University of Ljubljana
Faculty of Education

SEEMPE 2012

1st South-Eastern European Meeting on Physics Education 2012

Book of abstracts

11th—12th September, 2012,
Ljubljana, Faculty of Education

Book of abstracts
SEEMPE 2012, 1st South-Eastern European Meeting on Physics Education
Faculty of Education, University of Ljubljana
Ljubljana, September 2012

Editor: Katarina Susman
Publisher: Faculty of Education, University of Ljubljana
For the publisher: Janez Krek, Dean

Online at: http://www2.pef.uni-lj.si/SEEMPE/index_files/SEEMPE_book_of_abstract.pdf

CIP – Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

37.091.3:53(082)(0.034.2)

SOUTH-Eastern European Meeting on Physics Education (1 ; 2012 ; Ljubljana)
Book of abstracts [Elektronski vir] / 1st South-Eastern European Meeting on Physics Education 2012 - SEEMPE 2012, 11th-12th September, 2012, Ljubljana ; [editor Katarina Susman]. - El. knjiga. - Ljubljana : Faculty of Education, 2012

Način dostopa (URL): http://www2.pef.uni-lj.si/SEEMPE/index_files/SEEMPE_book_of_abstracts.pdf

ISBN 978-961-253-098-3 (pdf)
1. Susman, Katarina
263400704

Book of abstracts

CONTENT

WELCOME

Dear participants,

Welcome to the **1st South Eastern European Meeting on Physics Education (SEEMPE) 2012**. The mission of this meeting is to bring together educators, researchers and scientists from neighbouring countries in the south Eastern region of Europe working on physics education. Interested researchers from other parts of Europe are welcome as well. The aim of the meeting is to present the results of the research in physics education by participants from neighbouring countries, to exchange research experiences and discuss various problems, possible initiatives and projects.

Physics education research and physics education in general is becoming more and more important, as the authorities are becoming aware, that future needs scientists. The school is the environment that is often the reason for later decision for studying science.

In the past physics education research was often considered as an art and not as a science from the majority of physicists; however results of our research are becoming more and more respected. The way of teaching, the understanding of the teaching intervention effect on students' knowledge, students' conceptual understanding, misconceptions, and cognitive abilities of students to understand difficult or easy concepts in physics are playing more and more important role in physics and science lectures at all levels.

We have to bear in mind, that our work is important. Physics education research is the basis for the education of future scientists.

Although the idea for this meeting has come rather late, almost 40 people are joining the meeting with 24 talks, 2 workshops and 10 posters. These facts indicate that our part of Europe is very active within this research field. We are looking forward to have a scientifically strong and interesting meeting, which would also result in future collaborations.

Mojca Čepič, chair of the meeting

Program

Tuesday, 11. 9. 2012

	presenting author	title	chair
9.00 - 9.10	**opening**		
9.10 - 9.40	*Bojan Golli*	Higgs Boson for Dummies	Mojca Čepič
9.40 - 10.00	*Leopold Mathelitsch*	Competencies in Science Teaching	
10.00 - 10.20	*Nada Razpet*	We love experiments, we do not like theory	
10.20 - 10.40	*Robert Repnik*	Universe in a liquid crystalline droplet	
10.40 - 11.00	*Jerneja Pavlin*	Presentation of the European research project SECURE	
11.00 - 11.30	**coffee break + poster session**		
11.30 - 12.30	*Mojca Čepič, Jerneja Pavlin, Maja Pečar, Katarina Sus-*	Liquid crystals in school	Stevan Jokić
12.30 - 13.20	**lunch**		
13.20 - 14.00	*Lillian McDermott*	Physics Education Research: the key to improving student learning	Maja Planinić
14.00 - 14.20	*Ana G. Blagotinšek*	Physics in primary and kindergartens!? It is already there...	
14.20 - 14.40	*Maja Stojanović, Elvira Đurđić*	Overcoming the problem of decreasing the number of physics students	
14.40 - 15.00	*Ursula Gorska, Daniel Dziob*	The last ring before matura exam in physics and astronomy	
15.00 - 15.20	*Jurij Bajc*	Formation of a rainbow - an experiment in optics	
15.20 - 15.40	*Sergej Faletič*	The International Young Physicists' Tournament - a way to develop rese-	
15.40 - 16.10	**coffee break + poster session**		
16.10 - 16.40	*Josip Sliško*	Active physics learning: An "online plus classroom" design of activities	Leopold Mathelitsch
16.40 - 17.00	*Mirjana Božić*	School as a 3D lecture book of natural sciences	
17.00 - 17.20	*Ana Sušac*	Brain research in education	
17.20 - 17.40	*Katarina Jeličić*	Research on students' reasoning in electromagnetism	
19.30-	**Dinner at the restaurant Dubočica**		

Program

Wednesday, 12. 9. 2012

	presenting author	title	chair
9.00 - 9.30	*Janez Vogrinc*	Qualitative research in physics education	Gorazd Planinšič
9.30 - 10.00	*Zalkida Hadzibegović*	Changing university students' alternative conceptions in optics by active learning	
10.00 - 10.20	*Barbara Japelj*	International measurement of physical knowledge: TIMSS study	
10.20 - 10.40	*Mihael Gojkošek*	Do learning activities improve students' ability to construct explanatory models in prism foil	
10.40 - 11.00	*Tomaž Kranjc*	Estimating the Quality of the Environment by School Experiments	
11.00 - 11.30	**coffee break + poster session**		
11.30 - 12.30	*Gorazd Planinšič*	Simple experiments with computer scanner for learning about linear relative motion	Josip Sliško
12.30 - 13.30	**lunch**		
13.30 - 14.00	*Maja Planinić*	Comparison of students' understanding of graphs in mathematics, physics and other	Zalkida Hadzibegović
14.00 - 14.20	*Stevan Jokić*	Inquiry Based Science Education (IBSME) in Serbia	
14.20 - 14.40	*Bor Gregorčič*	A student activity for a better understanding of the rolling shutter effect	
14.40 - 15.00	*Lana Ivanjek*	Identifying student difficulties with atomic spectra	
15.00 - 16.00	coffee break + discussion of future perspectives		
16.00	**closing**		

ORAL CONTRIBUTIONS

Formation of a rainbow – an experiment in optics
Jurij Bajc, Barbara Rovšek
Physics in primary and kindergartens!? It is already there…
Ana Gostinčar Blagotinšek
School as a 3D lecture book of natural sciences
M. Božić , D. Cucić, Lj. Ivančević, T. Marković-Topalović, J. Slisko, G. Stojićević and J. Volarov
The last ring before *matura* exam in physics and astronomy
Daniel Dziob, Urszula Górska
The International Young Physicists' Tournament – a way to develop research skills in high school
Sergej Faletič, Gorazd Planinšič, Irena Drevenšek-Olenik
Do learning activities improve students' ability to construct explanatory models in prism foil problem?
Mihael Gojkošek, Gorazd Planinšič, Josip Sliško
Higgs Boson for Dummies
Bojan Golli
A student activity for a better understanding of the rolling shutter effect
Bor Gregorčič, Gorazd Planinšič
Changing university students' alternative conceptions in optics by active learning
Zalkida Hadzibegovic, Josip Slisko
Identifying student difficulties with atomic spectra
Lana Ivanjek, Peter Shaffer, Lillian McDermott and Maja Planinić
International measurement of physical knowledge: TIMSS study
Barbara Japelj Pavešić
Research on students' reasoning in electromagnetism
Katarina Jelicic, Gorazd Planinsic, Maja Planinic
Inquiry Based Science Education (IBSME) in Serbia
Stevan Jokić
Estimating the Quality of the Environment by School Experiments
T. Kranjc and N. Razpet
Competencies in Science Teaching
Leopold Mathelitsch
Physics Education Research: the key to improving student learning
Lillian McDermott
Presentation of the European research project SECURE
Jerneja Pavlin and Barbara Rovšek
Comparison of students' understanding of graphs in mathematics, physics and other contexts
Maja Planinić, Zeljka Milin-Sipus, Ana Susac, Lana Ivanjek
We love experiments, we do not like theory
N. Razpet and T. Kranjc
Universe in a liquid crystalline droplet
R. Repnik, D. Jesenek, M. Ambrozic, Z. Bradac, S. Kralj
Active physics learning: An "online plus classroom" design of activities*
Josip Slisko
Overcoming the problem of decreasing the number of physics students
Maja Stojanović, Dušanka Obadović, Branka Radulović, Ivana Rančić and Elvira Đurđić
Brain research and education
Ana Susac, Maja Planinic, Lana Ivanjek
Qualitative research in physics education
Janez Vogrinc

Formation of a rainbow – an experiment in optics

Jurij Bajc[1], Barbara Rovšek[1]
[1]University of Ljubljana, Faculty of Education, Kardeljeva ploščad 16, SI-1000 Ljubljana, Slovenia
e-mail: jurij.bajc@pef.uni-lj.si

In the paper generation of the rainbow is explained through an illustrative and easy-to-do experiment. The experiment shows the students that the light refracted at particular angle upon shining on a spherical "drop" of water is much brighter than the light refracted at other angles. The equipment to perform the experiment is at hand in most schools: a laser pointer and a spherical or a cylindrical vessel with thin transparent glass walls.
At the beginning of the presentation typical characteristics of the rainbow are summarised with the emphases on the things that can be observed by the students and requires no particular mathematical skills and just the basic knowledge of physics, typically obtained after the first year of physics classes at the age of around 14 or 15. Some of these characteristics are: one or two rainbows can be seen at the same time, each having different order of colours; a rainbow typically appears, while it is raining, but there is the Sun behind our back and some clouds (i.e. water droplets) in the sky, where the rainbow appears to be; the rainbow bow is circular, i.e., it is a part of a circle; the inner and brighter rainbow is red on the outside edge and blue at the inside edge.
The core of the presentation is the experiment, done with the laser pointer and the glass vessel, filled with water. The students should be observing the spreading of the laser dot, exiting the vessel after one internal reflection, because this type of light contributes light in the rainbow (Adams, 2002). The teacher is changing the offset, at which the laser beam hits the vessel surface. First the vessel is hit in the direction of its centre and next the laser pointer is slowly shifted outwards and the students are observing the size of the refracted laser spot. The refraction angle is slowly decreasing from 180° as the offset is growing. At the same time the size of the refracted laser spot is spreading from a small dot at the beginning. At first the offset is changed relatively fast in order to make the students see the corresponding change of the refraction angle. It is decreasing until the offset of the incident laser beam is approximately 0.85 of the radius of the vessel. Here it reaches the minimum and starts to grow as the offset is increased beyond 0.85 of the vessel radius. It is important to point out this minimal refraction angle to the students. Next the change of the offset from zero up to the vessel radius is repeated slowly and the attention is turned to the size of the exiting light beam, i.e., the size of the spot the refracted light makes. Around the minimal refraction angle the refracted light beam narrows significantly and at the same time the refracted laser spot becomes very bright. This is the light that we see as coming from the rainbow, if enough water droplets are just at the right place relative to our standing point and the position of the Sun. Because of the slightly different refractive indices of different wavelengths of visible light in the water, each wavelength (i.e., each colour) is refracted at a slightly different angle. With the Sun shining onto sufficient water droplets in the right parts of the sky the rainbow is seen by a suitably standing observer.
At the end of the presentation a few particularities regarding the rainbows are explained, relating the explanation to the above written rainbow formation, for example, the fact that the rainbow does not change its "size" as we move closer to it. By closing the lesson this way the students on one hand see and appreciate the power of understanding how the rainbow is generated and on the other hand improve their memory of the whole derivation by connecting the impressive rainbow property that it is always of the same size with the explanation of how the rainbow is generated.

References

Adams, J.A. (2002). The mathematical physics of rainbows and glories. *Phys. Rep.* **356**, 229-365.

Physics in primary and kindergartens!? It is already there…

Ana Gostinčar Blagotinšek

University of Ljubljana, Faculty of Education, Kardeljeva pl. 16, Ljubljana, Slovenia

e-mail: ana.blagotinsek@pef.uni-lj.si

Physics formally appears on the timetables sometime in grades 6 to 8, depending on the country. It is usually unpopular among the pupils, and quite often even among teachers. Public opinion is also negative, although physic shares its fate with chemistry and technology education. The reason seems to be the way those subjects are taught at school.

There is consent, even among the highest rank of politics that something should be done to reverse the negative trends in attitudes towards (natural) sciences. And the solution seems to be to change the way those subjects are taught at school. But, as there are findings, indicating that attitudes towards science are formed as early as at the age of 11 (or, even 7), physics teacher can do a lot with making the lessons active, challenging and engaging, but a lot more attention should be paid to primary and kindergarten years of education, too. Curricula for stages K - 5 include a lot of physics – related topics, which are often neglected by physics educators.

The problem with physics –related content in primary is as described before. Kindergarten and primary teachers are non – specialists, and share average public attitudes; they dislike physics, and tend to avoid teaching it, or teach it "paper and pencil" style.

A team of educators at Faculty of Education is developing a system of support for primary teachers, teaching science. It includes deepening content knowledge, improving experimental skills, and didactic materials for classroom use. To support classroom implementation, use-ready sets of experimental equipment for the pupils are rented to the teachers and refurbished after use. Inquiry based approach (IBSE) is also promoted and supported by workshops for the teachers, and materials for classroom use. Materials, developed at the Faculty of Education in Ljubljana will be presented, together with some results of teachers' and pupils' questionnaires.

School as a 3D lecture book of natural sciences

M. Božić[1] , D. Cucić[2], Lj. Ivančević[3], T. Marković-Topalović[4], J. Slisko[5], G. Stojićević[6] and J. Volarov[3]

[1]Institute of Physics, Belgrade; Center for Talents „Mihajlo Pupin", Pančevo; [3]Primary school" Djordje Krstić", Belgrade; [4]Medical High School, Šabac; [5]Benemérita Universidad Autónoma de Puebla, Puebla, México; [6]Regional center for professional advancement of educators, Šabac

E-mail:bozic@ipb.ac.rs

History of physics is teaching us that the rise of knowledge about basic natural laws frequently had beginning in observations of intriguing phenomena in nature. In the next step, scientists started to perform experiments in nature and later created experimental laboratories. Good physics teaching should provide opportunities for students to repeat some of observations, experiments and reasoning of giants of science. Such a goal imposes that a wider space than a classroom is necessary for science education. So, an entire campus and building should be included. One needs a corridor, a courtyard, a roof, a terrace in order to incorporate devices and elements for mapping natural phenomena and studying them. This can be achieved treating the school building and its environment as a 3D lecture book and science lab [1,2]. The net of such schools might develop into a dispersed science museum.

Out classroom installations for teaching physics may be very useful not only for learning physics but also for using physics knowledge in learning mathematics, astronomy, geography, environmental topics. The main function of out-of-classroom installations is to induce associations. Associations are very important in understanding, accepting and memorizing new knowledge.

Authors of articles in Deck the Halls columns in Physics Teacher, published from 1972 to 2001 and collected by Pizzo [3], proposed many devices for demonstrations along the hallway. European Physical Society published posters of biographies of famous European physicists to be used in laboratories and halls [4,5]. In Ellinogermaniki Agogi in Athens [6] installations for teaching science are distributed all over the building. Since 2003 many examples of cognitive installations and patterns suitable for spreading the physics laboratory throughout the school building and its courtyard were described by the team of authors from Serbia, USA, France and Mexico [1,2,5-11].

Since 2009 Ministry of science/Ministry of education and science of Serbia, Municipality of Šabac and the Network of regional centers for professional advancement of educators have been supporting the implementation of this concept in schools and educational institutions through the project "Inspiring environment for learning natural science"[12]. In this talk we shall present the set of installations planned and built in Šabac, Primary school Djordje Krstić in Belgrade, Center for talents "Mihailo Pupin" in Pančevo and Mathematical high school in Belgrade. This set includes: Day and night globe – DING [7,8,11], educational fountain [1,2], LED color mixer [13,10], brachistochrone, external meridian [9], internal meridian [9], window color mixer [7], wire models of geometrical bodies, mathematical dial, Galileo thermometer, retrograde motion of planets, sound mirrors, optical phenomena at and near the window, devices for demonstration of laws of reflection and refraction of light, uranium decay series along the staircase ...

References

1. M. Božić, V. Milićević and S. Nikolić, *Innovative school design for science education*, Proc. Conf. Advanced Technologies in Education, ed. by S.Sotiriou and N. Dalamagas, (Ellinogermaniki Agogi, Athens, 2007) pp. 113-122.

2. M. Popović-Božić, J. Sliško and T. Marković-Topalović, Podsticajna okolina za učenje prirodnih nauka, Zbornik Republičkog seminara o nastavi fizike, Vranje, 2011 (Društvo fizičara Srbije, Beograd, 2011).

3. J. Pizzo, editor, *Interactive Physics Demonstrations* (AAPT, College Park, 2001)

4. A. Wolfendale, *Europhysics News*, **30** (4) (1999) 111.

5. M. Božić, M. Popović and I. Savić, *Out Classroom Installations for Learning Physics: Learning Environment*, *Proc. of BPU7, AIP* **CP1203** (2009) 1250.

6. http://www.ea.gr/ea/main.asp?id=100&lag=en

7. M. Božić, L. Vušković, D. Pantelić, S. Nikolić and V. Majić, *School architecture and physics education,* The Physics Teacher **43** (2005) 604-607.

8. M. Božić and M. Ducloy, *Erathostenes' teachings with a globe in a school yard*, Physics Education **43** (2008) 165-172.

9. M. Božić, D. Cucić, T. Marković-Topalović and I. Savić, *Određivanje i primena meridijana*, Zbornik konferencije „Kalendarsko znanje i doprinos Milutina Milankovića", Beograd, 2011 (Udruženje Milutin Milanković, Beograd, 2012).

10. J. Volarov. Lj. Ivančević, D. Cucić, T. Marković-Topalović, B. Panić, M. Popović-Božić, I. Savić, J. Sliško. G. Stojićević, *Podsticajna okolina za aktivno učenje prirodnih nauka*, Zbornik Republičkog seminara o nastavi fizike, Beograd, 2012 (Društvo fizičara Srbije, Beograd, 2012)

11.Tatjana Marković-Topalović and Mirjana Božić, *Serbia hosts teachers' seminar, Physics Education*, **46** (2011) 365.

12. http://www.poko.ipb.ac.rs

13. G. Planinšič, *Color Mixer for Every student*, Physics Teacher **42** (2004) 138-142.

The last ring before *matura* exam in physics and astronomy

Daniel Dziob, Urszula Górska

Institute of Physics, Jagiellonian University, Reymonta 4, Cracow, Poland

e-mail: daniel.dziob@gmail.com, u.j.gorska@gmail.com

″The last ring before *matura* exam in physics and astronomy″ is the name of workshops directed to students in the last class of high school. It was organized at the Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University. Workshops were attended by 53 graduates from south Poland, which was a significant number with respect to the population of students who take the *matura* in physics.

The workshops started with the lecture ″The most common mistakes and traps during *matura* exam″ and then each student could take part in three following workshops groups. We organized groups in six fields: ″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. After the session participants were asked to fill in the evaluation questionnaire.

Workshops groups were led by 14 students from four scientific circles and 5 other students were responsible for technicalities such as a coffee break and registration. The program was supported financially by the Dean and the Director of Institute of Physics, Jagiellonian University.

The International Young Physicists' Tournament – a way to develop research skills in high school

Sergej Faletič [1], Gorazd Planinšič [1], Irena Drevenšek-Olenik [1,2]

[1] *University of Ljubljana, Faculty of mathematics and physics, Jadranska 19, 1000 Ljubljana, Slovenia*

[2] *Institut "Jožef Stefan", Jamova 33, 1000 Ljubljana, Slovenia*

E-mail:sergej.faletic@fmf.uni-lj.si

The International Young Physicists' Tournament (IYPT) is an experimentally oriented physics competition with 25 year tradition, where teams of high school students research 17 complex physical problems in one year time. In the concluding event, one team presents their findings and then defends them against a challenger from another team. In the end, a third team reviews the debate. This is called a "physics fight". The problems do not necessarily have a known solution, so the scientific method and the argumentation are emphasized. The key feature of this competition is that it is basically real research, all of which is done by high school students: from the research questions (within the specified problem), through experimental setup, data analysis, presentation of findings, defence or scrutiny of findings, right up to the review. Some findings even produce professional articles in internationally recognised publications [1, 2]. Here I will present how such a "fight" works on an example that will illustrate the application of the scientific method during the research as well as the mechanics of the "fight" itself.

References

[1] Kewei, L. et al., 2011, *The vertical oscillations of coupled magnets*, Eur. J. Phys. 32, S1–S14.

[2] Kunesch, M., Usunov, A., 2010, *Tic-tac: accelerating a skateboard from rest without touching an external support*, Eur. J. Phys. 31, 4, S25-S36.

Do learning activities improve students' ability to construct explanatory models in prism foil problem?

Mihael Gojkošek[1], Gorazd Planinšič[1], 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*

E-mail:gojkosek@fmf.uni-lj.si

One of the main learning goals according to current reform effort in science education states that students who understand science should be able to "generate and evaluate scientific evidence and explanations". Nevertheless, studies, which explore how students construct explanations related to specific physical phenomena, are still rare. The aim of this study is explore how different previous students' experiences with light beams and prism interactions influence their explanations of behavior of light beam when coming in two ways to the prismatic foil.

Three test groups of high-school students were formed: first group observed three experiments with three-sided rectangular prism, which were accompanied by teacher's explanation. Second group got additional task to construct a predictive model for result of the third experiment, before it was actually performed, while students in third group had to carry out experiments by themselves. Approximately a week after activities took place students were tested with so called »foil test«, which is based on the prism foil problem. Students had to construct explanatory model for behavior of prism foil on the basis of observation of simple experiments. In addition, every subject was tested with Lawson's Classroom test of scientific reasoning.

Results were compared to the preliminary research conducted with the prism foil. We found that overall more students solved the problem correctlly when they were included in the activity with prism. Goup with prediction activity benefited the most; progress was smaller in the lab-activity group and was not observed in the »traditional« group. Time spent on activity showed not to be the most important factor for succesful transfer. In the talk detailed results will be presented and discussion on their application will take place.

Higgs Boson for Dummies

Bojan Golli

[1]*University of Ljubljana, Faculty of Education, Kardeljeva ploščad 16, SI-1000 Ljubljana, Slovenia*

E-mail:bojan.golli@pef.uni-lj.si

Ordinary matter is made up of heavy nucleons and much lighter electrons; the nucleons are responsible for the mass - the "weight" - of objects, while the electrons determine their sizes and properties of matter. But why is the electron so much lighter than the nucleon? What determines the mass of elementary particles? What is the mechanism that generates their masses? In the Standard Model of particle physics, the mass arises as a consequence of a coupling of particles to a new field which exists even in otherwise empty space, called the Higgs field. The field can be excited and the smallest excitation corresponds to the so called Higgs boson which immediately decays into other particles. The recent discovery of a new boson with the properties as predicted for the Higgs boson represents a strong support for proposed mechanism of mass generation.

A student activity for a better understanding of the rolling shutter effect

Bor Gregorčič, Gorazd Planinšič

Faculty of Mathematics and Physics, University of Ljubljana, Slovenia

E-mail:bor.gregorcic@fmf.uni-lj.si

Implementing modern technology and everyday objects into the physics curriculum can have a positive impact on learners' motivation. Integration of physics into students' everyday lives has been shown to improve appreciation of physics and foster better learning. The mobile phone camera is an excellent example of a widely accessible piece of technology that is used daily by most high school students. The mobile phone cameras usually use a CMOS light sensor, that differs from the better known CCD sensors in many ways. Electronic limitations usually prevent the CMOS sensor from capturing the entire frame at the exact same moment in time, a problem not encountered in CCD sensors. Thus, CMOS sensors usually employ a rolling shutter. This means that the sensor captures the image line by line in a progressive manner similar to the sequence of the computer scanner. This becomes apparent on photos of rapidly changing scenes, where the time it takes for the scene to change a considerable deal is somewhat comparable to the time it takes for the rolling shutter to "scan" the entire frame. Similar effects can also be observed on photo finish images. We will observe and explain the artifacts formed on images of fast rotating objects taken by mobile phone cameras and photo finish cameras. An experiment also appropriate for a student activity will be presented, where a computer scanner is used to mimic the operation of the rolling shutter in a phone camera. We will see what are the basic parameters that determine the shape of the patterns in the final image. In order to understand and explain the peculiar patterns, we must address topics that are part of a typical high school physics curriculum such as relative motion, vector addition and relationship between tangential and angular velocity. The presented example offers students a chance to develop a better sense and a deeper understanding of velocity as a vector quantity.

Changing university students' alternative conceptions in optics by active learning

Zalkida Hadzibegovic[1], Josip Slisko[2]

[1]*Department of Physics, Faculty of Science, University of Sarajevo, Bosnia and Herzegovina*

[2]*Benemerita Universidad Autonoma de Puebla, Mexico*

E-mail: zalkida@yahoo.com

Active learning is individual and group participation in effective activities such as: in-class observing, writing, experimenting, discussion, solving problems, talking about learned topics (DeBard & Guidera, 2000; Niemi, 2002). Some instructors believe that active learning impossible, or, at least, very difficult to achieve in large lecture sessions. Nevertheless, Beichner and colleagues (2000) gave experimental evidence, the most impressive in SCALE-UP learning environment, that such beliefs are false. In this study we present a possible design of an active learning environment with strong positive effects on the students', based on the following elements: (1) helping student to learn from interactive lecture experiment; (2) guiding student to use justified explanation and prediction after observing and exploring the observed phenomenon; (3) development of conceptual question sequence designed for use in interactive lecture with students answering questions in worksheet and discussing them; (4) assessment of student conceptual change and gains by questions related to reflection, refraction, and image formation in an exam held a week after the active learning session. Data were collected from 95 freshmen who were with different secondary school background in learning of optics.

Research results, gained after only one active learning session, have showed that around 60 % of students have changed their initial alternative conceptions of vision and of image formation for the situations in which light refracts and reflects by passing through different media. Students who have adequately participated in the active learning sequence confirmed their better knowledge of the optics phenomena which they had never understood adequate before. This paper presents also the role demonstrations and experiments should play in student learning in large-class learning environment. It was also found that a large group of university students like to be actively involved in their learning instead of being obliged to a passive role during teacher's talk-based lectures.

References

Beichner, J.R., Saul, M.J., Allain, J.R., Deardorff, L.D. and Abbott, S.D. (2000). "Introduction to SCALE-UP: Student-Centered Activities for Large Enrollment University Physics," presented at the Annual Meeting of the American Society for Engineering Education, Seattle, Washington, 2000. [Online] available http://www.ncsu.edu/per/scaleuppub.html

DeBard R., & Guidera, S. (2000). Adapting asynchronous communication to meet the seven principles of effective teaching. Journal of Educational Technology Systems, 28(3), 219–230.

Niemi, H. (2002). Active learning-a cultural change needed in teacher education and schools. Teaching and Teacher Education, 18(7), 763-780.

Identifying student difficulties with atomic spectra

Lana Ivanjek[1], Peter Shaffer[2], Lillian McDermott[2] and Maja Planinić[1]
[1]University of Zagreb, Croatia
[2]University of Washington, USA
E-mail:lana@phy.hr

Physics education research is still mostly focused on student understanding of basic topics from classical physics, with less emphasis on topics from modern physics. Examples of such a topic are line spectra. It is important that students develop good understanding of spectra as a prerequisite for understanding of quantum mechanics, as well as astrophysics. The structure and formation of spectra are a part of university and secondary school curricula both in Croatia and in the United States. Systematic investigation of student understanding of atomic spectra was conducted among 1000 science majors in introductory physics courses at University of Zagreb, Croatia and University of Washington, USA. A major focus of the research was on the ability of students to relate the energy levels of an atom to the corresponding discrete line spectrum. Three written questions that probed that ability were constructed, and administered to students after standard instruction on spectra. The results indicate low student understanding of the process of line spectrum formation. Most of the students failed to associate one spectral line with a transition between two energy levels, and tended instead to associate one spectral line with only one energy level. One additional question that probed student understanding of the role of the experimental setup in formation of a line spectrum was constructed and also administered to students. Only between 20 % and 30 % of the students recognized that the type of the light source is critical for the formation of a line spectrum. Identification and analysis of student difficulties guided the design of a set of new instructional materials, tutorials, to supplement instruction in a standard calculus-based physics course. The instructional materials have been validated and proved to be effective at helping students construct and apply a model of spectra formation.
Findings from the research questions will be presented, and students' most frequent conceptual and reasoning difficulties will be discussed. Students' posttest results and the examples from the tutorial will also be presented and discussed.

International measurement of physical knowledge: TIMSS study

Barbara Japelj Pavešić

Educational Research Institute, Slovenia

E-mail: barbara.japelj@pei.si

From 1995, the international comparative study of student knowledge of mathematics and science, called TIMSS, systematically asseses also physical knowledge of students in grade 4 and grade 8 every four years. In 1995 and in 2008 TIMSS Advanced study measured physical knowledge of students in their last year of secondary school before entering the univeristy study. Participating countries (from 10 to 90 in each measurement) use the same internationally designed tests and questionnaires to simultaneously collect the data on knowledge and other factors about school, teaching and students' background to explain measured students' outcomes. Slovenia participate in the study from 1995. The strenghts and weaknesses of the study will be presented with regard to known issues of physical education in Eastern Europe from the perspective of 17 years of experiences of the national research center for the study.

Physics knowledge differs between countries and between grades. In our presentation, comparisons across the countries will be given regarding achievement, organisation of teaching, differences in curriculum and most important students attitudes and background factors that have been found influential on physical knowledge through years. The access to the sources of data, description of study framework and results will be shown as some materials (such as test items) could be used in development of national physical education.

References

Description of the study and materials are available free on http://timssandpirls.bc.edu/

Research on students' reasoning in electromagnetism

Katarina Jelicic[1], Gorazd Planinsic[1], Maja Planinic[2]

[1]*Department of Physics, Faculty of Mathematics and Physics, University of Ljubljana, Slovenia*

[2]*Department of Physics, Faculty of Science, University of Zagreb, Croatia*

E-mail: katarinajelicic@gmail.com

Many PER studies have shown that students' understanding of concepts from electricity and magnetism is often inadequate after standard instruction based on lectures. Students are seldom engaged in activities that would allow them to construct deeper understanding of physics concepts. The standard lecture – based teaching may lead to deficiencies in their knowledge structure.

The objective of this research was to investigate students' understanding and conceptual models of several electromagnetic phenomena, formed after standard lecture – based instruction in Croatian high schools. The investigated phenomena included magnetic fields around a steady current-carrying wire and inside coils, force on a current-carrying wire in a uniform magnetic field, electromagnetic induction and Lenz's law.

For the purpose of this research, nine Croatian high school students, aged 16-17, were interviewed after they had completed a course on electromagnetism. After having been shown a demonstrational experiment, students were asked to describe what they had observed and whether they could explain their observation. Each student was asked to think aloud, so that their reasoning could be analysed. Students were not corrected if they had arrived at the wrong conclusions. After they had formed their conclusion and stated that they had nothing to add, the interviewer gave them clues in form of additional experiments, as an attempt to create situations for students to test and revise their own ideas. The interviews were recorded with a video camera and transcribed for later analysis. Students seem to have created their own incorrect models of electromagnetic phenomena, even though they had just successfully completed a course on it. They had difficulties in explaining how a magnetic needle works, or why it changes direction when put under a current-carrying wire, and needed to form their own new model of the phenomenon. They were able to regulate, re-evaluate and upgrade their model in a way an expert would do when given clues and asked questions.

The results of the research suggest that standard instruction on electromagnetism may be insufficient for students to form correct models of the electromagnetic phenomena and to achieve the correct conceptual understanding.

Inquiry Based Science Education (IBSME) in Serbia

Stevan Jokić

Institut VINČA, University of Belgrade, Serbia

E-mail: sjokic@vin.bg.ac.rs

Ruka u testu (La main à la pâte) is Serbian program aiming at renovating science education in elementary and low-secondary schools. It recommends that teachers implement *Inquiry Based Science Education* (*IBSME*), which aims:

– at renovating science education in elementary schools, allowing exchanges and enhancing the development of good practices: teacher's training, evaluation, *on-line* projects and dissemination.

– to stimulate and support a Primary School education by experimentation, based on scientific method.

Our strategy was, on the first place, scientific literacy for all children by creation of different resources for teachers:

– translated Books: *La main à la pâte; Seeds of science 1, 2, 3, 4, 5, 6, 7; Teaching Science at School; Discovering the World at Nursery School*;

– Collaborative and interdisciplinary projects: *On the steps of Eratosthenes, European discoveries, Living with sun, Climate, my planet and me!*

– Free Pedagogical Kits for Primary Schools

– Many appendixes in Serbian Educational weekly journal *Prosvetni pregled* and three E-Bulletins with instructions for teachers;

– Exhibitions: *Sciences à l'ecole: quelle histoire! Nanomonde; Science festivals* in Belgrade, Novi Sad and Podgorica (Monte Negro);

– Website ***http://rukautestu.vinca.rs***, the semi-mirror of the French website (***www.inrp.fr/lamap***), in use (in Serbian) form the end of 2008, on which teachers can find many important resources for the work in classes...;

– Training workshops for more than 3000 teachers.

International relations: Member of EU-FP7-FIBONACCI consortium, as TC1 center for dissemination of IBSME method; The *Greenwave* network includes 50 schools from entire Serbia**;** Five South – East European workshops for *Hands on* primary science education **(*http://rukautestu.vin.bg.ac.rs/handson4/)***

Estimating the Quality of the Environment by School Experiments

T. Kranjc and N. Razpet

University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

University of Primorska, Faculty of Education, Koper, Slovenia

e-mail: tomaz.kranjc@pef.uni-lj.si

We present an inquiry based student project where the school physics was related to some current issues, which frequently occur in everyday life. At instigation of students, several estimates and measurements of some aspects of the quality of the environment were performed. The project work had several aims: to motivate students to take part in physics experiments and to appreciate the physics knowledge in treating common everyday issues, to acquire some quantitative knowledge regarding the environment and to learn some important general physics concepts arising in a natural way while considering environmental issues.

Using school instruments students measured and estimated noise (in the city, by freeways, in the countryside), the light pollution in the city, and ion radiation. Using the school knowledge of physics they performed simple calculations and compared them with measured values and with values from other environments.

We present the practical work of the participating students regarding noise issues, their entering and exit knowledge, and a questionnaire used to measure the motivational effect of the project.

Competencies in Science Teaching

Leopold Mathelitsch

Institute of Physics, University of Graz

e-mail: leopold.mathelitsch@uni-graz.at

Competence models have been discussed in many countries for the last years. But how do teachers adopt these ideas and implement them in their class rooms? We report on an ongoing continuing professional development program in Austria in which teachers perform one-year school projects on the topic "Competencies in Mathematics and Science Teaching". The level of the schools is from primary to secondary I and II. Teachers do not only have to carry out the projects with their students, but they also have to evaluate several aspects of their work with action-research tools. The teachers get support in various aspects: finances, interaction with experts in didactics, support in evaluation and with their final report. Experiences of the first two years have shown that concentration on few competencies improves considerably the output of the projects: there is more interaction between theory and actual work at school, it is easier to communicate the results to other teachers by best practice examples.

Physics Education Research: the key to improving student learning

Lillian McDermott

University of Washington, USA

e-mail:

Presentation of the European research project SECURE

Jerneja Pavlin and Barbara Rovšek

University of Ljubljana, Faculty of Education, Kardeljeva ploščad 16, SI-1000 Ljubljana, Slovenia

E-mail: jerneja.pavlin@pef.uni-lj.si

Faculty of Education from University of Ljubljana collaborates in the European FP7 project **SECURE** (**S**cience **E**ducation **CU**rriculum **RE**search) which have started in November 2010. The project involves 10 European countries, Austria, Belgium, Cyprus, Italy, the Netherlands, Poland, Slovenia, Sweden and United Kingdom.

The aim of the project is to gain the relevant data on the current status of teaching MST subjects (MST = Mathematics, Science and Technology) for four age groups of students (5, 8, 11 and 13 years old). The data enable the measurements and the interpretation of differences among existing MST curricula between the countries and to answer on a question how to increase the interest of students in these subjects.

In Slovenia 15 primary schools and kindergartens from different parts of the country participate in the project. We are currently halfway through the project and have already collected the data. Data collection took place by questionnaires filled in by students and teachers in all participating schools and in 6 schools also with the semi-structured interviews. The semi-structured interviews were done also with the youngest age group of the involved students (5 years old) in all kindergartens.

The evaluation process is still in progress and the project will finish in October 2013.

In this contribution we will present the project in general as also the activities and first impressions from the data collection in Slovenia.

Comparison of students' understanding of graphs in mathematics, physics and other contexts

Maja Planinić[1], Zeljka Milin-Sipus[2], Ana Susac[1], Lana Ivanjek[1]

[1]*Department of Physics, Faculty of Science, University of Zagreb, Croatia*

[2]*Department of Mathematics, Faculty of Science, University of Zagreb, Croatia*

e-mail: maja@phy.hr

Students are introduced to graphs rather early in their education and through different school subjects. They acquire most of their knowledge about graphs through the study of mathematics and physics. However, students also encounter graphs in contexts other than those of mathematics and physics, such as biology, chemistry, everyday life, economy etc. The ability to interpret graphs is considered one of the important outcomes of high school mathematics and physics courses, and is often assumed by university faculty to be fully developed by the time that students enroll in university. This study investigates university students understanding of graphs accross three different domains: mathematics, physics (kinematics) and contexts other than physics (economy, biology, everyday life), which did not require any substantial context - dependent knowledge. Eight sets of parallel mathematics, physics and other context questions about graphs were developed by authors. Questions were parallel in the sense that the required mathematical procedure for solving the question was the same in each set of three items. However, depending on the domain, the interpretation of the meaning of the obtained solution differed among parallel questions. A test consisting ofthose eight sets of questions (24 questions) was administered to 385 first year students at University of Zagreb, who were either prospective physics/mathematics teachers or researchers. The test was administered at the beginning of the first semester. Four sets of questions were multiple choice, and four were open ended, but in all questions explanation of the answer was required. Data was analyzed with the Winsteps 3.66 software for Rasch analysis and linear measures for item difficulties were obtained. Average difficulties of items in different conceptual areas (graph slope, area under a graph) and in different domains (mathematics, physics, other contexts) were computed and compared. Analysis suggests that the concept of graph slope is of equal difficulty in all three domains, whereas the difficulty of the concept of area under a graph differs across domains. Mathematics was, for students in this study, the easiest of the three domains. It appears that addition of either physics or other context to mathematical items significantly increases difficulties of those items. No significant difference was found between average item difficulties in physics and in other contexts domain, suggesting that physics as a context was not easier for students than other contexts presented in the study, although all students had previously studied physics in high school. Students' reasoning on parallel problems in different domains will be illustrated by examples and discussed. The findings of the study suggest that students' mathematical knowledge is not the most important factor for students' success in solving graph problems in physics or other sciences, and point to important differences in student understanding of graph slope and area under a graph.

We love experiments, we do not like theory

N. Razpet and T. Kranjc

University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

University of Primorska, Faculty of Education, Koper, Slovenia

e-mail: nada.razpet@pef.uni-lj.si

Every year, at the end of the school year and before the exams, we administer a questionnaire in order to get to know how students are satisfied with our work. In particular, we want to know which contents they liked and which they did not like. As usually, also this year students of Preschool Education at the Faculty of Education in Koper wrote that they liked the lab and field work, but they did not like the “theory”. They explained that the theory is too difficult for kindergarten; it could be understood that the theoretical background given to them at the experiments is unnecessary as such explanations would not be given in kindergarten. The students of the Elementary School Program – the future teachers in elementary schools – have the same attitude. Therefore, before performing experiments, we check the prior knowledge of students and choose appropriate experiments accordingly. After performing a group of experiments, we again check students’ knowledge and understanding and, depending on their response, propose new experiments to be done by themselves or we prepare additional experiments to be performed at the course or at the lab work. We draw attention to errors and misconceptions and emphasize the need to know some “theory” also when doing experiments. In the presentation, we give an example from mechanics and from electricity.

Universe in a liquid crystalline droplet

R. Repnik[1], D. Jesenek[1], M. Ambrozic[1], Z. Bradac[1], S. Kralj[1]

1 FNM, University of Maribor, Maribor, Slovenia

e-mail: robert.repnik@uni-mb.si

Liquid crystal (LC) phases and structures are adequate testing ground to study and demonstrate several universal phenomena in nature. Furthermore, they are promising to play a vital role in numerous future nano-based applications. In our pedagogical multimedia presentation we intend to illustrate (i) topological defects in LCs and analogues in cosmology, particle physics, superconductivity and (ii) potential LC driven future nano-based devices. In the following we briefly present content of our presentation.

Physics of topological defects exhibits several universalities because it is based on topology and topological properties are not sensitive to microscopic details. We will start our presentation in thin nematic films in which we will illustrate different defects in orientational ordering and conservation of topological charge [1,2]. Analogy with electrostatics will be presented on curved surfaces where Gaussian curvature mimics role of external electric field and topological charges plays similar role as electrical charges. Curvature driven unbinding of defects will be shown. Next we will consider coarsening dynamic of defect textures during isotropic-nematic LC quench [3]. Relationship between annihilation of defects and domain growth will be stressed [4,5]. Analogy with coarsening dynamics of the Higgs field in the early universe will be given [3]. We will continue with topological defects in translational order in smectic A LCs. Analogy between smectic A phases of type I and II and superconductors of type I and II will be presented. Comparison between TGB LC structures and Abrikosov vortex structures will be stressed.

In the second part role of LC in nano-based devices will be presented [6,7]. We will demonstrate how relatively easily manipulated LC patterns could be exploited to form different nanotube-based structures. Possibilities of forming scaled crystals using LC shells will be given [2].

References:

[1] R. Repnik *et al.*, *Physics of defects in nematic liquid crystals*, Eur. J. Phys. {**24**}, 481 (2003).

[2] D. Jesenek *et al.*, *Thin Nematic Films: Laboratory of Physics for Topological Defects*, Mol. Cryst. Liq. Cryst. {**553**}, 153 (2012).

[3] Z. Bradac *et al.*, *Early stage domain coarsening of the isotropic-nematic phase transition*, J. Chem. Phys. {**135**}, 024506 (2011).

[4] M. Ambrozic *et al.*, *Annihilation of edge dislocations in SmA liquid crystals*, Phys. Rev. E {**70**}, 51704 (2004).

[5] M. Svetec *et al.*, *Annihilation of nematic point defects: pre-collision and post-collision evolution*, Eur. Phys. J E {**19**}, 71 (2006).

[6] P. Schoot *et al.*, *Alignment of Carbon Nanotubes in Nematic Liquid Crystals*, J. Phys. Chem. B {**112**}, 4512 (2008).

[7] E. Karatairi *et al.*, *Nanoparticle-induced widening of the temperature range of liquid-crystalline blue phases*, Phys. Rev.

Active physics learning: An "online plus classroom" design of activities*

Josip Slisko

Facultad de Ciencias Físico Matemáticas, Benemérita Universidad Autónoma de Puebla, Puebla, México

e-mail: jslisko@fcfm.buap.mx

There is an experimental evidence that instructional designs which promote active physics learnig give better results (in conceptual, cognitive and affective domains) than traditional lecture-based physics teaching.

Nevertheless, sometimes group active learning carried out in classroom leaves a possiblity that some students do not work seriously enough on their personal ideas and arguments regarding predictions, explanations or possible problem solution plans. In that case, students avoid to know and improve their self-regulated learning skills.

It is believed that one way to deal with this flaw in group active learning in classroom is to ask every student provide their personal ideas and arguments online before classroom session. Possible initial experimental explorations of this desing will be discussed briefly.

---

*This work forms part of the sabbatical research project "Active physics leaning on-line" funded by CONACyT (National Science and Technology Counsil, Mexico), carried out at the Faculty of Mathematics and Physics of the University of Ljubljana (Slovenia) with Prof. Gorazd Planinsic as host-scientist.

Overcoming the problem of decreasing the number of physics students

Maja Stojanović, Dušanka Obadović, Branka Radulović, Ivana Rančić and Elvira Đurđić
Department of Physics, Faculty of Sciences, University of Novi Sad, Trg D. Obradovića 4, 21000 Novi Sad, Serbia
e-mail: maja.stojanovic@df.uns.ac.rs

At the present time we are witnessing the evidence showed considerable reduction in the number of students in physics. In order to overcome this problem and popularizate Physics, a group from the Department of Physics, Faculty of Sciences University of Novi Sad, take the following steps:
- Mentoring talented students of special math classes, which have more classes in physics in relation to other High School in science direction
- student competitions in all four national and one international level
- promotion in Secondary schools
- actively participating in the Festival of Science and the Researches Night
- Theater performance
- TV shows

For the teachers we organize a one-day seminar, dedicated to specific areas of physics, where in addition to interesting lectures we have workshop where teachers, organized into a small groups, perform »hands on experiments« and at the end have a discussion.
As a result of these activities, we can point out that this year for the first time, we have more students than Ministery of Education predict by the budget.

Brain research and education

Ana Susac, Maja Planinic, Lana Ivanjek

Department of Physics, Faculty of Science, University of Zagreb, Croatia

e-mail: ana@phy.hr

Educational neuroscience is a new interdisciplinary research field, where traditional methods of educational research are combined with neuroscience techniques. Neuroimaging methods, such as electroencephalography (EEG), magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI), provide tools for the measurement of the brain activity of participants while they are performing a task relevant to education. Neuroscience research offers an important insight into the brain development and function. Many studies are focused on developmental disorders, such as dyslexia and dyscalculia. On the other hand, there is a wide research area on basic learning mechanisms of normally developing children and adults.

Few examples of neuroimaging studies, relevant for physics teaching and learning, will be presented. We will show results of our EEG study on proportional reasoning of university students. Student's ability to solve simple algebraic equation is a prerequisite for problem solving in physics. We employed different methods to explore students' strategies in equation solving. The present results will be reported and future studies proposed.

Qualitative research in physics education

Janez Vogrinc

University of Ljubljana, Faculty of Education, Kardeljeva ploščad 16, Ljubljana, Slovenia

e-mail: janez.vogrinc@pef.uni-lj.si

In the field of science education, two paradigms of scientific research were developed in the past. Regarding their attributes, they are called quantitative and qualitative. This presentation focuses on qualitative research. The qualitative research regarding its ontological, epistemological and methodological aspect is not a consistent phenomenon; namely, it combines different kinds of research, e.g. a case study, life history, action research and others. Bogdan and Biklen (2003) use the term »qualitative research« as the superordinate concept, joining different research approaches with certain common characteristics as well. With the expression »qualitative research« the research is denoted consisting of the basic empirical material, collected in the research process, which is verbally described or narrated. Furthermore, the collected material is worked on and analyzed in words without numerical operations (Mesec 1998). The aim of qualitative study is to gather data in the form of rich content–based descriptions of people, events, and situations by using different, especially non–structural, techniques, to discover the stakeholders' views and similar, and to analyse the gathered data verbally, and finally to interpret the findings in a form of a concept or grounded theory which is contextually dependent. At analyzing the gathered data the qualitative analysis are used, the essence of which is searching for codes in the analyzed materials (Bryman 2004). The main part of the qualitative analysis of the material is formed by the coding process namely, i.e. interpreting the analyzed text and attributing the meaning (of key words, notions, codes) to its individual parts (Charmaz 2006; Bryman 2004), respectively.

At the end of presentation some insight for future science education research will be put into perspective of where the science education research is heading.

References:

Bogdan, R. C., & Biklen, K. S. (2003). *Qualitative Research for Education. An Introduction to Theory and Methods*. Boston: Allyn and Bacon.

Bryman, A. (2004). *Social Research Methods*. New York: Oxford University Press, Inc.

Charmaz, K. (2006). *Constructing Grounded Theory*. London: Sage Publications Ltd.

Mesec, B. (1998). *Uvod v kvalitativno raziskovanje v socialnem delu. / Introduction to Qualitative Research in Social Field.* Ljubljana: Visoka šola za socialno delo.

WORKSHOPS

Liquid crystals in school

<u>Mojca Čepič</u>, Jerneja Pavlin, Maja Pečar, Katarina Susman and Saša Ziherl

Simple experiments with computer scanner for learning about linear relative motion

Gorazd Planinšič

Liquid crystals in school

Mojca Čepič, Jerneja Pavlin, Maja Pečar, Katarina Susman and Saša Ziherl
Faculty of Education, University of Ljubljana, Slovenia
E-mail: mojca.cepic@pef.uni-lj.si

Today, developed countries are confronted by a decreasing interest in the science and technological studies. One possible reason is a detachment of topics taught in school from the everyday life. Most of the science topics taught were discovered more than hundred years ago, topics are old from the students' perspective and they do not relate to anything in a real life [1]. Another problem is that teaching of natural sciences is often too traditional [2] which suppresses the excitement that science can so readily offer.

Liquid crystals have attracted physicist from the beginning of the 20th century. 35 years ago many properties of liquid crystals still seemed to be mysterious oddities, while today they are successfully used in displays and other applications. What is more, they are willingly taken as starting points, reference systems and physical models for scientists working in such different fields as anisotropic superfluids, surfactants or even cosmology [3]. Liquid crystals are a modern material, which are used every day in several devices. They are a constituent part of the flat screens, mobile phones, touch-screen devices and similar. As such, they are a modern topic, which supports relevance of physics for everyday life. Even more, the topic is a part of an intensive academic research and an on-going development of new technological devices is very important for technological advances. As such, liquid crystals are a topic, which can seriously increase motivation for physics if properly introduced into the classroom.

Having in mind all mentioned above, we designed a set of hands-on experiments based on liquid crystals, which could be synthesized in the school laboratory, and show all the basic properties of liquid crystals. The first part of the experimental set presents the liquid crystalline state as a special state of matter and how the temperature dependent properties can be observed and used for determination of phase transitions. Next, the participants of the workshop will construct three cells – the cell with disordered liquid crystals, the cell with oriented liquid crystal and the wedge cell, which allows for more detailed studies of their optical properties. Experiments with liquid crystals will be accompanied with the set of experiments that serve as models of liquid crystalline structures and their properties. We will show structures of liquid crystalline phases (nematic, smectic, cholesteric) made of wood and how the structure influences the microwaves in the same way as it affects optics of liquid crystals. We will show the mechanical analogue of the first and the second order phase transitions, as both types of phase transitions appear in liquid crystals. Finally we will show the experimental sequence for studying anisotropic optical properties of everyday materials like tapes or food wrappers and how they are related to the complexity of the conoscopic image used in academic research of liquid crystals.

The set experiments is adapted to teachers use, accompanying explanations are adapted to the students cognitive level from lower secondary level to the university level for students of physics.

References:

[1] J. Osborne, S. Simon, and S. Collins, *Int. J. Sci. Ed.* **25**, 1049-1079 (2003).

[2] A. Šorgo, and A. Kamenšek. *Energy education science and technology. Part B, Social and educational studies*, **4** (2), 1067-1076 (2012).

[3] O. D. Lavrentovich, Book Review: The physics of liquid crystals. *Liq. Cryst. today* **4**, 7 (1994).

Simple experiments with computer scanner for learning about linear relative motion

Gorazd Planinšič

Faculty of Mathematics and Physics, University of Ljubljana, Slovenia

e-mail: gorazd.planinsic@fmf.uni-lj.si

An earlier version of the workshop material material was originally used in the MUSE workshop at WCPE Istanbul, June 1-6, 2012. MUSE is part of Physics Education Division (PED) of the European Physical Society (EPS).

See website http://education.epsdivisions.org/muse/

This is a hands-on workshop designed for teachers interested to engage students in practical work that mirrors scientific practice and thus helps them develop scientific habits of mind. The participants will be invited into a series of activities on relative motion in one dimension using computer scanner as a main experimental device. These activities will be carried out in small groups that will work in parallel on the same tasks.

The main part of the workshop will require active engagement of the participants in analyzing, solving and discussing problems. There will be emphasis on using multiple representations, such as labeled images, diagrams, graphs and equations. A whole group discussion will follow in order to share the experiences gained in the small groups, and envisage the transfer of the workshop to different audiences (students, teacher educators).

POSTER CONTRIBUTIONS

From preschool to teacher training – physics for all!
Selected educational proposal by Institut of Physics, Jagiellonian University
Daniel Dziob, Urszula Górska, Dagmara Sokolowska
Primary school students' views about scientists' outlook and usefulness of biographical information
Zalkida Hadžibegović, Armina Kafedžić
Physics in Slovenian school
Saša Kožuh
Teaching model of liquid crystal elastomers
Marta Lavrič, George Cordoyiannis, Mojca Čepič, Zdravko Kutnjak
Birefringence of a uniaxial nematic liquid crystal – direction-dependent property
Jerneja Pavlin, Nataša Vaupotič and Mojca Čepič
Observing optical properties of transparent anisotropic materials under different illuminations
Maja Pečar, Vitomir Babičand Mojca Čepič
Supplementary way of introducing electrical resistance
Katarina Susman, David Rihtaršič, Tomaž Kušar
Explaining functioning of a fish swim bladder with Cartesian diver
Tjaša Švelc, Mojca Čepič
Illustrating birefringence and direction dependence of extraordinary refractive index with a wood model
S. Ziherl, J. Bajc, M. Čepič

From preschool to teacher training – physics for all!
Selected educational proposal by Institut of Physics, Jagiellonian University

Daniel Dziob, Urszula Górska, Dagmara Sokolowska
Institute of Physics, Jagiellonian University, Reymonta 4, Cracow, Poland
e-mail: u.j.gorska@gmail.com, daniel.dziob@gmail.com

On the poster we present various activities of Institute of Physics related to popularization of natural science. They are dedicated for a wide range of people at different age and educational level.

Researcher's Night is organized annually in the last Friday of September. During 6 hours many workshops, lectures, experiments and shows are provided parallel in different institutes and universities in Cracow. The event is dedicated to the whole society and each year it integrates thousands of people, in 2011 there were more then 31 thousands of participants.

The Cracow Festival of Science is the three-days event which takes place in the Main Square in Cracow. At this time students from all Cracow's schools (universities, academies, colleges) present experiments, giving workshops and providing information about studies. Every year Institute of Physics presents there around 6 stands.

Foton and Neutrino are the quarterlies issued by Institute of Physics for teachers, students and pupils. They always contain discussion about actual problems in physics, propositions of home-made experiments, answers to tasks from physics competitions and some interesting articles about physics around us.

Physics Academy is a session of scientific lectures for lower and upper secondary school students, held at the Institute of Physics twice a year: Winter Physics Academy - in February and Summer Physics Academy - in June or September. They are dedicated to the students particularly interested in physics. Each session consists of one day designed for junior high school students and a three-day cycle for high school students.

The last ring before *matura* exam in physics and astronomy is the youngest event dedicated to students in the last class of high school, just before their *matura* exam. It consists of a lecture and sessions of workshops, in which a general repetition in six main fields, needed for exam is provided.

The Firefly is a nationwide competition in natural science whose goal is to motivate pupils to learn science from different sources and to try doing experiments on their own. It consists of two main parts: individual performance of obligatory experiments and then filling in a test. The best pupils are given some awards (books, puzzles, DVDs). Schools represented most frequently are awarded with science workshops for the whole school community.

The workshops. At the Institute of Physics there are organized different physics workshops dedicated to students at each education level. They differ in themes and forms of educational issues. The participation in them is always free of charge.

Turn on the physics – PhysicsON is a project, which is still in progress. We plan to create an educational platform for teachers and students from junior high school where we want to place some interactive materials, e.g. simulations, games, experiments or films recorded by ourselves. The first part of it will be connected to electricity and magnetism.

Institute of Physics participates also in three European educational grants under 7th Framework Program: Fibonacci (teacher training in IBSE), SECURE (research on MST curricula) and SAILS (assesment in IBSE).

Primary school students' views about scientists' outlook and usefulness of biographical information

Zalkida Hadžibegović, Armina Kafedžić [2]
[1]Department of Physics, Faculty of Science, University of Sarajevo, Bosnia and Herzegovina
[2]Gymnasium IV, Ilidža, Sarajevo County, Bosnia and Herzegovina
E-mail: zalkida@yahoo.com

The aim of this study was to determine primary students' views concerning information related to the history of physics in their textbook. Data gathered from an in-class worksheet writings by students were used to analyze their views about a role of a picture and a short biographical text in their understanding of corresponding textbook content. The study involved 173 primary school students in grades seven and eight. Students were asked to answer how a Celsius picture and a short note about his scientific contribution presented in their physics textbook could help them to image a scientist in general. Students identified Celsius as a scientist-physicist in most by his hairstyle (66 %) and by his clothing (43%). A group of students (25%) considered that Celsius's facial appearance (eyes, lips and eyebrows) could also be the key elements form part of the image of a scientist. Research findings have showed that students have built up a stereotypical image of scientists.

A few questions about the Celsius' biographical information in a textbook, which accompanies a photo attached, were given to students with the main goal to see if their understanding of the text has something to do with the main theme treated in this textbook chapter: an introduction for primary-school students into the temperature concept, temperature measurements and its units. But the accompanying text is about Celsius research on the polar lights, a content that is outside of the textbook chapter and primary school physics curriculum. It was found that around 70% students did not have any idea about the polar lights. Only a few of them have showed some understanding of that phenomenon, obviously gained in out-classroom environment. One can considered that such kind of usage of biographical information can't help student understand better physics and process of its development.

Physics in Slovenian school

Saša Kožuh

OŠ Ketteja in Murna, Ljubljana, Slovenia

E-mail: sasa.kozuh@guest.arnes.si

Difficulty of teaching physics in elementary school is reflected in different ways.

The pupils meet physics and organized and systematic treatment of physical concepts for the first time. Many problems in the classroom reveal substantially different every day experiences of children from the physics concepts. The development of abstract thinking in school may be a problem, as all children in the classroom are not able to interpret physics concepts at the same level.

There is no clear beginning of teaching physics, or the first, main, physical concept from which others follow. This question is also engaged in the curriculum of physics. The order in which to teach physics is only a recommendation for a teacher, which clearly shows the problem of "correct" order.

One of the important factors is the fact that physics and mathematics are among the least popular subject in schools [Dnevnik, 23. 6. 2007; Slana, 2007].

The presented study reports on the general practice in the obligatory school assessed by the questionnaire responded by 150 teachers. I wanted to assess how they rate the complexity of physical concepts; how often they experiment in the classroom and how often children experiment themselves. In the analysis I was especially interested in how work experience, gender and other subjects teachers teach affect the frequency of using experiments in the classroom. My aim for the survey was to cover about 5% of all physics teachers in elementary school. However, the response was outstanding and the number of teachers who responded to the questionnaire is very high, between 15% and 20% of all physics teachers in elementary school.

References

Ivelja, R. (2007). Osnovnošolski učitelji pri svojih učencih izdelali s prav dobrim, Dnevnik 23.06.2007. http://www.dnevnik.si/novice/aktualne_teme/zgodba/253506/

Slana, R. (2007). Priljubljenost fizike v osnovni šoli. Fakulteta za naravoslovje in matematiko. Univerza v Mariboru. http://fizika.fnm.uni-mb.si/files/seminarji/06/Priljubljenost_OS.pdf

Teaching model of liquid crystal elastomers

Marta Lavrič [1], George Cordoyiannis [1,2,3], Mojca Čepič [1,4], Zdravko Kutnjak [1]

1 Condensed Matter Physics Department, Jožef Stefan Institute, 1000 Ljubljana, Slovenia

2 EN FIST Centre of Excellence, 1000 Ljubljana, Slovenia

3 Physics Department, University of Athens, 15784 Athens, Greece

4 Faculty of Education, University of Ljubljana, 1000 Ljubljana, Slovenia

E-mail*:* marta.lavric@ijs.si

Liquid crystal elastomers (LCE) are composed of liquid crystals (LC) and crosslinked polymer chains. The LC main microscopic properties are orientational and positional order and that is why we find LC in different phases between crystal and liquid phase the so-called liquid crystal phases. Liquid crystals may flow, drip and they take a shape like a liquid, but they are similar to crystals because their molecules may be oriented in a crystal-like way. Elastomers are made from polymer chains, which form an elastomeric polymer net. That gives them macroscopic properties like shape and deformation. If we act on them with a force, they stretch in the direction in which they were pulled. When the deforming force is removed, they resume their original shape, unless if the force was over some threshold that may permanently deform the elastomer.

LCEs have properties of both LCs and elastomers. A very interesting property is their thermomechanical response. The liquid crystals in LCEs go upon heating from the ordered LC phase (N, SmA) into the isotropic phase. LCEs are longer along the direction of the LC phase director [1]. The thermomechanical response can be tailored by various parameters, among them the crosslinking density. This response is reflected to the critical behavior of heat capacity, since a steep first order transition corresponds to "on-off", whereas a broad supercritical transition to a "smooth" change between two states. By increasing the crosslinking density in smectic LCEs the heat capacity anomaly is broadened and, hence, the thermomechanical response is slower. Moreover, the released latent heat is decreased. [2] .

Our mechanical model contains LC molecules, made of artificial mass and little magnets (used for putting molecules on board easily), and ordinary elastics with colored wire for crosslinkers presenting elastomers. All these components together can be used to show how LCEs are made. The model can be used at school with intention to introduce to the children the various LC phases, the role of crosslinkers in elastomers, the construction of LCE and finally to explain their thermomechanical response.

References:

[1] M. Warner, E.M. Terentjev, *Liquid Crystal Elastomers,* Oxford University Press: New York, 2003.

[2] G. Cordoyannis, D. Kramer, M. Lavric, H. Finkelmann, Z. Kutnjak, *Calorimetric study of smetic elastomers,* Mol. Cryst. Liq. Cryst., **553**, 193 (2012).

Birefringence of a uniaxial nematic liquid crystal – direction-dependent property

Jerneja Pavlin[1], Nataša Vaupotič[2,3] and Mojca Čepič[1,2]

[1]*Faculty of Education, University of Ljubljana, Ljubljana, Slovenia*

[2]*Jožef Stefan Institute, Ljubljana, Slovenia*

[3]*Faculty of Natural Sciences and Mathematics, University of Maribor, Maribor, Slovenia*

e-mail: jerneja.pavlin@pef.uni-lj.si

Science lessons should be based on experiments which directly and illustratively demonstrate the phenomenon. Double refraction (birefringence) is usually introduced by the experiment where students look at the text through the calcite and observe doubled letters. The explanation of the experiment is usually simplified only to refraction however the proper explanation should include both the refraction and reflection. The experiment which shows only the double refraction and helps in explaining thoroughly the double refraction can be done with a wedge liquid crystalline cell. In addition, the experiment can be used for a quantitative measurement of both refraction indices of the uniaxial liquid crystals [1].

We present an experiment in which two wedge cells with different molecular orientations of the nematic liquid crystal are used. The experiment enables the explanation of double refraction and the observation of variation of extraordinary refractive index as a function of the direction of light. By the mentioned experiment the qualitative and quantitative measurements of the extraordinary refractive index direction dependency in a uniaxial nematic liquid crystal can be done.

Reference:

[1] D. K. Shenoy, *Measurements of liquid crystal refractive indices*, Am. J. Phys. **62**, 858 (1994).

Observing optical properties of transparent anisotropic materials under different illuminations

Maja Pečar[1], Vitomir Babič[1,2]and Mojca Čepič[1]
[1]University of Ljubljana, Faculty of Education, Kardeljeva ploščad 16, SI-1000 Ljubljana, Slovenia
[3]School Centre Celje, Pot na Lavo 22, 3000 Celje, Slovenia
e-mail: maja.pecar@pef.uni-lj.si

An anisotropic material is birefringent and consequently one ray of light splits into two rays with different polarization after passing through it. Because the two polarizations have different phase velocities, the phase shift results in elliptical polarization. Using polarisers, one detects variation of intensity of light for different elliptically polarized states. A confusion arises, when the white light is used instead of monochromatic illumination. In that case, the transmitted light is coloured . We present a set of experiments to suppress this confusion.

The experiments are based on anisotropic materials (transparency or some layers of scotch tape) between two crossed polarisers. To illustrate the problem, students are illuminating the sample with a monochromatic light (laser beam) and the whole spectrum of wavelength (white light). They observe with naked eye (or, in the case of a laser beam, with the photodiode) the change in intensity of the transmitted laser beam and the colour changes when illuminated with white light, while they are changing the thickness of the sample and the angle of incidence (observation).

To understand and clarify the problem, why they see colours in the case of white light illumination, they measure the spectra of transmitted light. They observe also the colours and relate them to the spectrum changes, while rotating one of the polarizer. The experiment shows students that different wavelengths become differently polarized and consequently differently absorbed [1].

For an additional experiment, students can observe the conoscopic figures of the same sample with lasers with different wavelength and with diffused white light. They can observe the difference in the distance between minimums and maximums of intensity of the pattern while using different monochromatic light sources and the mixture of the monochromatic patterns while using white light.

Referencies

[1] Babic, V. and M. Cepic, *Eur. J. Phys.*, **30**, 793–806, 2009.

Supplementary way of introducing electrical resistance

Katarina Susman[1], David Rihtaršič[1], Tomaž Kušar[2]
[1]*Faculty of Education, University of Ljubljana, Slovenia*
[2]*Primary school Mokronog, Slovenia*
E-mail: katarina.susman@pef.uni-lj.si

In the primary school physical education the electricity is one of the topics that is abstract and often difficult to visualize. With ambition to bring the concept of resistance closer to students an alternative or supplementary device for visualization the effects of resistance is presented in this contribution.

Who does not know the kids' toys that start to work at the moment when one simultaneously touches the two contacts? Connecting the two contacts through human body, toys usually start to emit light and/or sound. But, how does it work, what is inside the toy? An investigation reveals that the electronic circuit is rather complicated to unravel.

In this contribution we present an electronic circuit that has similar effects as the complicated circuits in the toys. An accompanying teaching sequence where primary school children (age 10-14) investigate and deal with the above problem is presented as well. The objectives of the teaching sequence lay a great stress on students' active learning, where they develop motoric skills, identify the electronic elements, getting to know the electric circuits with its basic components and connect their knowledge with a daily life.

Further on we present another simple electronic device that is a "detector" of resistance that can be introduced to school as a means of an experiential learning [1]. The diodes in the detector alternatively emit light. The frequency of blinking LEDs depends on the resistance or conductivity in the circuit. Larger frequency indicates better conductivity. Since we are using the resistors in range between 200 and 500 kΩ -which are in range of resistance of human body - the students not only have the opportunity to experiment with different combinations of resistors, but also have the opportunity to become one. They can represent the resistor with their own body.

Using this simple device many additional problems can be introduced. When students observe the influence of the skin moisture on the conductivity, they start to comprehend the basis of the devices such as lie detector, stress detector etc. If in the circuit a thermistor is used instead of a human body, the frequency of the light signal is changing when the temperature is changed.

The described electronic circuit is a device that can be used at different school levels from primary up to the higher education [2].

References:

[1] Charles Platt, Make: *Electronics Learning Trough Discovery*, O'Reilly Media /Make, November 2009.

[2] Rihtaršič, D., Šantej, G. and Kocijancic, S., *Promoting engineering studies through summer camps of electronics and robotics*, Proc. 2nd WIETE Annual Conf. on Engng. and Technol. Educ., Pattaya, Thailand, 64-69 (2011).

Explaining functioning of a fish swim bladder with Cartesian diver

Tjaša Švelc[1], Mojca Čepič[2]
[1]Institute of Biophysics, Faculty of Medicine, University of Ljubljana, Ljubljana, Slovenia
[2]Faculty of Education, University of Ljubljana, Ljubljana, Slovenia
E-mail: tjasa.svelc@gmail.com

Cartesian diver is one of the most popular classic science experiments and it is frequently used in all levels of physics education. Simple accessories and uncomplicated construction encourages thinking about different physical characteristics and phenomena. In this contribution, a different version of the Cartesian diver is presented - the pressure differences are applied by the height of the water column and not, as usual, by the application of the force on the bottle [1]. Suitably equipped diver is immersed in a large water column by using a magnet. By changing the diver's depth, the position, where buoyancy and weight equilibrate, is found within the water column. This provides a more realistic model for a fish with a swim bladder. Once, the diver is putted some depth, we notice that, the diver either floats to surface or sinks to bottom, depending on whether we put it above or below its buoyancy equilibrium depth. What happens to the diver at its buoyancy equilibrium depth? Theoretically, the diver stays at this depth, but practically, because the buoyancy equilibrium is unstable, the diver swims or sinks. It can be concluded that without constantly managing and adapting its gas bladder a fish would float to the surface or sink to the bottom.

Reference:

[1] J. Guemez, C. Fiolhais, M. Fiolhais: The Cartesian diver and the fold catastrophe, The American Journal of Physics, 70 (7), (2002): 710-714.

Illustrating birefringence and direction dependence of extraordinary refractive index with a wood model

S. Ziherl[1], J. Bajc[1], M. Čepič[1,2]

1 Faculty of Education, University of Ljubljana, Ljubljana, Slovenia

2 Jozef Stefan Institute, Ljubljana, Slovenia

E-mail: sasa.ziherl@pef.uni-lj.si

Among many novel technological materials, liquid crystals are present all around us. That is why liquid crystals are promising as a topic to provoke interest of students for physics. On the other hand, a recent study by Pavlin *et al.* showed that students have limited knowledge about liquid crystals [1]. The combination of "interesting" and "not knowing much about it" indicates suitable motivational topic. Yet another point of view should be taken into account – it is difficult to show and explain various properties of liquid crystals in an easy-to-understand way. That is why we developed a series of experiments to show typical optical properties of liquid crystals by analogy, using microwaves and suitably prepared wooden models [2].

The anisotropy of wood is obvious due to clearly visible fibres. Since wood is transparent for microwaves, experiments with wood samples and a simple school microwave kit, consisting of a microwave transmitter, a microwave receiver, and a multimeter can serve as an analogy for optical experiments with liquid crystals [3]. The prime reason for choosing wood over liquid crystals is the easily observable and well pronounced anisotropic structure of wood. Another important advantage of wood in comparison with liquid crystal cell is that wood can easily be cut in any direction, so preparing samples with different fibre orientation is simple and not expensive.

In the contribution the experiment that enables simple demonstration and measurement of extraordinary refractive index is presented. Suitably polarised microwaves are passing through a few centimeters thick wooden plates with different fibre orientation. The amplitudes of the transmitted microwaves are measured for different receiver-transmitter polarisation angles. The birefringence value of each plate is obtained by fitting the measured amplitude dependence on the receiver-transmitter polarisation angles with the theoretically obtained one. Finally, the dependence of the extraordinary refractive index on the fibre orientation is shown by plotting the dependence of birefringence values on the angle between the incident beam and the fibres.

We therefore show that on one hand, wooden samples and microwaves represent excellent analogy of liquid crystals and visible light, and on the other hand, experiments with microwaves and wooden models provide additional insight into the macroscopic properties of complex liquid crystal structures.

References:

[1] J. Pavlin, N. Vaupotič, S. Glažar, M. Čepič, I. Devetak, *Slovenian pre-service teachers' conceptions about liquid crystals*. Eurasia, **7** (3), 173 (2011).

[2] S. Ziherl, K. Susman, J. Pavlin, J. Bajc, M. Čepič, *Teaching liquid crystals with a wood model*, Molecular Crystals and Liquid Crystals, **547** (1), 241 (2011).

[3] S. Ziherl, J. Bajc, B. Urankar, M. Čepič, *Anisotropy of wood in the microwave region*, Eur. J. Phys. **31**, 531 (2010).

NOTES







Univerza *v Ljubljani*
Pedagoška fakulteta