, our participants often start their university studies in science and technical branches, many of them at our faculty, and belong to the best prepared. In addition, the summer camp plays an important role for university students – future math and physics teachers – who lead the summer camp. They have the possibility to manage a secondary school students groups and to get in contact with experienced organizers - secondary school teachers.

In our poster presentation we will present some remarkable projects from the latest summer camps, the schedule of a common participants´ day and our experience with organizing such a type of event. Our know-how that makes our summer camp very sought-after event may be interesting for conference participants.

Keywords: Summer camp, mathematics, physics, secondary school students, science projects

Topics: Experiments, ICT, Informal Physics Teaching & Learning

216.P2

Adapting diagrams from physics textbooks: improving the autonomy of blind students

Alexandre O. Martins, Adriana G. Dickman, Amauri Carlos Ferreira and Lucas Mateus Andrade

Pontifícia Universidade Católica de Minas Gerais, Brazil

Social inclusion in Brazilian schools is guaranteed by law. This process demands effort and willingness to understand the epistemic organizations of each field of study. Despite this, very little has been done to improve instruction of blind students. As a consequence, teachers face a lack of suitable methods and materials for teaching these students. Although, the use of figures is a very common didactic resource in science classes, such as diagrams illustrating Physics, Biology and Geography situations, we verify that, in general, the figures or images in textbooks are suppressed when they are converted into Braille. This practice increases the challenges blind students face in the classroom. In this context, we ask: How are such diagrams or figures described to a blind student? Does the description allow a proper interpretation by a blind student? To determine how pictures are actually described for blind students in classroom activities and exams, we interview three blind students using the oral history method, and analyze the recorded narratives to characterize their school experiences. The data define the relationship between the student and a reading assistant, and some of the difficulties the students face in understanding the figures in textbooks. In general, the description of these figures is inadequate, using terms and analogies unknown to the students. Based on these results, we elaborate a glossary consisting of a set of objects and their symbols, based on a model for representing figures in Braille. The symbols in the glossary are designed to represent objects frequently used in mechanics diagrams, such as vectors, ropes, pulleys, blocks and surfaces, and can be used to adapt drawings of physics situations in textbooks for blind high school students. The educational product was tested at the São Rafael Institute in Belo Horizonte (state of Minas Gerais), a specialized school for the blind. The test consisted of an interview in which the symbols were introduced to four people, together with the objects they represent and situations illustrating their use; simple questions helped us to verify if the interviewee was able to identify the objects and understand the situation as a whole. Three participants, all high school students, had difficulties in understanding the symbols, and needed an oral description to visualize the situation. One participant, whose work involves adapting texts and figures into Braille, understood the symbols and visualized the situation easily. We believe that adequate training will help blind students to become familiar with the symbols, and to identify them in a problem without the need of a description. We also believe that our educational product will help blind students to achieve the same conditions of autonomy as sighted ones, when studying physics.

Keywords: Secondary education: upper, physics education, blind students, autonomy, diagrams, inclusion

Topics: Socio-cultural Issues

217.P2

Planning Activities to Teach Kinematics based on Geometrical Software

Sara Daraei[1], Azita Seyed Fadaei[2] and César Mora Ley[3]
[1]Department of Mathematics, Sharif University, Tehran, Islamic Republic of Iran
[2]Department of physics, Instituto Politécnico Nacional, Mexico City, Mexico
[3]Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada del Instituto Politécnico Nacional, Mexico

Learning concepts related to specific phenomena becomes easier and more effective when learners are allowed to experiment them with their own senses. Science classrooms are filled with the voices of teacher and students, it is clear that communication and learning in the classroom are achieved by more than just linguistic tools. Therefore a learning tool which involves the sense of seeing should be welcomed, especially if it is easy to implement. In this plan Mathematical part of Yenka software is used for creating the facility to help students try to explore position and movement concepts related to kinematics, in the virtual space. Yenka Mathematics is a free of charge program that lets students experiment easily with 3D mathematical models, to learn about statistics, probability, geometry and coordinates. It can be used as a flexible demonstration tool and there's a wide range of ready-made lessons and activities that they can use in their lessons, and a set of training videos to help them get started.

Some researchers have identified and analyzed specific difficulties that students have with the kinematical concepts and their graphical representations, and with the relationship of the concepts and graphs to the real world. Also Students have difficulties with vector kinematics and relating kinematical concepts with their graphical representations and motion of real objects. Even after instruction many students confused position with velocity and velocity with acceleration. In this work we planned some activities in Yenka environment to help teachers and students to study kinematics subject. The main steps of planning these activities (for example about distance and displacement) as follow:

1. Taking a pre- test questionnaire about distance and displacement from text book for discussing in groups.
2. Motivating students to find the relation between distance and displacement concepts in real life.
3. Using Yenka to concentrate on real life using distance and displacement samples in Yenka .
4. Using Yenka to find the solution of problems in questionnaire step 1 in classroom as a problem solving method.
5. Discussing about concepts in each group and show results to class.
6. Using Yenka to solve more problems in this subject.

Keywords: Kinematics, geometrical software, high school

Topics: ICT, Learning

224.P2

Processing and visualization of measurement results in physical laboratory

Michal Cerny
Department of Physics, Faculty of Education, Masaryk University, Czech Republic

Specially processing of the measurement results is not very popular students work and is often also strongly pedagogically neglected part of lessons. At this point it must be said that handwritten protocols with drawn charts are not so useful for students. They do not receive an overview of how the results are processed outside the school and they do not learn how to write science texts on computer. That may lead to an unpleasant consequence in their future. Often we can see that the charts are created and analyzed in programs such as MS Excel or LibreOffice Calc. But this software was designed primarily for business applications and if students work with them it may teach them quite a bad habits especially in analysis and data visualization. Total work with them is for the purposes of analyzing the results very inconvenient and limited.

Graphs have very little variability settings, reading of values is also problematic as well as interleaving curves. And I think we do not need to do much talking about problem with identifying errors. Students are literally pushed to interleave the curve not by using functional dependencies but simply using sufficient scale to match the shape of a paper protocol according to the theoretical assumption. It is obvious that such a conceived work in the physical laboratory is not dispose of good quality in the field of evaluating results.

For this reason it seems appropriate option to reach for one of the programs that is directly specified for working with charts and analysis. In the poster we will try to focus in greater detail on some free programs that can be used for work during the measurements using (for example SciDAVis, QtiPlot, LabPlot, …).

Keywords: Secondary education: upper (ages about 15-19), university education, visualization, measurement, ICT, SciDAVis, QtiPlot

Topics: ICT

232.P2

Classroom settings for science lecture to realize inspirational learning and teaching

Shinjiro Ogawa
Waseda University High School, Japan

The science activity in school is not only lecture where a teacher talking to 40 students. It ranges from 100 people watching demonstrations to individuals reading textbooks ore solving scientific problems. Inspirational learning and teaching can be realized by using versatile environment for science lecture [1].

Science rooms designed for a newly-established school in 2010 with concrete examples of classroom settings for several types of activities in science lecture will be introduced in the presentation.

References:
[1] Department for Children, Schools and Families, Project Faraday: exemplar designs for science, 2008

Keywords: Laboratory design, active learning, classroom setting

Topics: Experiments, Teaching

234.P2

Formation of research competence in student's physical and technical specialities

Oleg Lavrishev[1], Akmaral Imanbayeva[1], Saule Baimuldina[1] and Rabiga Syzdykova[2]
[1]Institute of Experimental and Theoretical Physics, Kazakhstan
[2]Almaty University of Power Engineering & Telecommunications, Kazakhstan

At present system of physical education in the Republic of Kazakhstan is in a state of modernization, which requires the development of new approaches in pedagogy. One of this areas is the development of a competent approach. There is no doubt that a necessary component of the training of physicists is developing in students a general scientific competence, providing them with the experience of the research activities. In this respect, the most promising are the stages of integration of education with the fundamental science and industry. The integration of basic and professional knowledge of the Physico-Technical faculty of the al-Farabi Kazakh National University is the conduct of scientific research and practices on the basis of the Institute of Experimental and Theoretical Physics (IETP), the National Nanotechnology Laboratory of the open type, and other, as well as the revitalization of the work to attract students to carry out scientific work. IETP, since its founding in 1992, promotes Physico-Technical faculty in the preparation of qualified scientific personnel and specialists in physical, engineering and technical fields. The Institute provides its logistical base for research practice for undergraduate and graduate majors "Physics", "Technical Physics", "Nuclear Physics". Successful educational activities of the university is not conceived without it high-impact research, including extensive involvement of students. Currently IETP is implementing research projects and grants successfully participating students, masters and person working for doctor's degree.

Leaders of many research papers, graduate works of students, masters and person working for doctor's degree are members of the Institute.

Conducting research practices directly in academia, the performance of individual stages of research papers by students showed deepening theoretical knowledge of students in the specialty, mastery of modern methods of scientific research, develop their skills of independent search of scientific and technical information, the acquisition of the ability to analyze research results and to form conclusions. Thus, the experience of participating IETP training leads to the conclusion about their effectiveness in improving research competence of students of physicotechnical specialties.

Keywords: Research competence, specialists in physical and technical fields, research practices

Topics: Learning

237.P2

Noise Pollution in Project Teaching

Marie Volná
Palacký University, Olomouc, Czech Republic

Nowadays, the trend is to search for topics that are able to join together Science subjects and to look at one topics of different field of Science. Especially, the environment and is the most common use word. This poster shows a way how to teach students about noise pollution. The project introduces 6 different activities which can be used in secondary school level. The project link up knowledge of different subject Physics, Biology, English, Art, Technology and involve ICT technology as well. In the beginning the USA TV show “The Doctors” provides motivation. Then the students can test their hearing, search information about noise pollution and its effect on human health and do creative work with information on computer or using art to present it. There is also an experimental part in which the students use their mobile phone to measure noise pollution around school or home and do conclusion of their results. A critical thinking as an art is involved in the project. The project Noise Pollution in our environment contains different ways how to discover knowledge about surroundings through varied parts of Science.

Keywords: Environment, health, ICT technology, noise, physics, project teaching

Topics: Learning

240.P2

Interesting Facts about Tides You Might Not Have Known

Tomas Franc
Charles University in Prague, Czech Republic

One of the most difficult parts of teaching physics is to help students become well motivated. Astronomy gives a great opportunity for this, especially the topics which students do not know – or they know only a part of a more complex phenomenon, which can surprise them with something very interesting. This is the case of the tides. Students imagine only tidal waves (high and low tides) but that tides occur also on other planets they have not known (or they just have not had that idea). At the poster we will present tidal effects on other planets than just on the Earth, for example the tidal effect on Triton from Neptune and on Phobos from Mars (these moons have retrograde movements), the other tidal effect on Io from Jupiter (there is volcanism) and cryovolcanism (which occurs on several satellites, for example on Europa from Jupiter). We will include also the Roche's limit and its relation to planetary rings. On the poster we will present the results of simple calculations of tidal forces on selected moons. All this should help motivate students in studying physics or astronomy.

Keywords: Tides, tidal forces, Roche's limit

Topics: Learning

243.P2

Physical Experiments CD-ROM

Stanislav Gottwald
Gymnazium Spitalska, Czech Republic

The poster describes the CD-ROM entitled "Physical Experiments" , which was created within the optional seminar "The Selected Chapters from Physics" by the group of 2nd and 3rd-year students attending Gymnázium Špitálská (grammar school located in Prague 9). Not only does the CD-ROM capture the experimental part of the seminar, but it also stimulates individual experiment on the part of students. Certain sections may serve as a suggestion for students' self-study.

The aim of the presentation is not only the description of the experiments but also, if possible, the inspiration to research itself. I am convinced that some parts might be used in the physics classes or self-study. Therefore many of the experiments and related theories are explained. On the other hand a few of the try-outs motivate students to individual experiments; these parts could be considered solely as suggestions for self-study (e.g. the part on friction and rolling resistance). Moreover, several parts are accompanied by photos as well as videos.

The presentation itself is divided into six sections: Atmospheric pressure, Bullet speed measuring, Molecular physics – Molecular structure of liquids, Phase transition, Leidenfrost effect, Rolling resistance. Each section is divided into several chapters. These can be run from the main screen or via hypertext links.

Keywords: Secondary education: lower (ages about 11-15), secondary education: upper (ages about 15-19), school experiments, labs, physical experiments, CD-ROM

Topics: Experiments, Informal Physics Teaching & Learning, Learning

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245.P2

Project PROFILES and Development of in-service Teachers' "Stages of Concerns" Regarding IBSE in the Context of the Implementation of PROFILES Modules in Georgia

Marika Kapanadze[1], Ekaterine Slovinsky[1], Claus Bolte[2] and Vincent Schneider[2]
[1]*Ilia State University, Georgia*
[2]*Freie Universitaet Berlin, Germany*

The PROFILES project is a four year European FP7 funded project in the field of "Science in Society", aiming at disseminating Inquiry-Based Science Education (IBSE) in Europe (PROFLES, 2010; Bolte, Holbrook, Rauch, 2012). To achieve this, the PROFILES partners are using and conducting innovative learning environments (PROFILES type Modules) and programs for the enhancement of teachers' continuous professional development. Both supportive action strategies are supposed to raise the self-efficacy of science teachers to enable them to take ownership in more effective ways in science teaching, so as much students as possible can benefit from the PROFILES approaches of teaching and learning science.

In the frame of the PROFILES project in-service science teacher trainings were conducted at Ilia State University, Georgia. To get an insight into profession-oriented attitudes of the in-service science teachers and their development, who participate in our CPD courses, we adapted a German SoC questionnaire (Schneider & Bolte, 2011; 2012) in accordance to Hall and Hord (2011) focusing on IBSE and the PROFILES lesson modules. Our investigation is based on a treatment-control-group-design with two occasions of measurement (at the beginning and at the end of trainings).

In our presentation we will focus on the "SoC profiles" of the treatment group and the control group.

The results of our investigation which we will present and discuss during the poster session – show a positive impact of our CPD courses on the participating physics teachers' professional attitudes.

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Keywords: Inquiry-Based science education, in-service science teacher trainings, physics teachers' professional attitudes

Topics: Learning, Teachers, Teaching

252.P2

An attitude survey on radiation for university students by questionnaire and the trends in radiology education in Japan

Akira Akabane
Saitama Medical University, Japan

On March 11, 2011, the Great East Japan Earthquake caused the Fukushima-Daiichi nuclear power plant accidents and after 4days, radioactive materials were spread to the surrounding area, then many people and students were thrown into a panic.

We made an investigative team up at my university staffs and conducted survey of understanding / awareness of the radiology subject to medical students by questionnaire. Survey radiological items related are as follows; learning time, unit, knowledge, contamination, deterministic effect, stochastic effect, mechanism of radiation damage and free description, etc. The survey results indicate that their greatest concern is on the radiation health effects throughout the school year. Free descriptions showed the following, lack of knowledge, fearfulness, deterioration of the environment, inaccurate press coverage, confusing government reaction, etc. In the poster presentation we will show the results of questionnaire with 15items and their analysis results and the trends in radiology education in Japan. We will discuss how the students think about the radiation effects and handle foods containing radioactive materials in daily life.

Keywords: University education, radiology education, response to reactor accidents, student attitudes and understanding level, survey by questionnaire, radiation health effects

Topics: Learning, Socio-cultural Issues

258.P2

Programming simulations as a way to understand physical laws

Pavel Kuriščák and František Lustig
Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic

While basic physics education is now focused on the inquiry-based phenomenological approach, we believe that the next step in understanding physics lies in the realization of one's ability to effectively describe and predict the real world using appropriate tool - the calculus.

Physics and calculus appear so deeply interconnected, that teaching them simultaneously should considerably benefit both. To greatly simplify the mathematical side of the topic, adoption of the finite difference framework might be beneficial, since in our view it lowers the required mathematical skills to upper-secondary level.

We present ideas and initial study of the web-based learning environment, which is currently under development and that implements this approach. It contains interactive learning materials centered around learning mechanics. It also provides participants with programming interface, allowing them to develop their own numerical simulations of various processes. This should provide them with mathematical insight while simulating interesting problems (e.g. nonlinear, coupled, multi-body, two-dimensional etc.). Final part of the learning environment involves access to the remote laboratory experiments, where the participants will be able to test the predictive power of their models.

Keywords: Secondary education: upper, e-learning, simulations, programming, finite differences, remote experiments

Topics: ICT, Teaching

261.P2

Introduction of Nanoscience and Nanotechnology in a Brazilian Secondary School through a partnership between the School and a Public University

Allan Victor Ribeiro[1], Alexys Bruno-Alfonso[2], Moacir Pereira Souza Filho[3] and Sergio Rykio Kussuda[4]

[1]*Sao Paulo State University – UNESP, Department of Physics, Faculty of Science and Educational Center 358, SESI/SP, Brazil*

[2]*Sao Paulo State University – UNESP, Department of Mathematics, Faculty of Science, Brazil*

[3]*Sao Paulo State University - UNESP, Department of Physics, Chemistry and Biology, Faculty of Science and Technology, Brazil*

[4]*São Paulo State University – UNESP, Graduate program in Education for Science, Brazil*

Emerging areas of knowledge, such as Nanoscience and Nanotechnology (NC&NT) have already affected our present day society and may determine its future [1]. In this sense, a scientific and technological literacy is needed at all levels of the educational system, and this task has been partially performed worldwide [2]. Moreover, since it involves interdisciplinary concepts and techniques, new educational methodologies should be devised and tested [3]. In the case of the secondary education, the experiences with NC&NT are quite incipient, contrasting a rather omnipresence of science and technology in the main broadcasting media. In the case of Brazil, several diagnosing works and proposals have been published [5], and the present contribution offers the science teachers a number of tips for effective pedagogical practices to introduce NC&NT as a part of their work. Our investigation involves a diagnosing of the previous knowledge and interest of the students on the ideas of NC&NT, presentation of the main achievements and challenges, concrete proposals for the collaboration between teachers of different disciplines, and visits of the students to research laboratories at Unesp – State University of São Paulo, Brazil. A group of 77 students of an upper secondary school in the city of Bauru, SP, Brazil, has participated in the didactical and scientific dissemination activities. They showed both a rather limited knowledge of the subjects of NC&NT and a strong interest to learn about them.

Acknowledgements. The Brazilian Institutions Unesp and SESI/SP and the Iberian-American Network NanoDyF have partially supported this work.

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Keywords: Secondary education, nanoscience, nanotechnology

Topics: Curriculum, Socio-cultural Issues, Teachers, Teaching

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262.P2

Architectonics of Problems Brought Closer to Real Life

Lea Valentina Lavrik[1], Vladimir Meir Shunyakov[1] and Josef Feigenberg[2]
[1]*Lifshitz Academic College, Israel*
[2]*Jerusalem Interdisciplinary Seminar, Israel*

To prepare a student for the new, fast-changing, unconventional conditions it is evident that a new system of educational problems is needed, possessing the informational structure typical for real situations. We shall call such construction which embodies the structure of real-life situations, architectonics (from architecton (Greek) – builder).

Traditional educational problems have as a rule one clear-cut correct solution. Real life, however, very often confronts us with situations where it is impossible to foresee with complete certainty their further development. Meanwhile, it is precisely this prediction, this prognosis, which determines the choice of means to achieve a desired result. The prognosis of further development of events, including the results of one's acts, has probabilistic character. Therefore, to prepare the student to decision-making in such conditions, there must be included, among various exercises, also problems that only allow probabilistic solution.

In real life, the question, more often than not, arises before we are in possession of all the necessary information. We have to decide precisely which data is necessary and sufficient for us to answer this question. We have to obtain this information, to seek it actively. Thus, problems with missing data must be included among the exercises offered to a student. Superfluous information confuses the pupil, impedes his work. And yet life problems more often than not present us with a wealth of data which are not needed for the solution of a given problem. Therefore, it is necessary to teach, as early as school, how to choose among the multitude of data precisely the ones that are needed to solve this particular problem. This means that problems whose conditions contain superfluous, unnecessary data must also be included in the teaching process.

Also it is worth considering the problems with a given solution, where the purpose is to detect a possible error in the offered answer.

Just as essential are evaluating tasks which arise frequently in research in natural sciences where it is important to know how to assess the scale and the order of values one deals with while solving a problem or conducting measurements. For instance, there are some evaluating problems

1) Under what conditions is a form of solar bunny does not depend on the shape of the mirror?
2) How fast the beetle has to run to flip over?

Sometimes we are asked: If exercises with new architectonics are so essential, why do not schools and universities include this type of problems in their teaching process? They do (as evident from such manuals as: Fermi's problems' or Kapitsa problems), but not, in our opinion, to a sufficient degree.

We believe also that it would be useful to build a bank of educational problems of various architectonics, for various fields of physics, which will enable the teachers to introduce such exercises widely into their everyday teaching practice.

Keywords: Problem solvig, real life, architectonics

Topics: Learning, Teaching

263.P2

Sheet of paper as a model to explain the concept of wave length

Giri Cahyono
MAN Serpong, Indonesia

There have been many references to teach the definition of the wave (transverse and longitudinal) mainly by using slinky. However the authors have not found a model or a tool to explain the particulars of a single wavelength.

A description of the wavelength only describes the distance between the peak or the distance between the crest still confuse some students.

Therefore we need some other way to explain the concept of wavelength by using the tool. This method uses free tools around us are able to explain the relationship between a circle (or ellipse) with a single wavelength.

The method is: each student was asked to make a circle with a marker on a piece of paper. Then the paper is torn into pieces in such a way, then assembled back into some form of a single wavelength.

In this way, students are able proven active learning and students are able to explain the concept of wavelength with their own language. And they were glad, because it is similar to preparing puzzle!

Keywords: Learning method, learning styles, learning model, wave length concept

Topics: Learning

269.P2

Experimental activity: conceptions and development of an instructional design based on investigative teaching

Dayane Carvalho Cardoso and Eduardo Takahashi
Universidade Federal de Uberlândia, Brazil

This paper presents both an analysis of the conceptions of researchers in physics teaching on experimental activity and a proposal of instructional design based on some of these conceptions to be used while performing a remote experiment. Remote experimentation consists in carrying out a real experimentation through the Internet, in which the user can view and control the experimental

apparatus as in hands-on laboratory. The analysis of the conceptions about experimental activity was carried from articles found in journals in the field of Education and based on Leontiev's Activity Theory. We tried to identify these concepts, especially the consciousness of applicant in relation to the role of activity in experimental physics teaching, the proposed actions (conceptions of strategies used in an experimental activity) and the intended goal (what is intended with the experimental activity). From these analyzes, we selected those that, in our opinion, were consistent with the proposal of an investigative teaching and we elaborated an instructional design to be used while performing a remote experiment for determining the charge-to-mass ratio of the electron to high school students. We tried to avoid that our proposal of investigative teaching was reduced to an imitation of the scientific investigative procedure by the students, but that could promote an attitude of interest in autonomous construction of their knowledge. Thus, we consider that the experimental activity must constitute as a problematical situation to the student, attempting to stimulate the autonomous discovery, the integration of knowledge, and the development of scientific memoirs, beyond to potentialize the collective dimension of the scientific work and developing students' critical thinking. The remote experiment has the advantages of secure access to the experimental apparatus, from anywhere and anytime, enabling the student to unlimited repetition of the experiment to check the data and testing new hypotheses that may arise during the data analysis related to the phenomenon, without requiring the physical presence of an instructor or lab technician. We will present an instructional design which is composed by a virtual teaching and learning environment with hypermedia instructional resources and synchronous and asynchronous communications, in which some problem-solving situations are presented to the student and the access to the remote experiment is reached by teacher or student from different access areas with specific permissions to each one.

Acknowledgements: The authors thank UFU (Brazil), CAPES (Brazil) and FAPEMIG (Brazil) for financial support.

Keywords: Secondary education: upper, activity, instructional design, remote experimentation

Topics: Experiments, Learning, Teaching

270.P2

Energy, power and climate change in physics lessons

Anikó Tasnádi
Karinthy Frigyes Gimnázium, Hungary

Energy crisis and climate change are both among the vital and yet unsolved problems that mankind must face in the 21st century. Though from the media we can learn about many catastrophes – floods, droughts, hurricanes – devastating different regions of the world, and continuously experience the increase of the price of electricity and gasoline, in Hungarian schools not much is taught about the different energy sources and global warming.

Realising the importance of these topics last year a questionnaire was given to the final year students (18-19 year old) in order investigate their physical background knowledge, and to find out how much they know and understand. This year some of the two years younger students were asked, and a teaching material concerning climate change and energy crisis was gathered. For example: the students could list some greenhouse gases, but did not know how they cause the warming of the Earth. The majority of the students were able to understand the answers and explanations concerning to the questions, and though they sometimes considered quantitative explanations difficult, they found the section interesting and useful.

To make students understand the greenhouse effect, as background knowledge the blackbody radiation, Stefan-Boltzmann law, Wien's law, and a little thermodynamics must be introduced. Using simple models the surface temperature of the Earth can be estimated without and with the atmosphere.

The explanation of Coriolis force and the general atmospheric circulation enables the introduction of the basic models of mid-latitude cyclones, anticyclones and tropical cyclones. Depending on the level of knowledge and ability of students, qualitative or quantitative explanation of the thermodynamics of the hurricanes can also be given.

With the help of the collected material a deeper insight is aimed to be given, in order to clear the beliefs and misbeliefs connected to the greenhouse effect and the global warming. In the poster the questionnaire, the collected teaching material, and some (easier and more difficult) models like the one-layer grey atmosphere model, hurricane as nature's steam engine and its super-Carnot efficiency are presented.

Keywords: Climate change, atmospheric models, hurricanes, questionnaire

Topics: Learning, Teaching

299.P2

Optics Conceptual Test for Research of Learning Styles in Physics

Blanka Zajacová
Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

Nowadays learning styles are discussed especially in pedagogy or in didactics of arts. There is a developing trend to respect differences between the learning styles of individual pupils. We suppose that for physics education it would be beneficial to find out if there is some learning style preferable because learning of natural sciences may include its particular specificities. [1] For this purpose we pursue a research that will compare learning styles and strategies of students with excellent and below-average results in physics. It could allow teachers to choose appropriate methodical tools to provide good physics learning environment to different types of students and to improve the effectiveness of physics education. Some researchers studied the correlation between learning styles and achievement of high school and university students in kinematics. [2] Our

research is aimed at optics because of two reasons: 1. it has not been explored in terms of learning styles and it contains topics with both a low level of abstraction (geometric optics) and a high level of abstraction (wave optics). 2. in the Czech Republic optics is usually taught in last two years of high school studies, when the students probably have their learning strategies fixed as reactions to their preferred learning style.

In this contribution we present our conceptual test in optics and its development. This tool was developed to assess student's understanding and interpreting of basic principles of geometric and wave optics. The test items are based on existing international conceptual tests in optics (LSCI [3], Cox and Junkin [4]). The content validity of test and also items representing the actual high school curriculum were emphasized. To validate this test and to verify if it meets expected time demands a pilot study is needed. We present results of a preliminary pilot study that included several tens of students. A full pilot study is scheduled.

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Keywords: Conceptual test, geometric optics, wave optics, secondary level education

Topics: Learning

350.P2

Optics - The spatial and spectral properties of light sources (inquiry-based learning with ICT)

Lenka Ličmanová and Libor Koníček
University of Ostrava, Czech Republic

Physics is a very important field necessary for the development of modern civilization. Today the students are not interested in science. Undoubtedly important part of today's modern education is information and communication technology. The research says that students want to use ICT in learning and also want to experiment themselves. Use of information and communication technology in student's experiments seems to be a good and interesting idea. This is not a simple experiment, but inquiry-based teaching, which contributes to the development of student imagination, and to better understanding and to better remembering the curriculum.

The aim of this work is to create a set of inquiry-based learning experiments using ICT. These experiments should development creativity, increase the level of knowledge and skills and teach students to work with ICT. In particular, students should be able to work with a data logging system and then to process and evaluate the measured data using some program such as Excel. Then students have to create a protocol. The protocol has the following parts: name and enter tasks, tools, theory, measurement procedure, measurement data, processing, conclusion.

Students will address some of the following issues:

Problem No. 1: In everyday life we encounter the concept of lighting. From parents and teachers we hear that it is important to read and work with adequate lighting. What is the dependence of illumination on the distance from the light source?

Problem No. 2: What kind of light source can be used to achieve maximum illumination at low cost? How much light do a bulb, energy saving lamp, LED lamp generate? Is the illumination the same in all directions in space?

Problem No. 3: Is the light of bulbs, of energy saving lamps or of LED lamps good for the eye? Compare the spectral properties of these sources with the spectral properties of the sun.

Inquiry-based teaching should contribute to the overall development of students, both in terms of knowledge and skills to develop creativity, as well as to develop skills for learning, problem solving, social and personal, communication and working.

Inquiry-based teaching should have its place in teaching, because as the old Chinese proverb states: "Tell me and I forget, show me and I remember, let me do it and I understand."

Keywords: Inquiry-based learning, ICT, data logging system, optics

Topics: Experiments, ICT, Learning, Teaching

Poster session 3, Thursday 11:00-12:00

046.P3

Nathan Rosen and Ukraine (1936–1938)

Oksana Koltachykhina
G.M. Dobrov Center for Scientific and Technological Potential and Science History Studies of National Academy of Sciences of Ukraine, Ukraine

Nathan Rosen was an American-Israeli theoretical physicist who noted for his study on the structure of the hydrogen molecule and his work with Albert Einstein and Boris Podolsky on entangled wave functions and the EPR paradox.

Nathan Rosen was born into a Jewish family in Brooklyn, New York. He attended MIT where he received a bachelor's degree in electromechanical engineering and later a masters and a doctorate in physics. In 1935 he became Albert Einstein's assistant at The Institute for Advanced Study in Princeton, New. After briefly working for two years in the Soviet Union at the Kyiv University starting in 1936, he returned to the United States, where he taught at the University of North Carolina at Chapel Hill from 1941 to 1952. In 1953, after permanently moving to Israel, he joined the Technion in Haifa, Israel. He was a founder of the Israel National Academy of Sciences and the Humanities and the Israel Physical Society.

Our report is devoted period in the Rosen's life in Kyiv in 1936–1938. This life period is a little-know. During his Kyiv period he published several papers that are unknown. How he came to Kyiv, what he did and analysis of his works are discussed. In his Kyiv period Nathan Rosen worked at the Institute of Physics National Academy of Science of Ukraine and taught at the Kyiv University: "I am working at the Physical Institute of the Ukrainian Academy of Sciences, doing research, and I also lecture at the University of Kiev".

It should be noted that Nathan Rosen taught in English and his lectures were translated into Russian.

After Einstein's correspondence with Molotov to permit to work Nathan Rosen in one of the institutes of the USSR, academician National Academy of Science of Ukraine A.G. Goldman (director of the Institute of Physics National Academy of Science of Ukraine) was summoned to Moscow: "Summer of 1936, to the Institute received a letter written on behalf of the Presidium of the USSR Academy of Sciences from Doctor of Physical and Mathematical Sciences V.M. Vul with an invitation to work at the Institute Dr. Nathan Rosen, a young American theoretical physicist closest collaborator of Professor Einstein. I [A.G. Goldman] immediately went to Moscow, found out the circumstances of the next offer and met with Dr. Rosen took action to approve it at work at the Institute, which was achieved after overcoming a major difficulty" [from the A.G.Goldman's archives]. During Kyiv period Nathan Rosen published thee works: Of plane waves in the general theory of relativity (1937); Corrections to the atomic model of Thomas-Fermi (1938); Elementary particles in the field theory (1939).

Keywords: Nathan Rosen, Ukraine, A.G. Goldman, the Institute of Physics National Academy of Science of Ukraine, the Kyiv University

Topics: Socio-cultural Issues

062.P3

A simple experiment, but not a trivial explanation! Reflection and circular polarization in 3D glasses

Jair Lúcio Prados Ribeiro and Maria De Fátima Da Silva Verdeaux
University of Brasília, Brazil

A simple experiment can be conducted using a polarizing glasses, used in 3D film screenings. Looking in the mirror while wearing these glasses, the viewer closes one eye. The lens covering the opposite open eye will appear black, while the closed eye is normally seen. Although it may seem trivial, the explanation of the experiment involves the understanding of circular polarization concept.

Keywords: Secondary education: upper, optics, reflection, polarization

Topics: Experiments, Learning, Teaching

133.P3

Applying the "Colorado Learning Attitudes about Science Survey" to Physics in Italy

Fabrizio Favale[1] and Maria Bondani[2]
[1]Universita' degli Studi dell'Insubria – Dipartimento di Scienza e Alta Tecnologia, Italy
[2]Consiglio Nazionale delle Ricerche – Istituto di Fotonica e Nanotecnologie, Italy

The CLASS questionnaire (http://www.colorado.edu/sei/class/) was used to check learning attitudes about Physics in Italy.

The aim of the investigation is threefold:

- Collecting opinions and perceptions of students about learning Physics to give suggestions to High School teachers to improve teaching.
- Looking for possible correlations between the choice of the University studies (e.g.Physics, Chemistry, Biology or Medicine) and the perception of the Physics.
- Trying to devise different strategies within the Piano Lauree Scientifiche (PLS) devoted by the Italian Ministery of Education to support the access of students to Hard-Science courses.

To validate the CLASS questionnaire for the use in the Italian context, we made a translation of the original survey and gave it to a number of professors, researchers and PhD students at University of Insubria at Como. We analyzed the results according to the analysis instruments developed by the Colorado University and checked that the answers of the Italian experts actually fitted to those of the American experts.

In order to understand the evolution of the perception of Physics with the age of the students, the survey was administered to different samples:

- High-School students of the last two years participating to PLS laboratories and to LuNa project for teaching optics (http://luna.dfm.uninsubria.it/).
- Students of introductory Physics courses at several Italian Universities (Insubria, Milano-Celoria, Milano-Bicocca, Napoli, Palermo).

Preliminary analysis of the results show that there is a great similarity between the answers of Italian students and those of American ones, both for what concerns the perception of Physics and the differences among the opinion of students and experts.

Keywords: Learning attitudes, survey, students' opinion and perception

Topics: Learning, Socio-cultural Issues

195.P3

Teaching Newton Laws Based On ICI and ISLE in High school

Azita Seyed Fadaei[1], Sara Daraei[2] and César Mora Ley[3]
[1]IPN, Islamic Republic of Iran
[2]Department of Mathematics,Sharif University,Tehran, Islamic Republic of Iran
[3]Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada del Instituto Politécnico Nacional, Mexico

Newtonian mechanics is perhaps the most extreme example of the failure of science teaching at the high school. This paper is a pure research about planning some activities for undergraduate students in level 10 in High school to teach Newton Laws. The research focuses on ICI (Interactive Conceptual Instruction) methodology for teaching Newton Laws based on formative assessments. These formative assessments are built on ISLE environment. Developing an understanding of mechanics requires an interactive process in which there is opportunity for ideas to be talked through, and thought through, between teacher and students. Depending on ICI we planned some activities in this case to help students to analyze the Mechanics situations using Newton laws. These processes involve observing, finding patterns, building and testing explanations of the patterns, and using multiple representations to reason about physical phenomena.

Basic ideas of planning activities was found from Investigative Science Learning Environment (ISLE). ISLE is a comprehensive learning system that provides a general philosophy and specific activities that can be used in “lectures” (interactive meetings where students construct and test ideas), recitations (where students learn to represent them in multiple ways while solving problems) and labs. Each activity starts with a demonstration related to the subject of study. Activities are designed to show force concepts in real life. Their discipline using verbal description, pictures, graphs, motion diagrams, charts, free body diagrams. Hence it might be expected that these activities would offer the potential to promote enhanced learning gains in conceptual understanding of Newton Laws.

Keywords: ICI, ISLE, high schools

Topics: ICT, Learning, Teaching

207.P3

Implementing inquiry teaching to improve students' understanding of electromagnet and scientific explanation ability

Junyi Chen
National Chiayi University, Taiwan

Scientific explanation is the core of scientific work. The documents of science education reform suggested that students are literate citizens of great ability to reason, analyze and communicate information and understand scientific explanations. The purpose of this article was to investigate students' understanding of electromagnet and scientific explanation ability after inquiry teaching. The subjects were 6 sixth grade students from an elementary school in Taiwan. Several inquiry activities which integrate with the strategies of scientific explanation were designed to guide these students to explore and discuss electromagnetic phenomena and practice making scientific explanation. The pre-post tests were adopted to collect data. The electromagnet conception test has 20 items and the scientific explanation test has 5 items. It was found that all students acquired higher scores on electromagnet conception test. They realized an electromagnet is a type of magnet in which the magnetic field is produced by the flow of electric current after teaching. They were able to increase its magnetic field by changing current, adding batteries and putting iron inside electromagnet. However, half students confused magnetic pole with geographic pole. In addition, most students made an appropriate claim but they cannot provide evidences and reasons in the pre scientific explanation test. Through inquiry teaching, they can use sufficient evidences to support their claim and give reasoning that is consistent with their claim and evidence. Thus, the inquiry teaching which stresses on scientific explanation is effective to raise students' electromagnet conceptions and scientific explanation abilities.

Keywords: Secondary education: lower, electromagnet, inquiry teaching, scientific explanation

Topics: Learning

235.P3

The Human Heart as an Interesting Interdisciplinary Topic in Lessons of Physics and Biology

Marie Volná
Palacký University, Olomouc, Czech Republic

Many attractive topics which are close to each others can be found in the curriculum content of Physics and Biology. One of these interesting topics is the heart and circulatory system in our body. This topic was processed and a module was created. The module links up knowledge of Physics and Biology. In this poster the heart and circulatory system as interdisciplinary topic is introduced as we were teaching students. The main part of the poster is attended to the experiments where the

primary role play EKG sensor EKG-BTA Vernier. There are introduced some easy experiments for lower secondary children but also more complicated experiments for upper secondary school students.

This interdisciplinary topic was chosen for a small experimental research. The first-year bachelor students of Physics were involved in the research. The task of the research was in order to determine if the students in the bachelor level of study are able to find some connection in Physics and Biology in this topic. And if they are able to describe physics phenomena in our body and explain what is happening when somebody has the heart attack or which physics phenomena are useful for measuring blood pressure, etc. In the poster the research results are detailed.

Keywords: Biology, electric potential, electrocardiogram, experimental research, heart, physics

Topics: Experiments, ICT

275.P3

A new teaching methodology inspired on Role-Playing Games and the Activity Theory

Maykell Figueira and Eduardo Takahashi
Federal University of Uberlândia, Brazil

Games are pedagogical tools that arouse curiosity, allow a mutual exchange of experiences and opinions among participants and create an environment favorable to the birth of new and good ideas. In this aspect, the sort of games chosen for a didactic project has a big influence on which abilities and concepts will be constructed in the cognitive structure of the apprentices. One game style that has been shown as very effective in the development of new teaching methodologies is the RPG (Role-Playing Game), a worldwide known and widely spread game style with several scientific papers pointing it as the new way to teach, since it brings out the ancient art of storytelling.

With this work, we aim to present new paths to approach the main concepts of Geometrical and Physical Optics within a methodology created for high-school ages, whose thematic center was guided by a RPG developed by G2T Group (Games to Teach) from the Massachusetts Institute of Technology (MIT) in partnership with Microsoft, a group that has created many educational game prototypes. The game "La Jungla del Optica" (The jungle of Optics), an interactive narrative adventure that allows players to immerse in a complete learning experience, was adapted to fit into a 12 hours methodology, during which experimental sessions and interactive softwares were used as skill builders among a group of 50 students (such as build and test simple lenses and telescopes; focalize sunrays lighting up a fire; repair a camera; shoot photographs with many kinds of media; send rescue signals using optical devices etc.) The entire work was registered in the form of written interviews and video recordings, by means of which it was possible to investigate the personal meaning of the participants about the role of games in Optics teaching. In order to adapt this methodology to a 12 hours experience, we invited the students to 4 meetings of 3 hours each at the

University's Science Museum, a place used to develop interactive demonstrations and sky observations.

Under the Activity Theory's perspective, developed in the middle 19s by Leontiev, Luria and Vigotski, such personal meaning differs from the social context when all those involved in the educational process (teachers, students, pedagogical coordinators etc.) do not comprehend why and how to apply an educational game, seeing it merely as an entertainment item. This work acts as a reconnection bridge between the personal meaning and the social context of classroom games, focusing specially on RPGs. This reconnection is necessary once the students might be able to realize that in their daily activities, such as playing cards or joining a chess club, there are very fertile chances to learn and teach.

Moreover, the preliminary analysis of our results indicates that this methodology was responsible for a drastic decrease of alienation in the educative process, which is a sign that it is a valid approach and it can be adopted and applied in other workplaces, making the necessary adaptations depending on the facing reality. We acknowledge the financial support given by UFU (Federal University of Uberlândia), FAPEMIG and CAPES and to all the students, professors and other collaborators involved in this work.

Keywords: Role-Playing Game (RPG), active learning, activity theory

Topics: ICT, Learning, Teachers, Teaching

276.P3

Students’ perception of the problem-solving process in physics

Marie Snětinová and Zdeňka Koupilová
Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

Students often struggle with many difficulties when they solve physics tasks. Understanding of these difficulties is crucial for teachers for mitigation of the students’ obstacles in solving physics tasks as well as for improving students’ problem-solving skills. For this reason, we wanted to determine main points how the problem-solving process runs in students’ minds and where they encounter problems and why. Observations mentioned in (Harper, 2006) served as the main inspiration for our research.

We focused on quantitative physics tasks. Our conclusions were based on questionnaires containing open format questions. The participants of this survey were 773 high school students (students at the age of 15 to 20), who were attending physics lessons during their studies. This contribution presents results of the questionnaire survey gained by using the grounded theory method. The results are compiled as students’ perspective on the problem-solving process in physics.

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Harper, K. A. Student Problem-Solving Behaviors. The Physics Teacher 44 (4), 2006, pp. 250-251.

Keywords: Physics, problem-solving, high school, students' perception

Topics: Learning, Teaching

277.P3

Relevance of thought-provoking experiences for teaching physics

José Luis Jiménez[1], Ma. Guadalupe Hernández Morales[2], Ignacio Campos Flores[3] and Gabriela Del Valle Díaz-Muñoz[2]
[1]*Universidad Autónoma Metropolitana - Unidad Iztapalapa, Mexico*
[2]*Universidad Autónoma Metropolitana - Unidad Azcapotzalco, Mexico*
[3]*Facultad de Ciencias, Universidad Nacional Autónoma de México, Mexico*

In the constructivist approach to teaching the students are usually confronted with thought-provoking experiences from which pertinent concepts can be developed. In the present work we propose three of such experiences which can be used with high school students. The first can be used to develop the concept of center of mass, and how motion of a particle is indeed motion of center of mass. The second experience has been used to distinguish heating from rising temperature, which in common language are taken as synonymous. Therefore the student acquires a clear concept of heat. The third experience is the radiometer, whose functioning is explained in many physics texts as resulting from radiation pressure. This experience can be used to propose alternative explanations, and discard the explanation in terms of radiation pressure.

Keywords: Constructivist approach, develop of concepts, thought-provoking experiences

Topics: Learning, Teachers, Teaching

279.P3

Remote and virtual experiments in active learning

Pavel Brom and František Lustig
Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic

Experiments are considered to be an essential part of physics education. In modern physics, however, it is challenging to perform some advanced hands-on experiments at secondary schools. For example equipment for the demonstration of the photoelectric effect or precise spectrometers are not available at schools, measurements on radioactivity are time-consuming etc. In the poster presentation we discuss the effectiveness, pros and cons of using real remotely controlled experiments and simulations within homework labs. We have used the analysis of log files from the measure-servers to support the conclusions of our pilot survey of the effectiveness of remote labs.

We often face to jams or technical obstacles. Questionnaires made with secondary school teachers have confirmed that both real remote and virtual experiments are considered to be an interesting and valuable contribution to physics education but the optimal way of their use is not clear.

We present the selected remote experiments available 24/7/365 in the Czech remote laboratory www.ises.info with suggestions how to use them in active learning during physics lessons and perhaps for the homework labs. We put emphasis on possible effective combinations and alternations of real remote experiments and virtual labs (i.e. simulations, applets), concerning more topics of advanced physics like introductories to quantum physics, optics, and radioactivity.

Keywords: University and upper secondary education, real remote lab experiments, virtual experiments, simulations, integrated e-learning strategy

Topics: Experiments, ICT, Teaching

281.P3

The Physics Learning Media Integration Tasks using concept maps

Gabriel Leonardo Castro Ronquillo
ESPOL, Ecuador

In the classrooms observed that teachers do not present an integrated teaching in isolation but which hinders student learning. It is suggested as an alternative integration method (Huber and Hutchings, 2007) but the use concept maps (Novak, 1975).

Currently, academic work requires innovation skills. Teaching a diverse student population requires more knowledge of pedagogy than before, and this advice is now extended to new areas, such as service learning and research. In most fields, the academic work is increasingly collaborative, interdisciplinary and appropriate, just as expectations are rising productivity (Hutchings, Huber, and Golde, 2003).

"A concept map is a technique (strategy, tool or resource) to represent and organize knowledge using concepts and linking phrases between these concepts" (Novak)

Concept maps were designed by Joseph D. Novak to implement meaningful learning model of Ausubel. They are a learning technique or method whose function is to help the understanding of the knowledge that students have to learn and relate them you already own.

The use of these techniques help achieve meaningful learning in students.

Keywords: Integration task, concept maps, significant learning

Topics: Learning, Teaching

282.P3

Can Dynamic Concept Be Acquired by Drawing a Conceptual Diagram?

Minoru Sato
Tokai University, Japan

The conceptual diagrams currently used in physics are abstract and scientific figures. However, the beginner of physics without physical concepts has a possibility of understanding the abstract conceptual diagrams as concrete pictures. Moreover, in the visual expression using figures, it seems that it is hard to grasp how they understand the physical concept.

Therefore, investigation about how university students grasp the conceptual diagrams currently used in statics was conducted. As a result, the scorer of FCI by the student who draw an abstract figure was higher than the student who draws a concrete figure. In statics, the person drawing an abstract figure has a high possibility of having a dynamic concept compared with the person describing a concrete figure.

Conversely, if the dynamic concept can be grasped by drawing an abstract conceptual diagram, drawing of a conceptual diagram may be able to be used by the physics education. Therefore, the trial that makes a dynamic concept acquire by drawing an abstract conceptual diagram was performed. It was evaluated using FCI whether the students has acquired the dynamic concept by drawing an abstract conceptual diagram.

Keywords: Conceptual diagram, FCI, undergraduates

Topics: Teaching

289.P3

Experiments and Students' Individual Work

Jiří Kvapil
Gymnázium Olomouc-Hejčín, Czech Republic

I would like to introduce how I let my students learn Physics in an active way at our secondary school in Olomouc-Hejcin, the Czech Republic. It is based on the ideas of the "Heuréka" Project. I and my students focus on experiments and measurement from the 1st year (11-12 years old). It is very interesting for many of my students to prepare an experiment and to measure something in an unusual way. Voluntary homework is a very important part of their learning. They are based on DIY, low-cost equipment and bright ideas. Students love voluntary homework because of four things: they have to invent, build or discover something unusual and it is the challenge, they can involve their parents, they can show their results in front of the class, they do not have to be afraid of bad results. This way of learning is also very attractive for girls.

Each student builds a low-cost experimental kit for electric circuits. They use them at school during Physics lesson but they bring them home to practise and revise or simply to play with them.

The poster shows a set of pictures of students' work, the description of their favourite homework, the description of low-cost experimental kit for electric circuits and the students' response.

Keywords: Secondary education: lower (ages about 11-15), experiment, homework, low-cost, kit, electric circuits, DIY, inquiry based learning, IBSE

Topics: Experiments, Learning, Teaching

301.P3

Students´ Epistemological Beliefs – adapting the EBAPS instrument in the Czech Republic

Martina Kekule and Blanka Zajacová
Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

The poster describes adapting EPISTEMOLOGICAL BELIEFS ASSESSMENT FOR PHYSICAL SCIENCE (EBAPS) instrument in the Czech Republic. The tool has been created by a group of scientists at the University of California, Berkeley, and it assesses the students' beliefs along five dimensions: structure of scientific knowledge, nature of knowing and learning, real-life applicability, evolving knowledge, source of ability to learn. In contrast to MPEX or VASS survey, items of the EBAPS tool try to eliminate students' expectation of a particular science course from their epistemological beliefs. Despite the effort, the authors in their own critique of the instrument state the possibility of triggering the expectation sometimes at some students. That is why, when using the tool in (slightly) different cultural and educational environment the proper adapting of the tool is needed.

The adaptation includes not only meaningful translation into the native language, but above all appropriate statistical data processing (including for example item analysis, etc.) followed by interpretation and adjustment of the instrument. We present results based on data collected from more than 200 high school students in the Czech Republic. The tool was addressed to students during physics lessons. International audience can benefit from this poster presentation by comparison of slightly different original and Czech versions of the tool.

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Keywords: Epistemological beliefs, EBAPS, physical science, questionnaire adaptation

Topics: Learning

302.P3

High Schools Students´ Misconceptions in Electricity and Magnetism and How to Diagnose Them

Věra Koudelková and Leoš Dvořák
Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

Electricity and magnetism is one of topics in Czech curriculum for high schools´ physics. It is natural to explore how Czech high school´s students understand Electricity and Magnetism and which misconceptions are typical for them. At first we used CSEM [1], but it is intended for students of introductory physics courses at universities. Although we left out few questions, which are not taught at Czech high schools, it was shown that the survey is too abstract and difficult for Czech high schools´ students. The new Conceptual test from the area of Electricity and Magnetism, which is focused on high schools´ students, was presented at WCPE 2012 in Istanbul.

The test was slightly modified after last year pilot testing and we verified the modified version in the school year 2012-2013. There was about 200 students for pretest and posttest. Final test will be provided as a diagnostic tool mainly for Czech physics teachers, but the English version of this test could be provided too.

Results from this verification and concrete results about misconceptions from the area of Electricity and Magnetism, which students concerned in the survey have, will be presented at the poster.

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Keywords: Misconceptions, electricity and magnetism, high school

Topics: Learning

303.P3

Investigation of smart fluids properties in secondary schools

Tibor Medvegy
University of Pannonia, Institute of Physics and Mechatronics, Hungary

The electrorheological (ER) and magnetorheological (MR) fluids are complex fluids which can rearrange their structures in the presence of an electrical or magnetic field. The result of these structural changes increase the viscosity of these fluids up to several orders of magnitude. These fluids due to the controllable viscosity has emerged many applications in the modern engineering. Used as controllable shock absorbers in vehicles (MR Suspensions), as vibration dampers in washing machines and stepper motors, as torque transmission materials in brakes and clutches, or even in the field of cancer research as well.

In my work I present methods, how to familiarize high school students with the physical causes of the behavior of these advanced products of physics and materials sciences through demonstration and measurement experiments and how to prepare fluids, similar to these.

Keywords: Secondary education: upper, electrorheological fluid, magnetorheological fluid, smart material, smart fluid

Topics: Experiments

304.P3

Soap Films with Variable Frames of Prisms

Masako Tanemura[1], Masaaki Taniguchi[2], Tetsuya Iwamoto[1], Kanako Osawa[1] and Yoshinori Kitayama[1]
[1]*Osaka Kyoiku University, Japan*
[2]*Meijo University, Japan*

In 1873, Plateau, a Belgian physicist, proved that the mathematical problem which asks for the curved surface of the minimum surface area is able to be solved by using a soap film. Even for a very difficult mathematical problem, the curved surface of the minimum area can be obtained with the soap film physically stretched by the frame made from wire. It is because a soap film forms the curved surface of the smallest area by the surface tension. This experiment of the soap films is interesting teaching materials which can make students to study what kind of action the surface tension is.

We propose a new wire frame by which we can change freely the height of a triangular prism, a quadratic prism, a pentagonal prism, and a hexagonal column. When we change the height of each pillar, we easily show that the form of a soap film changes. For example, in a triangular prism, when height is small, a triangular soap film is made near the center of mass. If height is enlarged gradually, a triangular portion will become smaller and smaller. Eventually the triangle near the center of mass

is lost, and the ridgeline of a soap film is made. In this experiment we can see the minimum curved surface by a soap film move continuously by our eyes, and this is teaching materials which cause mathematical concern of students.

The purpose of this research is to clarify relation between the height of a square pillar and the form of a soap film.

Keywords: University education, soap films, surface tension, minimal surface, teaching materials

Topics: Experiments

305.P3

Peer Instruction for the age group 12–15

Jana Šestáková
Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

Peer Instruction is an interactive teaching method developed by Eric Mazur at Harvard University in the 1990s. It was originally used to improve learning in introductory physics courses at Harvard University. Peer Instruction has been adopted across disciplines and institutions mainly for high education and universities around the world. This method improves students' understanding of physics and helps overcome their misconceptions.

Learning by the Peer Instruction method has been implemented at secondary school Lingua Universal in Litomerice (the Czech Republic) since 2010 during physics courses for 43 pupils at the age of 12-15 years. The ConcepTests used at this school are from Eric Mazur's book "Peer Instruction: A User's Manual" translated into Czech and multiple-choice questions newly created according to the research on misconceptions in physics.

For collecting real-time feedback flash cards and audience response systems are used. Pupils don't practice learning with this method during every course and they don't prepare themselves at pre-class activities like Just in Time Teaching.

According to my experience as a teacher this learning method gives pupils a lot of advantages. During peer discussion pupils improve their communication skills, they try to ask correct questions and explain their opinion which is sometimes hard for them. The most interesting moments are when some children who were passive in the past can now after discussion understand the problem and try to explain the correct answer at the end of Peer Instruction period to all classmates.

Keywords: Peer Instruction, secondary school, age group 12-15

Topics: Learning, Teaching

309.P3

Impact of teaching practice on academic self-concept and self-efficacy of future physics teachers

Markus Elsholz and Thomas Trefzger
University of Wuerzburg, Germany

Content knowledge (CK), pedagogical content knowledge (PCK) and pedagogical knowledge (PK) are said to form teachers' professional action competence (Baumert, 2006). Although highly skilled in theroretical issues, applying their knowledge in practice is often difficult for future physics teachers.

Enhancing school-like interactions with pupils in a special course of study already at university might provide appropriate learning opportunities to gain students' academic self-concept as well as self-efficacy both acting on professional action competence.

In the „Lehr-Lern-Labor-Seminar" at the University of Wuerzburg future physics teachers first work out experiments on a certain topic (e.g. optics) and after this repeatedly instruct pupils in conducting these experiments. The students receive feedback from their fellow students as well as from lecturers in physics education.

A pilot study (Trefzger, 2012) suggested positive implications on students' self-rating. In this study the impact of school-like interactions with pupils within the framework of „Lehr-Lern-Labor-Seminar" on students' self-concept, academic self-concept and self-efficacy is assessed with a paper and pencil test in pre-post design. The self-concept scale (Schwanzer, 2005) is adopted from Marsh and O'Neill (Marsh,1984), the academic self-concept scale (Dickhäuser, 2002) is slightly adapted to cover the threepart structure of science teacher education according to the model of professional action competence mentioned above. Self-efficacy is assessed on a general level (Schwarzer, 1999) as well as on the specific level of science teaching self-efficacy (Bleicher, 2004).

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Keywords: Physics teachers education, academic self-concept, self-efficacy

Topics: Teachers

315.P3

A kinematics diagnosis test as an element of formative assessment

Andreas Lichtenberger
ETH Zurich, Switzerland

Formative assessment is among the most promising tools to improve learning at school. Due to its broad definition formative assessment has to be developed and adapted for every school level and teaching situation. We have designed a model of formative assessment for a basic mechanics course for Swiss Gymnasiums. One essential element of the model is a diagnostic tool. We have developed a kinematics diagnostic test that measures the student concepts and misconceptions in kinematics. Seven basic kinematics concepts have been identified. To every concept, a set of corresponding misconceptions is assigned. The kinematics diagnosis test reveals the gap between student learning and learning goals on an objective individual basis. Every student finally receives two diagrams. One illustrates the percentages of items solved correctly for each of the seven concepts and the other shows which misconceptions are still present. As the teacher gets feedback about the performance of the class, the test also discloses teaching deficits and advises teachers where lessons have to be disproved.

The test consists of 56 multiple-choice items on kinematics, each item containing one right answer and three or four distractors. Every distractor has been chosen in a way that it can be associated with one misconception. The items can be furthermore divided into three levels of abstraction: items with images, e.g. stroboscopic pictures (1), items with diagrams (2), items with tables of values (3).

The test has been performed by so far 285 students and has been adapted four times. For validation on the one hand interviews with students have been conducted in order to clarify if they have understood the questions properly and experts have been asked to revise the test. On the other hand classical test theory has been applied to the data. The Cronbach's alpha for the test has a value of 0.89. The item difficulties as well as the item-total-correlations indicate that the discriminators are well chosen. The test is going to be further validated by confirmatory factor analysis.

We have used the validated test in a preliminary study as posttest in mechanics courses at two high schools in Switzerland (56 students). The test results have revealed that often students with the same overall performance show completely different concept profiles. By means of latent class analysis groups of students with similar profiles have been identified and classified. This allows the teacher to prepare different materials such that these groups of students can work on their individual deficits and catch up. In this way a formative use of the diagnostic test is realized: teachers use the test results to adjust instructions and students adjust their learning.

Keywords: Secondary education: upper (ages about 15-19), formative assessment, kinematics diagnostic test, concept learning

Topics: Assessment & Evaluation, Teaching

323.P3

Pedagogical Content Knowledge of a Mexican Secondary School Science Teachers on Kinetic Molecular Model

Esther Marín Resendiz[1], Lina Viviana Melo Niño[2] and Florentina Cañada Cañada[3]
[1]*Universidad de Extremadura, Mexico*
[2]*Universidad de Extremadura, Colombia*
[3]*Universidad de Extremadura, Spain*

The overall objective of the present work was to characterize the initial Pedagogical Content Knowledge (PCK) of five (5) Mexican science teachers about the Kinetic Molecular Model in the first years of a new curriculum in secondary education (Science II-Emphasis in Physics). We analyze the PCK of each teacher attending the five components of Magnusson (1999): knowledge of the curriculum, of instructional strategies, of the pupils, and of evaluation and science teaching orientations.

This research is determined by a qualitative paradigm, it is based on interpretive arguments of a case and a topic in particular. We analyze quality of the answers, tools, and processes described by teachers on the teaching and learning this subject.
The participating teachers have different degrees: physics, veterinarian, engineer and degree in pedagogy with emphasis in physics, biology of science in general, with a age between 29 and 46 years, and between 5 and 15 years teaching experience. The ages of their pupils ranged between 13 and 15 years.

The data collection and analysis procedures were: (i) the curricular materials the teachers used; (iii) the lesson plans (1998); and (iv) the matrix designed by Loughran, Berry & Mulhall (2004) to represent content (ReCo), to which some modifications were made in the number of questions.

The results revealed the factors involved in his personal educational models. Teachers believe the subject is important to teach the students because they can understand abstract concepts, microscopic phenomena and basic characteristics of matter. Teachers believe the models are the only way to understand the structure of matter. If model has greater accuracy it is better.

For their, knowledge involves processes of reflection on existing theories, and consistent with this is that he considered it important to know the pupils' existing ideas. However about this topic, teachers consider students do not have a good idea about matter, only they recognize the particle as part constitutive of the matter after instructions. Teachers believe these problems are due to the preparation that students have primary school, lack of institutional support in the development of new proposals and infrastructure.

Keywords: Pedagogical content knowledge, kinetic molecular model, physics teaching

Topics: Teachers

327.P3

Effects of studying a refutational expository text on the force-motion student models, in a curriculum integrating language and physics subjects

Carlos Uribe and Alexander Bonilla
Universidad del Valle, Colombia

Guzzetti et al (1993) discusses the differential effects, on science conceptual change, of using refutational and nonrefutational expository texts in instructional interventions, across a wide range of quasi-experimental studies in the traditions of both reading education and science education research. By 'refutational expository text' they mean instructional material intended to explicitly refute a misconception by presenting contrasting information and counterarguments. A general finding from these studies is that this strategy supports conceptual change when used with other strategies to induce cognitive conflict (Kelly, 2007, p. 459). We report the findings from a one year intervention with Physics students in a Colombian University, focused mainly upon the confutation of the widely held and well-known "motion implies force" naïve model, according to which a force in the direction of motion is always needed to maintain it (Duit, Niedderer, & Schecker, 2007). This two-phase intervention was centered on a nonmathematical, conceptual research based textbook, designed to refute that model by reconceptualizing "the force of the hit", that supposedly maintains the motion of a Hockey puck, as the Newtonian momentum (Osborne & Freyberg, 1985). Its first phase took place in a reading and writing education course in the first semester of the physics program, and its second phase took place in the second semester mechanics course. In the first course, students practiced reading and writing strategies with this conceptual physics textbook, making summaries and then a critical review in several cycles of drafting, feedback and revising. The physics teacher participated in some classes of the language course, to discuss the student questions about the physics concepts in the book. The second phase of the intervention was the calculus-based physics course, taught by its author (and the author of this communication); this course also emphasized reading and writing activities with a physics content, and using argumentation in group work.

In order to assess the effect of the intervention we used qualitative and quantitative methods. Among the standardized instruments employed, it stands out the Force Concept Inventory (Hestenes, Wells, & Swackhamer, 1992) in its second edition, translated to Spanish by its developers. It was administered at the beginning the language course and as part of the final exam in the physics course. We processed the data using Bao and Redish "model analysis" (Bao & Redish, 2006; Bao, 1999), which extracts information about the probabilistic knowledge states of students from all choices to the subset of the FCI questions related to the force motion conception, through the so called density matrix of the class. The classic analysis is restricted to comparing scores, the number of questions correctly answered, leaving out the rich information that incorrectly answered questions provide on the probability of activation of the different mental models that coexist in students' knowledge system. The eigenvalues and eigenvectors of the density matrix, properly combined, give such a picture in a "model plot", a novel and very expedient way of representing the dynamics of conceptual change, graphically and numerically. Applying this method, we calculated the corresponding group model change for this intervention and compared it with the model change obtained in courses that did not use this refutational text. We found an effect that is in accord with the findings reported by Guzzetti et al (1993).

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Keywords: Integrating reading and physics education, force and motion relation, model analysis, conceptual change, refutational text

Topics: Learning, Teaching

328.P3

Nanotechnology: opportunity to find the intersubjects relations

Lucie Kolarova and Roman Kubínek
Palacky University Olomouc, Czech Republic

Trend in education is to apply the intersubject relations for understanding the context between science subjects. Nanotechnology has been described as a technology of the twenty-first century. We understand nanoscience as an interdisciplinary field that includes chemistry, physics, biology, material science and engineering. It has offered opportunities to find connections between science subjects.

In our case we want to introduce nanotechnology to the students of master study program Physics Teaching. These students have already necessary physical and mathematical background for broadening their science knowledge.

This poster presents fundamentals of module Nanotechnology for the above mentioned students of Physics Teaching. The module introduces terminology, description of methods, intersubject relations, characterization tools, usefulness and risk of nanotechnology.

Keywords: University education, nanotechnology education, teaching nanotechnology, intersubject relations

Topics: Teachers

329.P3

Agent based simulation of group performance: diversity versus faultiness

Clemens Wagner
ETHZ, Switzerland

Introduction

In recent years agent based simulations of problem solving have received increased attention in order to find a better understanding of how the interactions between group members influence the group performance. Hong and Page (1) developed a model where single agents were trained to solve an optimization problem and then sorted due to their performance. Two groups were formed: a group consisting of the 10 best performers and a group where 10 agents were randomly selected from the pool. The performance of the group of best problem solvers is then compared to a group randomly selected from the set of all possible agents with different problem solving strategies. The outcome of the simulation was that the 10 best problem solvers perform worse on a new problem than the 10 randomly selected. The explanation for this result is due to the diversity of the group. Since the agents were trained on a specific problem the 10 best problem solvers use similar solution strategies. In contrast, the randomly selected group shows a much higher diversity and therefore performs better on a new problem.

Despite the convincing results the model has a problem since all agents are perfect agents. They make no mistakes. If we would like to apply the model to group work in education we have to introduce imperfect agents. Thus, in this work we investigate the effect of errors on the performance of the group using the optimization problem suggested by Hong and Page.

The Model

The model consists of a ring of n = 1000 points. To every point x on the ring a random value between 0 and 100 is assigned. Agents have a perspective and an algorithm to solve the problem, which is called heuristics. The agents move in the clockwise direction around the ring searching for the largest value. The perspective of an agent is the l points on the ring in front of the actual position. The heuristics of the agent consists of k figures out of the l possible ones. An agent starts at an initial point 12 on the ring. Lets assume that the heuristics is [3 7 11] (assuming k = 3, l = 12). The next position the agent checks is point 15. If the value at 15 is smaller than value at 12 the agent takes the next figure from the heuristics (here 7) and compares the value at the position 19 to the value at the actual position. However if the value at position 15 is larger than the value at 12 the agent moves to position 15 and checks next the value at position 22. Thus, the heuristics is processed in a cyclic fashion. An error occurs if a larger value is ignored. It means, that if the agent is at position 12 and the value at position 15 is indeed larger that the value at position 12 the agent ignores it and checks next the value at position 19. The performance of an agent is the average of the maxima found over all initial conditions.

In a group the agents work sequentially. One agent after the next one searches for a local maximum. If a position is found where none of the agents can find a larger value the algorithm stops.

Results

For the simulations we have used n = 1000, l = 12 and k = 3. The values assigned to the 1000 points are randomly chosen integers from the interval [0, 100]. Thus the maximal performance of the agents is 100. We have found two transitions concerning the performance of the two groups with increasing error probability p. First of all with small error probability the diversity effect still holds and the best 10 problem solvers solve a new problem as a group worse than the randomly selected group (p = 0.01; best10 92.4; random 94.8). If the error probability exceeds the lower probability threshold pth, low approx. 15 % the diversity effect vanishes and the performance of the two groups becomes equal. However, if the errors occur to often the performance of both groups diminishes. The second threshold is found to be around pth, high = 80 % (p = 0.9; best10 70.7; random 70.6). Between the error probability of 30 % to 50 % the best as well as the random group work at the same performance (p = 0.4; best10 93.6; random 94.1).

Discussion

It has been hypothesized that diversity is the reason why diverse problem solvers outperform a group of high ability performers in an optimization task. This result holds only for almost perfect agents. However, human beings are error prone and this has to be taken into account considering e.g. recruiting problems as suggested by Hong and Page (1). Here we show that errors of agents can help to overcome the lack of diversity. Our simulation shows that any group of agents from the same error probability level in the medium range solves the optimization problem with the same performance. Moreover, the grade of the solution is equal to the grade of a group of randomly selected perfect problem solvers.

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Keywords: Agent based model, diversity, group performance

Topics: Learning, Teaching

330.P3

Dealing with students' representational competence in South African university physics

Anne Linder[1], John Airey[1], Paul Webb[2] and Nokhanyo Mayaba[2]
[1]*Uppsala University, Sweden*
[2]*Nelson Mandela Metropolitan University, South Africa*

Over the past two to three decades it has been convincingly argued that many of the learning challenges faced by science students are rooted in coming to understand and work with the specialized forms of communication that the teaching of science calls for. From such a viewpoint the disciplinary ways of knowing become inseparable from their discursive representations; for Physics these include written and oral language, diagrams, graphs, mathematics, apparatus, laboratory routines, etc. Taking representational competence in university physics to mean the ability to engage meaningfully with the discourse of physics we found no studies dealing with this. In particular, we found no studies looking at how physics lecturers think about the representational competence of their students and how they subsequently craft their practice to enhance the possibility of learning.

Our research question is: When South African Physics lecturers perceive a lack of representational competence in their students, in the particular contexts in which they work, what are their response strategies to address the issue? Twenty physics lecturers from five very different South African Universities were involved in our study. Mother tongue and socio-cultural diversity across both students and lecturers were important factors in selecting the participating universities (for ethical reasons neither the lecturers, nor their universities are identified). The participating lecturers took part in semi-structured and individual interviews of between 30 and 60 minutes. These discussions were recorded and then later transcribed.

Five qualitatively different categories of response strategies to deal with the perceived lack of disciplinary representational competence in their students were formulated, viz:

- Recognize but not the lecturer's problem
- Recognize but do not see as relevant
- Recognize but avoid facing

- Recognize and offer alternatives
- Recognize and offer passive support
- Recognize and actively engage

These categories and their implications for physics education are discussed.

Keywords: Representational competence, response strategies, crafting of practice

Topics: Teaching

334.P3

Is there a need for Foundation Programmes in Physics?

Deena Naidoo[1], Daisy Matlou[2] and Douglas Clerk[1]
[1]School of Physics, University of the Witwatersrand, Johannesburg, South Africa
[2]Engineering Support Programme, University of the Witwatersrand, Johannesburg, South Africa

In 1992, the College of Science was established in the Faculty of Science, University of the Witwatersrand. A new credit bearing BSc Foundation Program was designed for students who didn't meet the minimum requirements for admission into the 3-year BSc mainstream degree program. The BSc Foundation Programme was generally offered to the former socio-economically and educationally disadvantaged students and admission was based on selection tests. In 2006, the foundation program was transformed into a new BSc Extended Programme with similar entrance criteria as the foundation program. The 2+2 model program was designed to develop language, scientific and mathematical skills, bridge knowledge gaps and attitudes of these underprepared students through counselling, innovative teaching and learning experience. In this contribution, the course structure, content and activities of these Physics programmes both at foundation and mainstream levels will be outlined with particular attention given to how indirect interactive instructional skills and experiential learning has impacted on the effectiveness of lectures, laboratory and tutorials learning sessions. The presentation will focus on activities surrounding small group tutorial sessions which is the primary learning activity of any first year Physics course, in particular problem solving and conceptual understanding. In 1999, Heller and Heller emphasised the importance of cooperative group work in solving text-rich problems (Heller & Heller, 1999). The guided discovery approach developed by Redish (1999) and the Technology Enabled Active Learning program designed by Belcher (2001) both highlight the importance of small group learning activities. Although at Wits we have long employed "small" group tutorial sessions, we continually seek to improve the effectiveness of learning activities. Surveys will be presented that suggest changes that have implemented in these activities have had a positive effect on the learning of physics by the students in these courses. A direct comparison of the performance of "foundation students" who merged with new first-time mainstream undergraduate students will be compared over an eight year period.

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Redish E.F., (1999). Milikan Award Lecture (1998): Building a Science of Teaching Physics. American Journal of Physics, 67, 562-573.

Keywords: Foundation level, cooperative group work, small group learning activities

Topics: Assessment & Evaluation, Curriculum, Learning, Teaching

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338.P3

Project Day: Technology of metal manufacturing

Rita Chalupnikova
Lower secondary school Sec, Czech Republic

The article describes a one-day project targeting pupils of secondary schools (lower). The aim of the project was to get pupils familiar with the characteristics and technology of metal manufacturing.

Pupils experienced mechanical manufacturing and shaping of copper. They made simple copper jewellery, like our ancestors used to do. They also observed and experienced other metal manufacturing processes – smelting of tin and tin casting in tufa stone made by students themselves. Pupils gained knowledge in the characteristics of some metals and alloys, they experienced craftwork using simple tools, and using old techniques they understood how today´s blast furnaces work.

Pupils´ own effort and skill practice helped them awake their interest in craftwork and respect to honest work.

Keywords: Secondary school (lower), project´s day, mechanical shaping of copper, smelting of tin

Topics: Teaching

344.P3

Illustrative and easy-to-perform experiments with Vernier that connect physics to other subjects

Pavel Böhm
Department of Physics Education, Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

Computer-assisted experiments may help teachers to conduct experiments in more efficient and illustrative ways compared to classical ways that do not make use of modern technologies.

I will present two experiments in detail and mention a few more briefly based on several years of using Vernier in the classroom. Both experiments can be performed demonstratively, as student-experiments or combined (start with demonstration and than let students do their own observations).

Experiment 1 (melting of ice cubes in tap-water and in salt water) helps students to train their observation skills. Computer-assisted measuring is not needed here but it helps to make observation more illustrative.

Experiment 2 (fast measuring of light sources with light sensor) helps students to understand the importance of proper sampling frequency. Light bulb and fluorescent tube is observed using light sensor with several sampling frequencies: 10 kHz, 1 kHz, 200 Hz, 120 Hz, 100 Hz.

Keywords: Secondary education (lower & upper), computer-assisted experiments, Vernier, overlap with chemistry, overlap with biology, overlap with ICT, overlap with mathematics

Topics: Experiments

348.P3

Experimental investigation of electric power in an AC circuit at secondary school

Peter Zilavy
Charles University in Prague, Faculty of Mathematics and Physics, Czech Republic

Electric power is one of the quantities, which we meet in our everyday life "full" of various electrical appliances the most often. However, especially in the case of AC circuits, the real understanding of its principle is for many students (and also for some their teachers) unsolvable problem.

The paper presents a set of school experiments which (using an AC power supply, the Vernier system, PC and several other components) clarifies the concept of instantaneous and real electric power and which allows us to clearly understand their meaning in case of appliances of different characteristics. Subsequently, the paper shows some experiments related to the concept of RMS current and voltage.

Keywords: Secondary education: upper, school physics experiments, electric power, real power, instantaneous power, RMS value

Topics: Experiments, ICT

351.P3

Influence of textual contextualization in the solution of physics problems

Nathan Pinheiro and Fernanda Ostermann
Universidade Federal do Rio Grande do Sul, Brazil

One issue that has a central role in modern debates in psychology of learning is the nature of knowledge, especially to what extent it's universal or context-based. One perspective that participates in this debate is the situated cognition, which advocates that all knowledge is intrinsically situated in human activity and bound to cultural and physical contexts. This approach has many implications to teaching and to the understanding of learning, including that the kind of knowledge that a individual may use for explaining and predicting the physical world may vary from one context to another, getting to physically correct or wrong answer to the same kind of problems depending on the context in which they are presented.

This research is inspired by a research about mathematics learning held by Nunes et al. (Street and School Mathematics, 1993). One of the findings in the original research were that individuals who had poor achievement in mathematics at school but some ability in mathematics in everyday life would have better results in school tests if they were composed by questions with textual references to concrete situations (word problems) rather than a abstract calculation questions. This suggested that the reference to a familiar context were enough to activate different kinds of knowledge that helped to the solution of the problem. In search of the same kind of phenomena in the solving of physics problems, we elaborated a series of physics questions with two versions each one: one formulated in purely abstract terms and another with reference to a specific context. Both versions of each questions involved exactly the same stages to the solution of the problem and the same calculations, the only difference was the presentation of the problem. The two versions were ramdomly combined in tests that were applied to about one hundred high school students. The assumption was that the references to concrete situations would activate in students certain kinds of intuitive physics knowledge associated to everyday activities that, if on one side could be wrong from the scholar physics perspective, could help to get to write solutions. The results of the tests were analyzed statistically and discussed in the light of the theoretical framework.

Keywords: Secondary education, problem solving, situated cognition

Topics: Learning

352.P3

Student´s Competition in Science Theme – part Physics

Libor Koníček and Lenka Ličmanová
University of Ostrava, Czech Republic

The Faculty of Science of University of Ostrava provides a lot of promotion for secondary school students. Some activities are prepared individually by departments of faculty – Department of Mathematics, Department of Physics, Department of Informatics and Computers, Department of Chemistry, Department of Physical Geography and Geoecology, Department of Biology and Ecology, Department of Human Geography and Regional Development. There are some demonstrations of experiments, some presentations of new inventions or technologies. Collective activity named "Little Windows" was prepared as competition for secondary school students.

Activities for students were very different. In this contribution will be described activities prepared by Department of Physics. Results of some small investigation will be present too. Investigation was focused to estimation of students in Physics.

Keywords: Propagation of physics, estimation of students, investigation in physics

Topics: Assessment & Evaluation, Learning

353.P3

Conservation of energy in collisions of rolling spheres

Jerzy Jarosz and Aneta Szczygielska
Faculty of Didactics of Physics, University of Silesia, Poland

To analyse both elastic and nonelastic collisions of spheres, the principle of conservation of momentum is usually applied. It allows one to find the velocity vectors of spheres after the collision. A little attention is usually paid to the principle of conservation of energy. However, the application of this rule is necessary to understand properly phenomena related to collisions of rolling balls. In this case, the sphere's energy is accumulated in two forms: the kinetic energy of translational motion, which can be transferred to another sphere during the collision, and the kinetic energy of rotational motion, which cannot be transferred. If we collide two balls of equal masses, one of them rolling and another one motionless, the first one stops, but still rotates, and due to the friction starts to roll again, while the second one starts to slide without rotation, and finally, roll again too. Using bowling balls of various masses, changing the initial parameters of their motion, and taking into account the friction with the base, a rich variety of quite interesting effects could be observed. Using a high-speed camera to observe them, gives a clear view of transferring and dissipating mechanical energy, as well as of fundamental principles of mechanics.

Keywords: Secondary education, university education, principles of conversation, energy transfer, collisions of spheres, high-speed movies

Topics: Experiments, Teaching

354.P3

Creation of workbook in physics for pupils of technical fields at secondary vocational schools

Věra Kerlínová and Erika Mechlová
Faculty of Science, University of Ostrava, Czech Republic

The first version of the Workbook of Physics, Mechanics for the 1st year Secondary Vocational Schools with electrotechnical focus, began forming during the school year 2007/2008. First it was focused on explaining the physical concepts and solving physical tasks. On the basis of feedback getting within pre-researches in school years 2008/2009 and 2009/2010, i.e. the results of input and output tests, questionnaires, pedagogical observing and interviews with pupils, it was gradually expanded, innovated and updated. In the school year 2010/2011, when the pedagogical research was carried out at three secondary vocational schools and one grammar school, the Workbook has consisted of parts targeted on physical concepts, examples from practice and real life, physical tasks, physical terminology in English, records of pupils from viewed video projection and physical experiments. The Workbook was created so that it could contribute to improving the quality, streamlining and facilitating physics teaching and learning in the initial education at secondary vocational schools, to facilitate pupils´ homeworks, to awareness of interdisciplinary relations, especially in the natural sciences and technical subjects, to minimize psychological burden of pupils and to support pupils with learning disabilities.

By pedagogical research it was found out whether it is possible contribute to increasing knowledge and skills of pupil and improve his attitude to physics by introducing of appropriately designed workbook in physics inciting pupil's activity. There were one class with using Workbook and the second one without using it at every school. The quantitative aspect was examined by testing the knowledge and skills of pupil. The qualitative aspect, pupil’s attitude to subject physics and to physics teaching with using workbook, was found out by the questionnaire survey. It turned out that the both viewpoints are closely related to motivation of pupils in teaching physics at secondary schools. The group of pupils learning with special designed Workbook were higher motivated and its results in physics learning were statistically significantly better to compare with the second one.

Keywords: Secondary education upper, pedagogical research, workbook, technical fields, secondary vocational school

Topics: Teaching

355.P3

Early childhood science education

Milán Molnár and Katalin Papp
University of Szeged, Hungary

Our poster is presented one of the most pressing problems of science education, the situation of student's attitude. With the research that is based on domestic and foreign survey we analyze the changes in the attitudes. We are looking for explanations of low attitudes of chemistry and physics subjects.

From several explanations we highlight the significance of early childhood science education. We analyze why the scientific approach is overshadowed in lower grades of elementary school. Through our examples we present how science could be teaching in this age group with attitude shaping.

Our analyze present a program that is under preparation, and with this program we would like to examine the attitude of natural science of children from kindergarten and primary school with empirical studies. With this program we also would like to measure the impact of our methods.

We present the developed specific methods and programs that can be helpful for teachers who interested in the topic.

Keywords: Early childhood, science education, attitude

Topics: Experiments, Learning, Teaching

356.P3

Modern metal materials, how we can present materials physics to high school students

Zuzana Zdražilová
Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

Materials physics is very progressive branch and it needs new people with interest. However there is not much time for this discipline in the school and there are not many books for students interested in this theme. Therefor it is very difficult to learn something about phenomena in materials physics. We would like to introduce this branch for high school students, mainly at some special courses for talented student or during leisure activities. For this reason we prepared leaflets with basic information about various topics from materials physics like testing methods, preparing of materials or modern materials.

The main goal of our poster is to show what can be interesting in materials physics and how to introduce modern metal materials and their applications to students who would like to know more.

Keywords: Secondary education: upper (ages about 15-19), materials physics, modern metals, metal foams, composite materials

Topics: Informal Physics Teaching & Learning

361.P3

Use Of Analogies In Modern Physics Classes

Roberto Cruz-Hastenreiter
IFRJ / USP, Brazil

This paper investigates the use of analogies in teaching activities, specifically in physics classes. We review one hundred and ten publications (from 1990 to 2012) on the topic of the usage of analogies in physics instruction published in recognized journals specialized in science education. The data shows a peak in the number of such publications in 1993, likely due to a special issue on analogies of the Journal of Research in Science Teaching, published in that year.

In the literature, justifications for using analogies in teaching activities are sometimes based on the observation that, when two or more things are similar in at least one way, analogical thinking allows one to “draw a conclusion” about an unknown factor on the basis of resemblance to a familiar or known factor. However, in concordance with several papers on the present theme, we emphasize the danger in using analogies when the analogous (that which represents the “object”) is unknown to the student or, when they construct similarity relations based on their observations and these relationship are often different from teacher intentions.

Overall, our work highlights risks occurring when the instructional content is modern physics where the entities presented to students don’t have any relation with the immediate experience of the sensible world.

In order to do extend our analysis, we obtained transcriptions from the classes of two teachers from two different public schools in São Paulo. The themes discussed by the teachers were: (i) wave particle duality and photoelectric effect, (ii) atomic models and quantization of energy. The classes were aimed at students of the 10th grade, both of them at public schools in Sao Paulo. The students' age range was between 17 and 18 years old.

We generated a categorization of the analogies used in teaching activities based on the work of Curtis and Reigeluth (1984) entitled The Use of Analogies in Written Text. We used 18 categories comprising two sets. The first group of categories describes the nature of the analogies and the second describes the usage of the analogies in physics classes.

From this analysis we identified several problems with using analogies in classes of modern physics. Usually the teachers tried to use elements from classical (Newtonian) physics to represent a concept, for example, of quantum physics. This approach seemed to compel the students to learn the model but did not necessarily compel them to learn the concept that it was meant to present.

Because this part of the research was based on observations of only two teachers, the resulting data is not robust enough to inform a statistical analysis. We thus emphasize that our research wasn't based in empirical data analysis; rather we share our theoretical reflections stemming from the review of the selected works and the observations of teachers in a real world setting. This work is a part of a line of research addressing the question of representation based in the Philosophy of Symbolic Forms by Ernst Cassirer.

Keywords: Secondary education: upper (ages about 15-19), analogies, teaching and learning, modern physics

Topics: Learning, Teaching

363.P3

An inquired-based laboratory on friction

Vera Montalbano
University of Siena, Italy

Friction is a complex phenomenon, usually missing in high school laboratory. Nevertheless, sliding friction is often introduced in the easier way in mechanic because of simple exercises which can be done in this subject. Another important aspect is the relation between static and dynamic friction. A closer look in this topic allows to introduce interesting discussions on the structure of matter, relations between macroscopic and microscopic modelling, which aspects of a phenomenon are really relevant, which others can be omitted and for which reason, and so on. Last but not less, it can be the starting point for introducing to nanoscience world.

Inspired by a recent study in higher education, a learning path designed for high school student is presented. Students are invited to predict the behavior of different sliding surfaces by using their previous knowledge and their experience. Then, they can realize and observe what really happens. New previsions can be made and checked. Their description of phenomenon can be change during this qualitative path on friction, some hints are given by proposing an activity that can inspire which aspect can be relevant and which interaction is involved. After this introductory activity, two different quantitative experiments are proposed for studying Leonardo's laws for friction. All activities are realized with low-cost materials.

This laboratory on friction was tested with two high school classes (44 students, ages about 15-16) during a instruction trip in our department. Students were very involved in the inquired-based introductory activity and seemed to realize with care the measurements. However, the analysis of their reports on this laboratory shows some learning difficulties which are discussed.

Keywords: Secondary education: upper (ages 15-19), friction, active learning in laboratory

Topics: Experiments, Teaching

366.P3

Use of virtual grouping within online social networking: articulating new teaching-learning strategies aimed at high school

Allan Victor Ribeiro, Moacir Pereira Souza Filho, André Luiz Malvezzi and Sergio Rykio Kussuda
Sao Paulo State University, Brazil

One tool that has been in evidence, especially among young people, is Facebook, which can be classified as a synchronous communication tool allowing communities of people with similar interests to discuss and exchange experiences in real time, promoting the sharing of information and the creation of collective knowledge. In this sense we can not ignore the potentialities and the impact that virtual communities exert in the creation, dissemination and building of knowledge [1] [3]. The central focus of this work is to present some possible uses of Facebook as an educational tool to support the work done in the classroom and analyze the impact of creating closed groups on social networks for educational purposes [2]. The survey was conducted with a group of high school students from a private school in the city of Bauru – SP – Brasil. We investigated the interaction profile of students with a closed group created on Facebook and through a questionnaire analyzed whether students use virtual environments for personal or educational purposes. The data show that 67.1 % of students admit that the interaction through restricted groups inside online social networks is interesting because the exchange of information related to school activities, allows them to improve their knowledge and to learn new subjects. The research reveals that students investigated often interact with the new technologies primarily for educational purposes. Additionally, students reveal that the group created within Facebook provides interactive elements that strongly contribute for a meaningful learning which translates itself into a virtual learning environment. We highlight several positive aspects related to the use of online social networks in the educational context. We conclude that online social networks in the educational field can be a strong ally to the teacher in the work to be developed in extra-class activities, which through a well-designed plan with regard to the methodology of its use, can translate into a teaching strategy fruitful for the learning process.

The research reveals the perception of students about the relevant aspects and the potential use of this tool as a strategy for teaching and learning.

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Keywords: Online social networks, information technology and communication, teaching and learning process

Topics: ICT, Informal Physics Teaching & Learning, Teaching

367.P3

A Practice of Interactive Lecture Demonstrations for pre-service science teacher training in Japan

Kazunari Taniguchi and Takatoshi Murata
Kyoto University of Education, Japan

Since 2010 we have been practiced “Interactive Lecture Demonstrations [1]” on kinematics and dynamics including Newton’s Three Laws, in the pre-service science teachers training course in our university. To assess the conceptual learning gains, we carried out a pre-test and two post-tests, after of the practice with FMCE [2], once just after the practice (post 1), and another three months later (post 2). In addition, we asked the students to review a change of their own understanding through the activities, and to submit a report in 2 weeks after the end of the practice in order to promote the metacognition. The normalized gain [3] of post 1 and 2 were 0.70 and 0.62, respectively. This result shows that the students’ conceptual understanding is considerably revised and retained even after 3 months. This is similar to the results shown by Thornton and Sokoloff [2]. Furthermore, we obtained noticeable results that personal gains of about 30 % of students increase in post 2 than in post 1. In the submitted reports of these students, we noticed that metacognitive description of their observation and understanding is noteworthy.

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[3] R. Hake, Am. J. Phys. 66(1), 64 (1998).

Keywords: University education, active learning, Interactive Lecture Demonstrations, pre-service teacher training, metacognition, normalized gain

Topics: Assessment & Evaluation, Learning, Teachers

368.P3

Surprising behavior of a balloon and a foil boat in a gas denser than air: A video-based delayed transfer test for students' understanding of buoyant forces

Josip Sliško[1] and Jelena Radovanović[2]
[1]*Facultad de Cincias Fisico Matematicas, Benemerita Universidad Autonoma de Puebla, Mexico*
[2]*Elementary school "Slobodan Sekulić", Užice, Serbia*

The paper describes one video-based activity intended to serve as a four-month delayed transfer test of understanding of buoyant force, floating and sinking. The aim was to check if the students were able to apply their knowledge by explaining situations shown to them in a video sequence which, at first glance, looked quite surprising and almost surreal. This assignment was designed as a final part of pilot research on efficacy of active physics learning experiences inserted in traditional lecture-based teaching on buoyant force and related topics. The research took place during the second semester of academic 2011/2012 in Uzice (Serbia). The sample consisted of 68 seventh-grade students (age 13), divided into three groups. Each group was asked to fill in a worksheet relating to a video sequence ("SF6 Denser than air" at the video portal www.fizik.si) showing: a) sinking of an air-filled party balloon placed in a container filled with air, and then its floating in the same container filled with an invisible gas denser than air; b) floating of a tin foil "boat" placed in a container with the same dense gas, and then its sinking after the dense gas was poured into the "boat" itself. Students were asked to describe what they saw and to give their explanations why it happened. They were also given the opportunity to estimate how much this activity helped them test their physics knowledge, on a scale from 1 to 5, and to express if they liked or disliked the task. Different groups had different viewing experiences with the video sequence: 1) seeing the video with sound off; 2) seeing the video with sound on; 3) seeing video with sound on after a short predict-observe-explain activity which had equal elements as the video sequence, but with water being used instead of the dense gas. This poster presents the results we obtained and some selected opinions from students belonging to each of the groups. It seems that this task could be a transfer test of an active learning sequence dealing with buoyant force and related phenomena, since through this activity a clear estimate can be gained of students' understanding of conditions leading to floating and sinking. Success rate is significantly related to classroom and homework experiences with buoyant force. Students who have carefully completed the investigative homework assignment dealing with floating and sinking shown greater success than other students, even when compared with those students who had the predict-observe-explain activity before being shown the video, but who have not done the homework assignment. These results clearly show the importance of those activities in which students are directly involved with the phenomena they are learning about.

Keywords: Secondary education: lower (ages about 11-15), active physics learning, predict-observe-explain, floating and sinking, delayed transfer test

Topics: Assessment & Evaluation

370.P3

The last ring before Polish matura exam in physics and astronomy

Daniel Dziob and Justyna Nowak
Jagiellonian University, Institute of Physics, Krakow, Poland

“The last ring before matura exam in physics and astronomy” is the name of the series of workshops for students in the last class of high school. It is organized at the Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, since 2012.

In 2012 workshops were attended by 53 graduates from South of Poland, which was a significant number with respect to the population of students who take the matura exam in physics. The workshops lasted one Saturday. They started with the lecture entitled “The most common mistakes and traps during matura exam” and then each student could take part in three out of six successive workshop groups. The groups in following fields were organized: “mechanics”, “thermodynamics”, “vibration, waves and optics”, “electricity and magnetism”, “gravitation and astronomy”, “particle physics and structure of matter”, which discussed all the topics considered during the matura exam. Workshop groups were led by 14 students from four scientific circles and 5 other students were responsible for facilities such as a coffee break and registration. After the session all participants were asked to fill out the online evaluation questionnaire.

In 2013 workshops were attended by 88 graduates from all over the Poland. They consisted of six meetings, organized weekly, each in a separate field, as in the first edition. Every Saturday students met at the introductory lecture and subsequently took part in problem solving workshops in small group. After the last session participants were asked to fill out the evaluation questionnaire. The organization of workshops involved students from all scientific circles from our Faculty.

The program was supported financially by the Dean and the Director of Institute of Physics, Jagiellonian University.

Keywords: Informal education, matura exam, high school

Topics: Informal Physics Teaching & Learning

371.P3

Science lessons for 13 year old students in 10 countries in Europe: curricula, the perception of science teachers and perception of the 13 year old learners

Wim Peeters[1], Tom Lambert[1] and Job De Meyere[2]
[1]Dienst Katholiek Onderwijs vzw, Antwerpen, Belgium
[2]Thomas More Kempen, Vorselaar, Belgium

The SECURE project (1) has collected a huge amount of data for comparative analysis of the curricula of science, mathematics and technology of 10 countries spread all over Europe, for analysis of the perceptions of those that implement curricula (the teachers) and for better understanding of the perceptions of the learners concerning the science lessons they attend.

In this presentation we limit our focus to 13 years old learners, to science as a discipline and to the teachers teaching science. We present an overview of the curricula of 10 countries and look for particularities among the different countries. Interviews and questionnaires are the means by which we collected people's opinions on a range of topics provided by the curriculum spider web developed by van den Akker, J (2003) (2) of SLO, the Netherlands. This includes rationale, aims and objectives, content, learning activities, teacher role, materials and resources, grouping, time, location, activities and assessment. In the course of the project, SECURE added "motivation" as a topic to that list.

Curricula for the 13 years old are very different throughout the 10 countries. In 4 countries 13 year old learners are in the final year of a 4 year cycle, while in 6 countries they are in the second year of secondary education. In 9 countries science is consists of biology, chemistry and physics separetely, while only in Belgium there is an integrated science course. These different starting situations lead to a very complicated situation in view of comparative analysis. Nevertheless we will present some ideas, trends and conclusions.

The teachers' answers to the questionnaires reveal a rather traditional attitude towards the nature of teaching. Most activities take place for the whole class, where after the students make exercises in a book, mostly on their own. Active learning is organised only sometimes. However, we can see some indications of good practices too. In most cases interviews have confirmed but also deepened the insights provided by the questionnaires.

About 1200 13 year old learners that were questioned have given their opinion by filling out questionnaires. For science alone this leads to 90 pages of graphs on which the answers to about 170 questions in 6 spider web topics are shown. These graphs show that answers can vary in a significant way from country to country on some spider web topics, while, on the other hand some answers are almost the same. In general learners indeed are motivated but their ideal of learning differs rather drastically from reality. They like the lessons because of the topics rather than because of the teacher. They enjoy learning a lot (more than 70 %) but only 40 % want more.

The previous are only some conclusions that illustrate the richness of the outcomes.

Apart from questionnaires, interviews reveal good examples of general ideas coming up from the questionnaires.

Since the analysis of the results is in full progress now (April 2013), there will be more detailed information available in August 2013.

Special attention will go to the conference theme: "Active learning – in a changing world of new technologies", covered by the spider web components "teacher role" and "learning activities" combined with "teaching materials". This will be searched for in curricula, as well as in questionnaires and interviews of both teachers and learners.

Acknowledgement

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Keywords: SECURE project, 13 years old learners, comparative analysis, science, mathematics, technology

Topics: Curriculum

372.P3

Superconductor-magnet interaction studied through high-speed video-analysis

Assunta Bonanno, Giacomo Bozzo, Michele Camarca and Peppino Sapia
Physics Education Research Group, Physics Department, University of Calabria, Italy

In this work we present an experimental learning path on superconductivity, designed for university undergraduate students, tested during the current academic year at the University of Calabria, Italy, in the context of an Electromagnetics Laboratory teaching module. The experimental activity is based on high-speed video analysis of a magnet falling through an YBCO superconducting cylinder. The use of an Atwood's machine allowed us to vary the magnet's kinetic energy during its interaction with the superconductor. In this way, we highlighted the existence of two interaction regimes: below a certain crossing kinetic energy, the magnet is repelled by the superconductor and reaches a levitation equilibrium state; when the crossing energy exceeds such a value, the magnet passes through the superconducting cylinder, and a fraction of its energy is transferred to the magnetic field of persistent supercurrents. The use of a commercial-grade high speed imaging system, together with video analysis performed by means of the "Tracker" software tool, allowed us to attain a precision in space and time measurements sufficient to implement a quantitative modeling of the superconductor-magnet interaction. Receiving coils, mounted both on the superconducting cylinder and fixed to the falling magnet, allowed us to study the magnetic flux variations in both reference frames (i.e., the frame fixed to the falling magnet and that fixed to the superconducting cylinder). In this way, the magnetic flux patterns around the superconductor has been studied and connected to the Meissner and pinning effects.

The work aims providing students with an accessible quantitative experimental activity, allowing them to better understand either electromagnetic induction or superconductor physics. The proposed activity, with minor changes regarding quantitative aspects and modeling, is also suitable for last year high school students, allowing teachers to exemplify and discuss several topics, ranging from the superconductivity, to magnetic flux's variation, to the energetic issues related to the magnetic field.

Keywords: University education, secondary education: upper (ages about 15-19), superconductivity, video-analysis, electromagnetic induction

Topics: Experiments

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