

GIREP-EPEC 2023 Conference, Košice, Slovakia

Monday, 3 July 2023 - Friday, 7 July 2023

Faculty of Science, UPJS, Košice, Slovakia



GIREP-EPEC
3-7 July 2023
Košice, Slovakia

GIREP-EPEC conference 2023
Physics learning promoting culture
and addressing societal issues

Book of Abstracts

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Workshop Innovative strategies at university / 2**Introduction to Active Learning in Optics and Photonics (ALOP)****Author:** David Sokoloff^{None}

Active Learning in Optics and Photonics (ALOP) is a program to improve the secondary and university learning environment. A full 5-day intensive, hands-on-minds-on ALOP workshop updates participants on introductory optics and photonics and introduces them to strategies that have been demonstrated to be more effective than traditional instruction. These are characterized by use of predictions, discussions, and inexpensive equipment. This is a very short introduction to the ALOP strategies, with sample activities from some of the five ALOP modules. Participants will receive an electronic version of the ALOP Manual including all activities. More information on ALOP is at: <https://pages.uoregon.edu/sokoloff/ALOPwebpage.html>

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Workshop Remote and Online Teaching and Learning / 3**Home-Adapted Interactive Lecture Demonstrations: Active Learning at Home****Author:** David Sokoloff^{None}

Is it possible to maintain elements of active learning for introductory university and secondary physics students working at home? I have adapted Interactive Lecture Demonstrations (ILDs) for home use, using the wealth of multimedia materials currently available (videos, simulations, photos, computer-based laboratory graphs, etc.) for experimental observations. While small-group discussions have not been included because of potential difficulties in implementation, these Home Adapted ILDs retain predictions as an essential element in engaging students in the learning process. Participants will have the opportunity to work with examples from the 26 sets that are available.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Lab work and experiments / 4

Do It Yourself: a Simple Model of the Kibble Balance

Author: Leoš Dvořák^{None}

The Kibble balance is an instrument used for determining mass in the new definition of the SI system. The fact that this is a rather complex device may complicate students' understanding of how the unit of mass is now defined. A simple model (showing just the "electromagnetic part" of the Kibble balance, not the relation of a kilogram to Planck's constant) can help understand the principle of this device. The paper will present the construction of such a simple model, show how to use it in both velocity and force modes, and discuss the results of measurements.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Hybrid session - later / 6

Algebraic graphs and equations versus kinematics graphs and equations –High School teachers' perceptions

Author: Itumeleng Phage¹

¹ *Central University of Technology, Free State*

Algebra has a special and fundamental feature in the teaching of kinematics. The study was conducted with high school teachers teaching physical science from different types of schools and with different backgrounds. An open-ended questionnaire was distributed to them, and they voluntarily participated in the study. The study investigated their perceptions of their pedagogy of teaching kinematics and whether their learners are able to use their prior knowledge of algebra to solve kinematics graphs. The teachers were adamant that the majority of their learners are unable to use prior knowledge of and skills learned in algebra to solve kinematics problems.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Innovative strategies at school / 7

Critical Reading in Physics Lessons

Author: Klára Velmovská¹

¹ Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, Slovakia

We are surrounded by a lot of information and some of it is not based on truth. In physics classes, we should teach students how to identify information in scientific articles that are not scientifically correct – develop their critical reading skills. Activity will be presented using two newspaper articles, which were implemented by primary and secondary school pupils. After reading the text, they were supposed to answer the prepared questions. We evaluated these using the evaluation rubric that we created for this purpose. Arguing conclusions based on evidence, best reflects critical reading skills, causing them the biggest problems.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at school / 8

Fostering gifted students in physics

Author: Marianne Korner^{None}

Awakening, recognizing, and fostering gifted students is a challenge in science education, that teachers should address for the purpose of a comprehensive STEM support. A number of models and strategies are known for promoting giftedness. In this talk, we will discuss to what extent a format such as the Physics Olympiad is at all suitable to meet the desiderata of educating the gifted. Moreover, we focus on tasks to promote gifted students which have been developed within pre-service teacher courses at the University of Vienna. The tasks as well as results on the students' learning processes will be presented.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session 2 / 10

School science models of energy and their representation by in-service training

Author: Estelle Tison¹

Co-author: Emmanuel Rollinde¹

¹ LDAR

Energy is both a concept of everyday life linked with strong societal issues and an abstract scientific concept particularly complex to teach. Teaching energy requires the use of scientific school models and is facilitated by the use of energy chains. Through guided interviews, models and associated chains proposed by academic trainers (in-service education) have been clarified. These models and their representations are diverse and often diverge from those promoted by research in didactics. In particular, they generally do not take into account the degradation of energy, a property which is nevertheless fundamental to talk about energy in a societal context.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at school / 11

Measurement uncertainties: when to introduce the topic in secondary education?

Author: Karel Kok¹

Co-author: Burkhard Priemer¹

¹ *Humboldt-Universität zu Berlin*

Despite its relevance in secondary science education, measurement uncertainty is a topic that is largely neglected in classroom practice and for which hardly any suitable (evaluated) teaching material exists. Consequently, it is a topic that many students have conceptual difficulties with. To investigate how this topic can be introduced, we developed a digital learning environment and report on its evaluation with 154 students from grade levels 8 to 11.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Contemporary and modern physics / 12

Seeing Quantum Physics in the Classroom: Navigating the Landscape of Demonstration Material

Author: Bart Folkers¹

Co-authors: Alexander Brinkman¹; Kirsten Stadermann¹

¹ *University of Twente*

We present an overview of demonstration material used in quantum physics education. Our study categorises over 400 articles, covering experiments and demonstrations for quantum education from 1970 to now. Common research questions or goals of studies on demonstration material are identified, together with the number of studies per quantum physics topic. We share insights from studies regarding the use of demonstration materials to teach quantum physics to secondary school and undergraduate students and share considerations reported in these studies. Understanding choices and considerations made in previous studies can contribute to the development of new demonstration materials for quantum physics.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

13

Starting points for a new physics curriculum according to leading physicists

Authors: Petr Kolář¹; Vojtěch Žák¹

¹ *Charles University, Faculty of Mathematics and Physics*

This contribution is focused on the physics upper secondary school curriculum. We present the results of longitudinal research whose methodology is inspired by an objectivist grounded theory approach. We conducted in-depth interviews focused on the physics curriculum with 29 leading Czech physicists and we identified 56 ideas they agreed on. Two years apart, the questionnaire survey based on the 56 ideas was held among the original group of the physicists, other scientists, physics education experts and physics teachers. All groups of respondents generally support physicists' ideas that emphasize all curriculum orientations but the cognitive processes and the humanistic orientation most.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

14

Evaluation of professional profiles and teacher training for physics teachers in Mexico and Chile

Authors: Mario Humberto Ramírez Díaz^{None}; Jhonny Alexis Medina Paredes¹; Irene Gómez Jiménez²

¹ *Universidad Austral de Chile*

² *Universidad de Guadalajara*

The teaching of physics and its use as a means for developing different competencies requires teachers with a professional profile and an ideal teaching profile for it. For the above, it is necessary to have instruments to evaluate if the professional profile and the teacher's training allow them to reach the ideal profile to develop in the classroom the competencies requested in the physics courses at different educational levels. This study shows the procedure for designing, constructing, and validating evaluation instruments for physics teachers, oriented to two agents, directors and teachers

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

University education

Target education level (secondary, optional):

In-service teacher education

Innovative strategies at school / 15

Trustworthiness as Central Design Principle for Introducing Uncertainties of Measurements to Students

Author: Clemens Nagel^{None}

Two curricula of introducing measurement uncertainties for high school students have been developed. The central design principle was "trustworthiness of experiments and data" following the GUM recommendations of Type-A and Type-B methods. A time-delayed post-test showed the long term acceptance of the key ideas.

SEK-1 starts with an experiment that leads them to measurement uncertainties. Sources for uncertainties and the trustworthiness are discussed and data is analysed by simple statistical means. In SEK-2, students first build a measuring instrument by themselves for introducing Type-B uncertainties. Both curricula together provide a complete introduction in how to deal with uncertainties of measurement.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Physics teacher education / 16

Teachers' responses to students' explanations

Author: Danijela Dodlek¹

Co-authors: Eugenia Etkina ²; Gorazd Planinsic ³

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We present the results of our research on the teachers' ability to interpret student explanations and respond to them effectively. Students were solving a non-traditional problem involving momentum and energy. Teachers took the survey that contained the text of the problem and students' written explanations of their answer choice. Teachers were asked to comment on the student's strengths/weaknesses, and describe their hypothetical response to the student. To analyse teachers' responses, we used the Tasks of Teaching from the content knowledge for teaching energy (CKT-E) framework.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Pre-service teacher education

Innovative strategies at school / 17

Multimedia-supported electricity teaching via the application "Puma : Spannungslabor"

Author: Christoph Stolzenberger^{None}

Co-authors: Florian Frank ; Thomas Trefzger

Learning about Electricity suffers from the fundamental concepts being difficult to understand for students. The multimedia application "PUMA : Spannungslabor" was developed to support students by visualizing didactic analogies for electricity. The application uses Augmented Reality-technology to place a digital representation atop a real-world circuit. It is connected to the real-world circuit by camera and via Bluetooth, which enables the measurement and presentation of real-life data via the app. An additional mode was implemented, enabling the use of the application as a simulation. This contribution presents the application and gives examples on how it can support learning about electricity.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Informal and non-formal learning / 18

Bridging the gap between cutting-edge science and school: non-formal education in high-energy physics

Authors: Boris Tomasik¹; Ivan Melo^{None}; Vojtech Pleskot²

¹ *Univerzita Mateja Bela (SK)*

² *Charles University (CZ)*

Covering the most exciting results that push the limits of our knowledge about the Universe is a challenge for school education. Several complications hinder the direct implementation of such content into school curricula. This gap can be bridged by outreach activities. We report on outreach activities in particle physics that are organised in the Czech Republic and Slovakia, most notably the International Particle Physics Masterclasses, coordinated globally by the International Particle Physics Outreach Group (IPPOG). Based on surveys that we have collected over several years of Masterclasses, we examined their long-term impact on the participants.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Pre-service teacher education

Hybrid session - early / 19

EXAMINING PRE-SERVICE PRIMARY TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE FOR TEACHING SCIENCE THROUGH VIDEO ANALYSIS

Author: Elisa Appiani¹

¹ *Università degli Studi di Bergamo (Italy)*

Corresponding Author: elisa.appiani@unibg.it

Effective and high-quality science teaching involves complex practices that depend on teachers' professional knowledge. Researchers have investigated the nature of pedagogical content knowledge (PCK) predominantly in the in-service secondary school teachers' context. This research project aims to investigate the PCK construct through video analysis focusing on pre-service primary teachers and examining one of the PCK components: teachers' knowledge of students' understanding. Fifty-nine participants, attending a degree programme in Primary Education, attempted two video-based tasks and their responses were analysed qualitatively. This study points out the need for primary teachers to extend learning opportunities to notice students' scientific thinking.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Primary school education

Hybrid session - later / 21

Old (but Gold) Quantum Theory –A coherent framework for high-school students and teachers

Authors: Luisa Loviseti¹; Marco Giliberti²

¹ *Department of Physics, University of Milan*

² *Università degli Studi di Milano*

Corresponding Author: luisa.lovisetti@unimi.it

This presentation describes the results of design and implementation of an educational laboratory on Old Quantum Theory (OQT), consisting of 5 afternoon meetings with 36 high-school students and 9 teachers, held in early 2023. The course was aimed to propose an approach to the OQT which is coherent, meaningful, and historically correct, without radically changing the physics contents, the mathematical formalism and the prerequisites actually used in Italy. A first evaluation of the activity's effectiveness was assessed by means of questionnaires –comparing the answers obtained with those provided by an external sample –and individual interviews.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Contemporary and modern physics / 22

The effectiveness of mathematical representations for the understanding of Quantum Mechanics

Authors: Stefano Campagnaro¹; Luisa Loviseti²; Marco Porta³; Marco Giliberti⁴

¹ *Department of Physics, University of Milan*

² *University of Milan, Department of Physics*

³ *Istituto Balbo-Palli, Casale Monferrato (AL), Italy*

⁴ *Università degli Studi di Milano*

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Multi-representations are fundamental to improve the conceptual learning of abstract topics (such as mathematical aspects), allowing students to actively manipulate concepts and instruments which would otherwise be difficult and little accessible. In this presentation we will show different (and interconnected) representations for the acquisition of the basic mathematical formalism of Quantum Mechanics, that can be used to provide a conceptual introduction and construction of quantum formalism in high schools.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Lab work and experiments / 23

Experimental study of opto-electronic effects using smartphone and Phyphox: solar cell and LED

Authors: Giacomo Torzo^{None}; marisa Michelini¹; Stefano Pasqualotto²; Elisa Corteggiani³

¹ *Udine University*

² *Labtrek*

³ *Liceo Fermi, Padova, Italy*

We present a new kit designed to perform an educational study of several common devices that exhibit opto-electronic phenomena: LEDs, solar cells, photodiodes.

The Devices Under Test (DUT) are studied using a cheap datalogger, controlled by a common smartphone, and a board with plugs (where the DUTs may be mounted) and potentiometers that allow to obtain characteristic I-V curves and other interesting graphs.

The kit fosters the students to measure the energy conversion of sustainable devices, such as photovoltaic panels and LED illumination, at miniature scale, allowing to introduce them to the working principles of widespread renewable energy technologies as well as to teach fundamental principles in a new way. Our experimental set up is also designed to enhance digital skills and competences while experimenting with physics.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Physics teacher education / 24

Elixir to Schools - 10 years of continuous support for teachers

Author: Irena Dvořáková¹

Co-author: Petra Prošková²

¹ *Charles University, Faculty of Mathematics and Physics, Prague*

² *Elixir to schools, Czech Republic*

Corresponding Author: dvorak.irena@gmail.com

Elixir to Schools started 10 years ago as a project aimed at improving physics education in the Czech Republic. Five years later it became an independent non-profit organisation. Nowadays it organizes more than 50 regional centres in the whole country for teachers of mainly physics and computer science but also from primary schools and kindergartens. Currently, over 3,000 teachers are involved in Elixir to Schools. The paper will describe support provided to leaders of the centres, annual conferences of Elixir and specific experience from the project as well as teachers' feedback gathered through the annual evaluation.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Workshop Innovative strategies at university / 25

Creating a Student-Centered Collaborative Learning Environment in a University Physics Classroom

Authors: Gerald Feldman^{None}; Guillaume Schiltz^{None}

An active-learning workshop is offered to provide an example of a collaborative group-learning pedagogical environment for introductory physics at the university level. Participants will engage in various hands-on and minds-on exercises to illustrate how such a dynamic classroom can transform the strategy for teaching physics in university classes. A discussion about the benefits and challenges of this innovative approach will help guide the participants in adopting this teaching methodology in their own physics classes. We are working to establish a network of pedagogical innovators among the participants so that this type of approach can be more widely disseminated.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Innovative strategies at school / 26

Introduction of Newton's laws through model rocket construction

Author: Sándor Gergely Pesthy¹

Co-author: Mihály Hömöstre

¹ ELTE Department of Materials Physics

The research focuses on the effectiveness of classical dynamics teaching methods. A group working with a frontal teaching method was compared with two groups working with a learning activity-

based method, one of which used a model rocket project to learn the subject. We investigated whether there were differences between the groups in the occurrence of conceptual changes related to dynamics and the impact on students' attitudes towards physics and their career choice plans.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Poster session 2 / 27

Fostering pre-service physics teachers' diagnostic skills and readiness through video vignettes and micro-teaching sessions: An exploratory single-case study

Authors: Ingrid Krumpal¹; Markus Sebastian Feser^{None}

¹ *University College of Teacher Education Styria*

Pre-service physics teachers should be prepared for diagnosing students' conceptions within the physics classroom. This demand is met by a seminar implemented in the teacher training program at the University College of Teacher Education Styria. Within this seminar, participants work with video vignettes and conduct micro-teaching sessions. The focus of this study is to investigate the impact of the seminar on pre-service physics teachers' professionalization. To this end, participants were surveyed after each session of the seminar via a self-assessment questionnaire. Our data analysis revealed both positive and negative changes in the pre-service teachers' self-assessed diagnostic skills and readiness.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Innovative curricula / 28

How well do physics textbooks meet the the development of Scientific Literacy skills

Author: Fadeel Joubran¹

Co-authors: Alexander Mazzolini²; Marika Kapanadze³; Gabriela Jonas-Ahrend⁴

¹ *Arab Academic College of Education in Israel*

² *Swinburne University of Technology, Hawthorn, Australia*

³ *Ilia State University, Tbilisi, Georgia*

⁴ *Paderborn University, Paderborn, Germany*

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Physics textbooks are viewed as primary resources for the implementation of curricula throughout the world. Scientific literacy (SL) skills are a core goal of physics education in many curriculum documents, in which four aspects of SL are recognized: Science as (1) a body of knowledge, (2) a way of investigation, (3) a way of thinking, and (4) the interaction amongst science, technology, and society. This paper, which forms part of a broader review, highlights a gap between curriculum and content and concludes that most physics textbooks cover aspect (1) of SL adequately, but that they significantly understate the other three aspects.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Poster session 1 / 29

Development of experimental sets in optics for inquiry-based laboratory

Authors: Lydia Ceháková¹; Tomáš Kopriva¹

¹ *Charles University*

Corresponding Authors: lydia.cehakova@matfyz.cuni.cz, tomas.kopriva@matfyz.cuni.cz

Our aim is to showcase the creation of inquiry-based experiment units used in laboratory environment. These units are focused on qualitative and quantitative optics experiments for upper secondary students. Worksheets guiding the students through each unit were created and tested several times to ensure quality using students' feedback. This contribution presents these worksheets for experimental sets in Interactive Physics Laboratory operated by the Faculty of Mathematics and Physics, Charles University as well as review of worksheets based on students' feedback.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Symposium / 30

Cultural Understanding of Physics: Instruments and Methods

Authors: Marco Giliberti¹; Grzegorz Karwasz²; Luisa Lovisetti³; Giovanni Organtini⁴; Tommaso Rosi^{None}

Co-authors: Pasquale Onorato⁵; Eugenio Tufino⁶; Stefano Oss⁵; Graziano Surace⁷

¹ *Università degli Studi di Milano*

² *University Nicolaus Copernicus, Torun*

³ *University of Milan, Department of Physics*

⁴ *Sapienza Università e INFN, Roma I (IT)*

⁵ *University of Trento*

⁶ *University of Trento, Physics department*

⁷ *Sapienza Università di Roma*

Corresponding Authors: karwasz@fizyka.umk.pl, luisa.lovisetti@unimi.it, marco.giliberti@unimi.it, giovanni.organtini@roma1.infn.it, tommaso.rosi@unitn.it

Although nowadays sciences are viewed by most people to be extremely important for society, their human, profound aspect –the one that allows touching, in a way similar to Art, the strings of the human soul –is still missing. Sciences are, in fact, deemed mainly for their utilitarian aspects. If we want science, and more specifically physics, to be truly considered cultural heritage of humanity in its most general sense, we must bring a deep, cultural vision of physics to all school levels, starting with university, highlighting connections and promoting synergies with other areas of human knowledge.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Poster session 2 / 32

Socioscientific Decision-Making –From Theory to Practice

Author: Matthias Fasching¹

Co-author: Martin Hopf¹

¹ *University of Vienna*

Environmental, societal and economic trends due to climate change require the promotion of socio-scientific decision-making (SSDM) in physics education. However, teachers have different attitudes and perceive multiple challenges about its implementation in their classroom. Goal of this project is the research-based development of an in-service teacher training module to change hindering beliefs and increase teachers' intentions to promote SSDM in their physics lessons.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Pre-service teacher education

Hybrid session - later / 35

Interdisciplinary Lesson Study in Italian High School focused on the energy transformations.

Authors: Roberto Capone¹; Maria Giuseppina Adesso²; Oriana Fiore³; Maria Rosaria Del Sorbo⁴

¹ *University of Bari*

² *Da Procida High School*

³ *University of Salerno*

⁴ *Da Vinci High School*

This research focuses on the educational experiment of Interdisciplinary Lesson Study, carried out with 15-year-old students in Italy on the energy transformations. The teaching was carried out following the IBSE model of 5E and involving teachers from several disciplines. The theoretical lens used to read the data is the Lotman's idea of Semiosphere revisited in the educational context. It seems that collaborative teaching processes make teachers aware that asymmetry between disciplines can be an engine of knowledge. Moreover, these processes can also improve the teaching disciplinary actions.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Workshop Physics teacher education / 36

Physics Card Games: Learning or Fun? Pedagogical Considerations and Teachers' Attitudes

Authors: Smadar Levy¹; David Perl-Nussbaum¹; Edit Yerushalmi¹

Co-authors: Kobi Shvarzbord¹; Adi Noga¹; Aliza Rot¹

¹ *Weizmann Institute of Science*

In this interactive workshop, participants will experience physics card games ("Phys-Cards") designed as a summative activity to help students organize what they have learned and make connections between externally different scenarios and underlying physics principles. The Phys-Card games have been implemented in a national network of Professional Learning Communities (PLCs) for high school physics teachers (~300 teachers). The design principles, pedagogical rationale, benefits, and potential challenges will be discussed. We will share results from two years of experience with Phys-Card games in the PLCs and in teachers' classrooms, as well as insights into teachers' attitudes toward gamification in physics instruction.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Innovative strategies at University / 37**A multi-representational simulation to learn about vector fields**

Authors: Larissa Hahn^{None}, Pascal Klein¹

¹ *University of Göttingen*

Vector fields, differential operators, and the integral theorems of Gauss and Stokes are a central part of Maxwell's equations to describe electric and magnetic fields. For physics applications, a conceptual understanding is of particular importance, which often causes difficulties for students. Therefore, previous research emphasizes the need to foster conceptual knowledge by multi-representational approaches. For that purpose, this contribution presents a vector field simulation that addresses empirical findings on student difficulties and aims to promote a visual understanding of vector fields and differential operators. Additionally, findings of an implementation study integrating the simulation in recitation-based learning tasks are presented.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):**Innovative strategies at school / 38****The influence of hypotheses before experiments on data-based conclusions after experiments**

Author: Sophia Chroszczinsky¹

Co-author: Burkhard Priemer¹

¹ *Humboldt-Universität zu Berlin*

Corresponding Author: chroszcs@physik.hu-berlin.de

This contribution reports the findings of a study with approximately 400 secondary school students in Germany. These students were introduced to a physics problem and had different opportunities to handle hypotheses, before analysing measurement data. First results indicate that if students have high data competencies, then the hypothesis does not influence students' data-based conclusions.

However, this is not the case if students have weak data competencies. Students' confidence in their hypotheses does not seem to influence their data-based conclusions.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Workshop Innovative strategies at school / 39

ARPHYMEDS Erasmus Project Educational Tool for Increasing Attractivity of Learning Physics Using Augmented Reality and 3D Models

Authors: Gabriela Pavlendova^{None}; Alžbeta Marček Chorvatová^{None}; Dumitru Dorin Lucache^{None}; Cristian-Gyozo Haba^{None}; Ioannis Ladas^{None}; Marco Cantarella^{None}

ARPHYMEDES Erasmus Project Educational Tool
for Increasing Attractivity of Learning Physics Using Augmented Reality and 3D Models

As long as physics has been taught at elementary and secondary schools, it has been one of the least preferred subjects of students. In general students have perception that physics involves complex concepts, the resulting insights of which they do not understand, and this makes solving problems for them a challenge. This sets the students on a path of failure, keeping them away from this subject. To avoid this path, we can make physics more accessible also with the use of IT technology.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Poster session 2 / 40

Case Studies for Small-Group Student Collaboration in Large-Enrolment Introductory Physics Classes

Author: Tetyana Antimirova¹

¹ *Toronto Metropolitan University (formerly Ryerson University)*

Multiple choice questions are a common teaching and evaluation tool in large-enrolment introductory physics classes across North-American universities. Unfortunately, they do not provide students with the opportunity to formulate their own ideas. Case studies developed for this project

allow the students to collaborate on more open-ended scenarios that cover the most fundamental concepts of a first-year physics curriculum. Examples of the case studies activities will be demonstrated. The effect of the case studies intervention on students' conceptual learning and effectiveness evaluation methodology will be discussed.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

University education

Innovative strategies at University / 41

Undergraduate Physics Laboratories for Remote Teaching and Learning

Author: Tetyana Antimirova¹

¹ *Toronto Metropolitan University (formerly Ryerson University)*

. As the COVID-19 pandemic spread through the world, universities switched overnight from in-person to remote teaching and learning. This immediate switch to remote teaching caused a negative impact on laboratory components of physics courses. Remote laboratory delivery illustrated the widespread need for high quality virtual science laboratory resources and served as the catalyst for developing new approaches and methods. Today it is clear that effective materials developed for remote laboratories during the pandemic will continue to support post-COVID teaching and learning. This presentation will focus on some successful approaches to online, remote undergraduate physics lab offerings.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

University education

Hybrid session - later / 42

The construction of PET bottle rockets with water propulsion were means used to develop a Meaningful Learning of Newton's Third Law in a High School class

Author: Grazielle Aparecida Correa Ribeiro¹

Co-author: Thais Rafaela Hilger²

¹ *CENTRO UNIVERSITÁRIO INTERNACIONAL - UNINTER*

² *Universidade Federal do Paraná*

In this research we intend to present Ausubel's Significant Learning (1980) as a central theme, linked to the construction of PET bottle rockets for teaching Newton's Third Law in a first-year high school class, with 32 students, from a public school in the state of Paraná, Brazil. Based on the empirical knowledge of the students on the subject, educational activities were planned and implemented with the aim of building reflection and generating learning of the physical concepts presented.

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

University education

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Innovative strategies at University / 43

Supporting collaborative conceptual change in Physics: analysing the voice, argumentation, and social interaction

Author: Anna-Leena Kähkönen¹

Co-authors: Antti Lehtinen ; Kati Järvinen ¹; Pasi Nieminen ¹; Terhi Mäntylä ¹

¹ *University of Jyväskylä*

Corresponding Author: anna-leena.m.kahkonen@jyu.fi

The students' difficulties around dialectical argumentation in Physics problem-solving tasks are studied through acoustic, interaction, and argumentative analyses. Our case study with teacher students shows that they struggle with their conceptual understanding –leading to uncertainty and therefore no debate –but also with the social norms of not challenging the other learners' ideas. We will show rich descriptions of these conversations and offer suggestions to ease the found difficulties.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Pre-service teacher education

Innovative strategies at school / 44

The Impact of Using Multimedia Technology in Learning Conceptual Electrical Knowledge

Author: Florian Frank^{None}

Co-authors: Christoph Stolzenberger ; Thomas Trefzger

Corresponding Author: florian.frank@uni-wuerzburg.de

Electrical concepts are difficult to grasp for secondary school students. According to multimedia learning theories, multimedia technology can be used to support the learning of didactic models and the collection of data in experiments. A study was conducted with 200 secondary school students, investigating the effects of using multimedia applications on students' conceptual knowledge gain and experienced cognitive load while learning. The multimedia applications used are an Augmented Reality (AR)-Application and a Simulation. This contribution presents the design, method and material of the student lab study and shares early results of the currently ongoing study.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Workshop Lab work and experiments / 46

LEGO building blocks sets as an experimenting tool in Physics Classroom

Author: Marina Babayeva^{None}

The following work concentrates on implementing building block sets in Physics Education in combination with smartphones' applications. The description of the sets and their possibilities are presented. The list of possible implementations in different Physics fields is given based on the available hardware tools. The paper also provides advantages and disadvantages of using aforementioned systems in the classroom. One particular example of activity on visualizing the sound waves propagation is under closer investigation in terms of a pilot project and a series of further experiments is in development stage.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Innovative strategies at school / 47

DBR projects in Physics Education Research –why and how?

Author: Claudia Haagen-Schützenhöfer^{None}

Co-authors: Markus Obczovsky ; Paula Kislinger

Corresponding Author: claudia.haagen@uni-graz.at

A central goal of PER is to improve the quality of physics instruction. Therefore, researchers develop and disseminate teaching-learning solutions, like course formats, teacher guides, or student materials to support teachers in practice. The paradigm of Design-Based-Research (DBR) is one framework used to develop such teaching-solutions systematically. DBR also aims to contribute to local theories about teaching-learning processes and to knowledge about how to design and implement these processes. Our project analyses DBR contributions to German-speaking PER-conferences of the last 20 years to shed light on the theory- and research-led design processes and theoretical and practical output of DBR projects.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Digital technologies / 48

Equipping the Youth for the 21st Century - Open Data and Scientific Literacy for All

Author: Peitsa Veteli¹

Co-author: Kati Lassila-Perini¹

¹ *Helsinki Institute of Physics (FI)*

Corresponding Author: peitsa.veteli@gmail.com

Our increasingly data-driven societies put pressure on the students' skillsets while schools struggle to fit the demands of global digitalisation into their curricula. Promoting data-based literacy skills in the students' upbringing requires their committed long-term application in meaningful contexts, in which open data from "the real world" of scientific experiments and governmental institutions serves a valuable purpose of increasing the authenticity of the learning experience. We present the case for educational use of open data and integrated programming in developing the students' cross-disciplinary thinking and appreciation of data-analysis. Feedback from teachers and students between 2016-2023 has been very positive.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Interdisciplinary approaches / 49

The student laboratory Labs4Future: How climate change knowledge can be linked to effective action

Author: Jonathan Grothaus¹

Co-authors: Markus Elsholz¹; Thomas Trefzger¹

¹ *University of Würzburg*

The talk presents the central elements of and thoughts behind the two-day student laboratory Labs4Future. This extracurricular offer for 15-year-old high school students tries to manage the linking of knowledge about climate change with effective individual and societal action. Based on a newly developed theoretical framework Lessons4Future, which integrates environmental psychology, sociology and science education, the talk showcases how we try to transfer the theory into experiments and activities.

Among the presented elements are the Carbon Credits, an area visualization of daily personal and societal emissions, and a Mystery that addresses responsibility for the problem and solutions of climate change.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Digital technologies / 51

Context dependence of machine-learning models for the analysis of argumentation in undergraduate lab reports

Author: Michael Fox¹

Co-authors: Efia Amankwa¹; Jiayang Zhang¹

¹ *Imperial College London*

Lab reports form an important part of learning experimental physics in undergraduate courses. Advances in natural language processing give us new tools that allow for the large-scale qualitative analysis of lab reports to understand how students demonstrate their skills and knowledge. Hence, we compare natural language processing techniques to understand whether it is possible to reliably extract information about student argumentation from lab reports on two different spectroscopy experiments. We find that the transformer model BERT results in the highest accuracy of $84 \pm 5\%$ and is the only model to show improved accuracy when analysing both experiments simultaneously.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Contemporary and modern physics / 52

Experiences in Teaching/Learning Quantum Information Science

Author: Kristóf Tóth^{None}

There is an effort on introducing quantum computation into education. In the last years, these were mainly addressed in advanced master's degree courses for physicist and computer scientist, but the experiences in secondary schools are quite few. I am presenting here a pilot project regarding teaching/learning quantum mechanics via polarisation approach extended with the basics of quantum information science. This project uses only real numbers and avoids the formalism of matrices and the time development of state, not exceeding secondary school mathematics.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Higher-secondary education

Hybrid session - early / 53

Short videos for elaborative encoding of physics principles before lectures with Peer Instruction

Author: Vegard Gjerde¹

¹ *University of Bergen*

Peer Instruction is an effective lecturing method in physics but introduces a high demand on student preparedness. Some of the existing methods of increasing student preparedness have problems concerning learning effectiveness, student usage, and alignment with knowledge needs. We made introductory videos to address these problems and used a survey and interviews to investigate its success. The findings indicate that the videos were helpful in increasing student learning during Peer Instruction and that students gradually became aware of this. This type of introductory video may elevate the struggling students especially, leveling the playing field during peer discussions.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

University education

Target education level (secondary, optional):

Hybrid session - early / 54

Teaching gain: a measure of Physics teachers' improvements

Author: Valentina Bologna¹

Co-authors: Francesco Longo¹; Maria Peressi; Paolo Sorzio¹

¹ *University of Trieste*

Corresponding Author: valentina.bologna@phd.units.it

In Physics Education Research (PER), Hake's learning gain is widely used to measure students' improvements. As learning gain tries to emphasise students' progression in learning, in the same manner, we used teaching gain to measure the trend in changing teaching practices. To define teaching gain, we referred to teachers' development of new habits of mind and practices when they start to adopt the ISLE approach in their classrooms. We report the results from the analysis of case studies of eight Physics teachers involved in an in-service training program which guided them to reflect on and change their tasks of teaching.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Lab work and experiments / 55

Electromagnetism in high school: Classroom experimentation with Arduino

Author: Mihály Hömöstre^{None}

Co-author: Dorottya Schnider

We offer a workshop for high school physics teachers to share good practices of using Arduino for teaching electromagnetism. Arduino-based classroom experimentation gives the opportunity to students to work in groups and conduct experiments with the application of modern devices. It involves students completely in the work processes and in their own learning processes, and develops those skills and competences that are essential for a successful member of the society. The method and the project-based lesson plan we will share with colleagues encourage students to participate actively in classes and acquire practical knowledge by observing, measuring and analysing different phenomena.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Innovative strategies at school / 56

Effectiveness of MiniPIX detector activities dispelling high school students' misconceptions about radioactivity and ionising radiation

Author: Daniel Parcerisas Brossa^{None}

Co-authors: Cristina Cabo ; Maria Cristina Trevisoi¹; Michael Campbell²; Rafael Ballabriga Sune²; Rita Pinho²; David Gonzalez Saba³; Francisco Barradas-Solas⁴; Massimiliano Fiorini⁵

¹ INFN and University of Ferrara

² CERN

³ Sagrada Familia School

⁴ Comunidad de Madrid

⁵ Università e INFN, Ferrara (IT)

Corresponding Author: d.parcerisas@safagava.edu

Much research has shown that students' misconceptions of radioactivity and ionizing radiation are common and have a significant impact on their learning process and their ability to act as responsible citizens. The use of MiniPIX cameras, based on the Timepix hybrid pixel detectors read out designed at CERN, is bringing experimental particle physics and radioactivity into secondary education. An analysis of the effectiveness of the MiniPIX as a learning tool to dispel these misconceptions is presented.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Interdisciplinary approaches / 57

Teaching Physics through Astronomy in secondary school: the Asiago Teachers' Network on Astrophysics

Author: Marta Carli^{None}

Co-authors: Alessio Mattia Leonardi¹; Ornella Pantano¹

¹ Department of Physics and Astronomy - University of Padua

Corresponding Author: marta.carli.1@unipd.it

We present a project called ATENA – Asiago Teachers' Network on Astrophysics. Based on authentic collaboration and action research, a teacher learning community was set up around the common research question of how Astronomy can be integrated into the secondary school curriculum to foster a coherent comprehension of the physics of the Universe. Four physics topics across the different grades were selected, and teaching-learning sequences informed by Physics and Astronomy Education Research were collaboratively developed. The experimentation of the teaching-learning sequences is ongoing and will be the basis for the development of pathways to be shared with more schools.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Interdisciplinary approaches / 58

FisicaMente al Liceo: a project for interlacing mathematics and physics in secondary school

Author: Stefania Lippiello^{None}

Co-author: Marta Carli¹

¹ *Department of Physics and Astronomy - UniPD*

Corresponding Author: stefania.lippiello@unipd.it

The project “FisicaMente al Liceo” aims at strengthening students’ mathematization skills and their understanding of physics. After a trial in a pilot school, in 2022 we started an experimentation with twelve teachers belonging to five high schools in the network of the “Licei Matematici” in our region in Italy. The creation of a community of practice of teachers allowed co-designing pathways to enhance mathematics-to-physics transfer and representational fluency. In this way, teachers are contributing to increasing data on the effectiveness of the FisicaMente al Liceo project and to improving it, extending its applicability.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Poster session 1 / 59

The Virtual School project: learning to teach Physics through a virtual community of practice

Authors: Marta Carli^{None}, Ottavia Trevisan¹

¹ *Department of Philosophy, Sociology, Education and Applied Psychology - University of Padua*

We present a preservice teacher development program called Virtual School, which was established at our university in Italy on the model of an Australian partner experience. Within the framework of a virtual community of practice, participants co-designed and co-taught online physics classes for secondary school students. The program entailed opportunities for reflection and feedback from different perspectives, and the design of lesson cycles was informed by physics education research. We describe the impact of the program in terms of the ways pre-service physics teachers conceptualize themselves, and we discuss possible evolutions of the experience and implications for initial teacher education.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Innovative strategies at University / 60

Understanding two types of notations for radio wave propagation

Author: Antti Rissanen¹

Co-author: Kalle Saastamoinen¹

¹ *National Defence University*

Radio waves are essential part of communication technologies as well as basic physics education. Understanding electromagnetic waves requires skills in mathematics and knowledge of the phenomena. Still, data from radio technology may pleasantly surprise an inexperienced or mainly solution-oriented student. The research considers the effect of two different teaching approaches at BA-level. We observed the relationship between the formalism of physics according to didactics and engineering-like solution-oriented pragmatism. This study presents empirical observations on how the parallelism of contents can be managed with exercises.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Poster session 2 / 61

Gender disparities in STEM degree programs and academic orientation actions

Authors: Eva Elisa Dryden Silva¹; Stefania Lippiello¹; Ornella Pantano¹

¹ *University of Padova*

This project aims to promote gender inclusion in STEM education at the University of Padova, Italy. The project has examined the level of awareness among secondary education students regarding gender disparities in STEM fields and attempts to develop new initiatives to improve academic guidance and challenge stereotypes and biases that may discourage students from pursuing Physics and other STEM fields. The project was initiated with an on-site questionnaire and a focus group gathering preliminary results and identifying needs and deficiencies that may prevent enrollment in STEM degree courses.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Outreach

Innovative strategies at school / 64

Measuring the effectiveness of motion simulation programs in high school physics education

Author: Tamás Radnai¹

Co-authors: András Juhász²; Péter Jenei²; Tünde Tóthné Juhász³

¹ *Jedlik Ányos Secondary School*

² *Eötvös Loránd University*

³ *Karinthy Frigyes Secondary School*

Corresponding Author: rad.tamas@gmail.com

Motion simulation programs can be key components in learning mechanics due to their sandbox approach and intuitive use. In our research we focus on examining, whether students who use a motion simulation program while learning mechanics learn the curriculum more effectively. To measure this, we conducted an experiment that involved 700 students. The data shows, that the students who learned dynamics with the help of motion simulation software mastered the course material better than those who learned it in a traditional way. We also proved that this effect is especially significant for students from weaker and medium-strength schools.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Innovative strategies at school / 66

Investigating high school students' gaze patterns when learning with Feynman diagrams

Author: Merten Nikolay Dahlkemper¹

Co-authors: Pascal Klein²; Andréas Mueller ; Sascha Schmeling¹; Jeff Wiener¹

¹ *CERN*

² *University of Göttingen*

Several research-based suggestions have been made on how concepts from particle physics can be taught to high school students. A frequently used subject-related representation within particle physics is the so-called Feynman diagram. However, very little is known about how this form of representation is perceived by students.

This project aims to design learning materials for 16-19-year-olds on Feynman diagrams so that they are conducive to learning concepts of elementary particle physics. We used an eye-tracking study to test the materials. The results give insights into the strategy development process of students when using this form of representation.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session 1 / 68

Teaching physics using artificial intelligence

Authors: Péter Kosztyó¹; Péter Jenei²

¹ *Doctoral School of Physics, Eötvös Loránd University*

² *Department of Materials Physics, Eötvös Loránd University*

In the field of education, in addition to the evaluation of the learning process, the examination of the effectiveness of teaching plays an important role. Teachers are often hopeless to see what prior knowledge and competencies the student is coming from and thus what the ideal developmental task is in the given lesson. In this research topic, our goal is to create a computer program that can learn what practice task a student should solve for the most optimal development based on his/her knowledge and competencies.

Introduction

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Informal and non-formal learning / 69

Investigating the colloquial knowledge of pupils and students in the area of understanding basic concepts of thermodynamics.

Author: Roman Rosiek¹

Co-author: Martyna Sacha²

¹ *Faculty of Exact and Natural Sciences*

² *SP 61,*

We present a study of **colloquial knowledge in understanding concepts in the field of thermodynamics**. The **TCE test** was adapted to local specificities [1]. Approximately 400 people were surveyed. The aim of the study was to find out how the understanding of concepts: heat, temperature and energy evolve with the age of the respondents, and whether education significantly changes the perception of these concepts. The conclusions we were able to draw from the collected results, when compared with publications and research in other countries, may have a impact on how we should structure the didactic process in our education system.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Lower-secondary education

Poster session 2 / 71

SCIENTIFIC REASONING OF STUDENTS OF PALACKÝ UNIVERSITY IN 1ST YEAR

Authors: Tereza Hrouzková^{None}; Lukáš Richterek^{None}

We used the Lawson test of scientific reasoning to check the level of operational reasoning for 660 students entering the Faculty of Science of Palacký University in Olomouc. Besides the standard item and test characteristics, we also identified possible factors affecting the scores. Our results confirm there was a statistically significant difference between the women's and men's scores, but no difference between future science teachers and students of technical programs. The scores correlate with the probability of completing at least the 2nd year of the bachelor's degree. The eye-tracking analysis showed a gender difference in problem-solving process.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Lab work and experiments / 73

Measuring the average speed of a comet

Author: Stefano Sandrelli^{None}

Co-author: Giulia Pantiri¹

¹ *Institut für Didaktik der Physik, Goethe Universität Frankfurt am Main*

Corresponding Author: stefano.sandrelli@inaf.it

The purpose of this activity is the measurement of the average speed of the comet C/2019 Y4 in the course of the observations of 2 April, made through SVAS. We provide 12 centered and aligned

images of the same celestial field: the comet is visible in the foreground. The average speed will be measured in relation to a reference system attached to the observation point. In the course of the activity, we will also detect the trajectory of the comet in the interval of observation. Eventually, we will discuss limitations and approximations of the measurement made.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Higher-secondary education

74

Teachers' and students' views on physics textbooks

Author: Tereza Fürstová¹

¹ Charles University, Faculty of Mathematics and Physics

This contribution is focused on getting feedback from students and teachers on science textbooks. A literature search was conducted to answer two questions: How are teachers' and students' views on science textbooks obtained? And what should a good science textbook look like? The search revealed the most commonly used methods for obtaining opinions on textbooks and several textbook analysis tools were found. The information obtained from the research will be used to develop a tool to get feedback on a new upper secondary school physics textbook, which is being created at the Faculty of Mathematics and Physics, Charles University, Prague.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Hybrid session - later / 75

New experiment to understand the role of CO₂ in global warming

Author: Valentin Maron¹

Co-authors: Jean-Louis Dufresne²; Lionel Pélissier³; Alain Rabier; Medhi Cochepin

¹ EFTS (Education, Formation, Travail, Savoirs), Université Toulouse Jean Jaurès –France

² IPSL (Institut Pierre-Simon-Laplace)

³ (Education, Formation, Travail, Savoirs), Université Toulouse Jean Jaurès –France

Corresponding Author: valentin.maron@univ-tlse2.fr

This research aims at designing a teaching approach to understand CO₂ influence on temperature, as accessible as possible. We first analyse the most common approaches, which led us to question the relevance of some experiments on radiative properties of solids, then extrapolated to gases. We show that this generalisation is not obvious at all for students, and thus deserves empirical evidence. A new experiment with CO₂ balloons viewed with an infrared camera is presented. The results, applied to the Earth system, enable to understand the temperature increase, without using the absorption spectrum of CO₂, inaccessible to most non-physicist people.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Workshop Interdisciplinary approach / 76

How to connect basic sciences and sustainable development in the school curricula

Author: Barbora Bruant Gulejova¹

¹ *Universitaet Bern (CH)*

Interest of youth in physics and engineering is declining, even though new generation of specialists is needed to ensure the continuation of cutting-edge research, primordial for innovation, economic progress and sustainable development (SD) []. While SD becomes ever more popular and even obligatory subject in schools, because of lack of teaching resources compatible with curriculum, high-school students situate SD outside of physics / STEM. Workshop aims to invite different stakeholders from science / academia, physics education and industry to brainstorm on how to tackle the issue of bridging the gap between science education and SD in the classroom.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Poster session 1 / 77

Optics Experiments as a Teaching Resource for the Development of Scientific Thinking in Elementary School Students

Authors: Claudia Carolina García Gaitán¹; Mario Humberto Ramírez Díaz²; Carlos Adrián Arriaga Santos³

¹ *Universidad Pedagógica Nacional 241, CICATA Legaria IPN*

² *CICATA Legaria, IPN*

³ *Universidad Politécnica de San Luis Potosí*

Corresponding Authors: mramirez@ipn.mx, garcia.claudia@upnslp.edu.mx

The development of scientific thinking is one of the objectives that is established through the teaching of Natural Sciences and Technology, during elementary education in Mexico. The objective of this study is to analyze the relationship between the use of experimental activities related to the optical phenomena of reflection and refraction of light as a didactic resource to promote the development of scientific thinking. The method is based on design-based research, carried out in three phases: a) preliminary research, b) prototype design, and c) prototype evaluation. The participants were 60 students from 8 to 10 years old.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Lower-secondary education

Hybrid session - early / 78

First outcomes a teaching-learning sequence on quantum information and computation

Authors: Massimiliano Malgieri¹; Claudio Sutrin¹; Giacomo Zuccherini¹; Chiara Macchiavello¹

¹ *Università di Pavia*

In this work we report on the results of the first refinement cycle of a teaching learning sequence based on the educational reconstruction of quantum information and computation at the level of secondary school. The results will serve as the base for refinements and improvements of the sequence, in view of a new testing cycle bound to start in late spring 2023.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Pre-service teacher education

Lab work and experiments / 79

The role of models in physics and in science: some educational experiments

Authors: Marco Di Mauro¹; Massimiliano Malgieri^{None}; Elena Dalbosco¹; Pasquale Onorato¹

¹ *University of Trento*

Corresponding Author: marco.dimauro@unitn.it

According to researchers in the Nature of Science (NoS), it is desirable that students are directly exposed to the process of building of scientific knowledge, in particular concerning the role of models and theories. In this contribution, a few experimental activities, aimed at explicitly showing several aspects of the role of models in science, are described. In order to set the stage, the role of models and theories in science is reviewed, and the views of both experienced researchers and non-experts are investigated and compared.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Lab work and experiments / 80

Students' intrinsic motivation in the context of their level of engagement in physics experimentation

Authors: Alexandr Nikitin¹; Marie Snětinová¹; Petr Káčovský¹; Jitka Houfková¹

¹ *Department of Physics Education, Faculty of Mathematics and Physics, Charles University, Prague*

The contribution focuses on exploring upper secondary students' intrinsic motivation and its predictors in relation to different student engagement in experimental activities. The data were collected via a questionnaire based on the Intrinsic Motivation Inventory and analysed using Welch's one-way ANOVA. Three experimental activities were compared: (1) lecture demonstrations with low student engagement, (2) science show with higher student engagement and (3) students' hands-on experimentation. Respondents' perception of these activities is as follows: (1) lowest interest, lowest effort, medium value, (2) highest interest, medium effort, lowest value and (3) medium interest, highest effort, highest value.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Hybrid session - later / 81

Fibonacci sequence in interdisciplinary laboratory: from electric nets to elastic springs

Authors: Maria Giuseppina Adesso¹; Roberto Capone^{None}; Oriana FIORE^{None}

¹ *Da Procida High School*

An interdisciplinary teaching activity in the Physics laboratory is described here using the hands-on methodology to experiment with high school students, an interdisciplinary learning crunch focused on the Fibonacci sequence. Students were involved in the equivalent resistance calculation of an infinite two-dimensional electrical circuit. In the laboratory, they built a system of resistances and, analogically, a system of springs, and they verified the same symmetric properties by rediscovering the gold number. The students developed content knowledge, critical thinking, collaboration, creativity, and communication skills. The hands-on experience increased students' motivation and participation, making them more involved in the educational process.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Hybrid session - later / 83

Introduction to Measurement Uncertainties for Middle School Classes

Author: Hannah Loidl^{None}

Co-author: Clemens Nagel

By teaching measurement uncertainties students in middle school should gain competences in critical thinking, conducting experiments and analysing results in a proper way. In the first author's master thesis, a teaching concept for the beginning of natural science classes was developed and evaluated in a middle school in Vienna. The concept was evaluated and improved in three cycles using the design-based research method. Students are performing an experiment that leads them to measurement uncertainties. Sources for uncertainties and the trustworthiness of the experiment are discussed. Using simple methods of statistics such as the arithmetic mean, the experiment will be analysed.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Innovative strategies at school / 85

Probing a space exploration awareness in a Swedish secondary school

Author: Oleg Popov^{None}

The advancement of space exploration is an important socio-scientific and political issue in Sweden. This study attempts to understand secondary school students' awareness about this national "space ethos" and roles of space technology in their everyday life. Methodologically, this research draws on a sociocultural framework and examines the reflections of 69 grade 9 students in a questionnaire about space exploration consisting of a total of nine multiple choice, short answers and open questions. Students shared awareness and high expectations about space contribution to monitoring climate and environmental problems, providing satnav and telecommunication services, but showed limited understanding about satellite technology.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Pre-service teacher education

Contemporary and modern physics / 86

Implementing quantum cryptography protocols using MACROBITS

Author: Joao Pereira¹

¹ *UNIRIO*

One amazing characteristics of quantum algorithms is how they can deliver results with 100% certainty despite their structure being based on the probabilistic interpretation of quantum mechanics. This type of algorithm requires a different way of thinking and sets a challenge for science educators. Two routines to emulate quantum cryptography protocols (BB84 and EK91) are proposed in this work. The educational procedure uses a tool we have developed and called MACROBIT as a mean to mimic algorithms of quantum key distribution. The MACROBITS are useful to illustrate quantum mechanics concepts such as superposition, change of basis, quantum measurements and entanglement.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Hybrid session - later / 87

Teaching Scientific Practices Through Low-Cost Tools: An Experiment with High School Students

Author: Lucia Gabelli¹

Co-authors: Giorgio Lissandron²; Ornella Pantano¹

¹ *University of Padova*

² *Liceo scientifico A. Cornaro*

A Teaching-Learning Sequence, designed to promote scientific practices in high school students, is presented. The TLS included laboratory experiences on linear motion using low-cost tools, as Arduino, which were easy to replicate in other schools. The focus was on the process of laboratory work, the use of different representations and the development of arguments based on evidence. Collaborative working methods were used; the TLS was modified to fit the teaching method of the teachers involved. The TLS was tested in three classes and replicated in two more. Preliminary results suggest that the TLS helped students to achieve the intended goals.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Innovative curricula / 88

Application of Item response curves analysis and Rasch model on physics knowledge tests of Croatian students

Author: Ivana Štibi^{None}

Co-authors: Jerneja Pavlin ; Mojca Čepič¹

¹ *University of Ljubljana, Faculty of Education*

Objective evaluation of learning outcomes is a major part of teaching. Choosing an appropriate test analysis method is crucial. Item response curve analysis, as part of item response theory, and the Rasch method effectively analyse test scores and indicate the possibilities of improving the selection of questions or the offered answers, in terms of identifying students' preconceptions. In the contribution, we will present the results of both methods on selected physics knowledge tests including multiple-choice questions, in order to indicate the method of analysing knowledge tests for the purpose of evaluating physics conceptual knowledge and understanding.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Innovative curricula / 89

What we know and can know from the TIMSS Advanced physics testing of the final-year students of secondary school in the Czech Republic

Author: Petra Pschotnerová¹

Co-author: Dana Mandíková¹

¹ *Charles University*

The central topic of the paper is the specialized physics test in which the Czech Republic participated in TIMSS Advanced 1995. We briefly recall the methodology of the TIMSS study and the test results of Czech students in the final-year of upper-secondary school. We present the repetition of the TIMSS Advanced physics test in the Czech Republic in 2023. We discuss future outputs of the currently running testing, its limits, and possible benefits.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session 1 / 90

Waves in a digital infinite mirror

Authors: Balla Norbert Csaba^{None}; Gergely Ádám Szabó^{None}; József Stéger^{None}; László Oroszlány^{None}

The COVID pandemic presented public education with overwhelming challenges but also unprecedented opportunities. Online educational platforms came to the forefront, they offered alternative methods to convey traditional teaching materials to students. In this work we present, experiments aimed at understanding wave propagation phenomena, which can also be performed in an online setting. Using the digital version of the infinite mirror effect, with the active involvement of experimenting students, we demonstrate that the infrastructure built for teleconferences is excellent for demonstrating concepts such as period time and face shift in the online classroom.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Higher-secondary education

Poster session 2 / 91

Learning Using Mentors (LUM) – a learning method designed to be easily implemented and to help teachers in the common school system

Author: Jaroslav Šmahel¹

¹ *Charles University*

Despite a growing number of research on different types of non-classical learning methods and widely known benefits, implementation in the common school system is still rare.

Although there are studies identifying challenges, many of the learning methods seem to assume a specialized school system and they are not simply transferable to practice. Method “Learning using mentors” was designed to be easily implemented and to help teachers bridge the gap between the common school system and the benefits of modern learning methods. This paper summarizes results of two years of experimental use of the method at the high school in physics.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Hybrid session - early / 92

The Quantum Jungle for Secondary-School Education

Authors: Simon GOORNEY¹; Jorge YAGO MALO²; Laura GENTINI³; Daniele LAGASCO³; Maria Luisa (Marilù) Chiofalo⁴

¹ *Department of Management, School of Business and Social Sciences, Aarhus University, Denmark*

² *Department of Physics “Enrico Fermi”, Largo Bruno Pontecorvo 3, I-56126 Pisa, Italy)*

³ *Department of Physics “Enrico Fermi”, Largo Bruno Pontecorvo 3, I-56126 Pisa, Italy*

⁴ *Department of Physics “Enrico Fermi” and INFN-Pisa, Largo Bruno Pontecorvo 3, I-56126 Pisa, Italy*

Teaching and learning Quantum Mechanics in secondary school is a unique challenge, at once requiring creativity, experimental, and mathematical literacies. Educating students to quantum science and technologies can therefore also be an opportunity to empower them with new ways of thinking, and the skills needed to navigate uncertain futures. However, engaging storytelling and interactive tools are required to complement or substitute limited experimental and mathematical competences. Here we present a didactic experiment offered to secondary-school students accompanied by their teachers which uses the interactive art-science installation Quantum Jungle within the Culturo-Scientific Storytelling framework, offering a model for fellow educators.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Outreach

Lab work and experiments / 93

STEM recipes for digital natives

Author: Fanni Vitkóczy^{None}

Co-author: Károly Piláth

These days, teachers face an increasing challenge in motivating students, especially in physics. Classical experiments are often difficult to carry out with outdated experimental equipment and cannot compete with the stimulating environment. These circumstances have led to a significant change in the attitude of students towards physics. Increasingly popular, low-cost and widely available microcontrollers can be used to solve these problems in physics class. In this presentation, we aim to introduce some of our home-made experimental devices controlled by Arduino, which contribute to the action-oriented education of students, provide a deeper understanding of physical phenomena and improve their attitudes.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Poster session 1 / 95

Periodic Motion in a little different way or supporting teachers' experimental activities using non-traditional digital technologies.

Authors: Martin Hruška¹; Miriam Spodniakova Pfefferova²

¹ *FPV UMB Banská Bystrica*

² *Faculty of Natural Sciences, Matej Bel University in Banská Bystrica*

The paper aims to show one of the possibilities of how simple devices based on microcontrollers and inexpensive electronic components can be used in the framework of pupils' exploration of the thematic unit of Periodic Motion. The experimental set-up designed at the authors' workplace has a modular design and contains a digital oscilloscope supplemented with suitable sensors. An optional component is the Arduino microcontroller used for direct digital sound synthesis and a function signal generator XR2206. The kit will be used at the authors' workplace in the framework of further education of teachers in the implementation of inquiry-based experiments.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session 1 / 96

Hanging the planets in the Sun

Author: Stefano Sandrelli^{None}

Co-author: Gloria Tirabassi¹

¹ *inaf*

The Olmicomics is a laboratory designed for the last year of lower secondary school. The students are challenged in representing the linear distances within of the Solar System, using a purely numeric one and some simple material as a long string and some pegs. At the end of the laboratory, we provide also a visual for comparison. The mixing of abstract and concrete reasoning results in a series of interesting methods to solve the posed questions. This activity allows them to take a step forward in their awareness of complex concepts as approximation, error, precision and simplicity.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Primary school education

Innovative strategies at University / 97

Developing an analytical framework to characterize physics teachers' approaches to the pedagogy of derivations

Author: Prithu Raj Ghosh¹

Co-authors: KK Mashood¹; Sanjay Chandrasekharan¹

¹ *Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, India*

We present a characterization of undergraduate physics teachers' approaches to the pedagogy of derivations. Six teachers were interviewed and to analyze the data, we are developing an analytical framework, comprising three categories: Algorithmic approach b) Representational approach and c) Model building approach. Analysis shows evidence of cohering clusters of practices and value systems. Based on this, we characterize teachers' approaches as leaning primarily towards one of the posited categories. This study is part of a larger project aimed at making the learning of derivations more meaningful and creating a smooth transition from physics derivations to computational modeling and machine learning.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

In-service teacher education

Poster session 2 / 98**Engineering students' understanding of the core physical concepts in Mechanics and Electromagnetism: Has anything changed during pre-university education?****Authors:** Ivana Štibi^{None}; Željka Mioković¹¹ *Faculty of Electrical Engineering, Computer Science and Information Technology Osijek***Corresponding Author:** istibi@fizika.unios.hr

Learning outcomes in engineering education, in addition to practical knowledge, include understanding concepts from natural sciences and mathematics as an important factor in strengthening engineering competencies and skills. The research was conducted using standardized conceptual tests in mechanics and electromagnetism among first-year undergraduate electrical and computer engineering students during several years. The data analysis of tests was performed by statistical methods (Classical test theory, Item response theory). The common “distractors” and levels of confidence in problematic tasks are discussed. The results indicate better understanding of concepts from mechanics, and difficulties in application of Newton's laws in the context of electromagnetism.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Symposium / 99****Methods and technological tools to support active learning at school and university****Authors:** Claudio Fazio¹; Eugenio TUFINO²; Micol Alemani³; Onofrio Rosario BATTAGLIA⁴; Pasquale ONORATO²; Peter DEMKANIN⁵; Silvia NOVOTNÁ⁵; Stefano OSS²¹ *Università degli Studi di Palermo*² *Department of Physics, University of Trento*³ *Institute of Physics and Astronomy, University of Potsdam,*⁴ *Department of Physics and Chemistry, University of Palermo*⁵ *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava*

Active learning experiences can be significantly enhanced by the use of appropriate methods and technological tools. Interactive videos, collaborative learning platforms, interactive simulations, real-time data collection and analysis tools, modeling environments, adaptive learning technologies, and learning management systems are all examples of tools that can promote engagement, collaboration, and personalized learning. By incorporating these tools into their teaching, educators can create more engaging and effective learning experiences for their students. In this symposium, the use of some of the aforementioned tools in an active-learning environment and the necessary planning of pedagogical activities based on them will be discussed.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Workshop Informal and non-formal learning / 100**PhysLab Break –escape games for physics education****Authors:** Ladislav Janiga^{None}; Viera Haverlíková¹¹ *Department of Didactics in Mathematics, Physics and Informatics, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Slovakia***Corresponding Author:** ladislav.janiga@fmph.uniba.sk

Increasing popularity of the escape rooms leads to using escape games in educational process. Attendants of the workshop will experience the game PhysLab Break –escape game designed for physics education. The game will be followed by discussion focused on potentials and obstacles of using escape games in physics education, and criteria for selecting physics tasks suitable for escape games.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Poster session 1 / 103****Some experiments to teach the physical bases of the greenhouse effect: thermal emission and selective absorption****Author:** Stefano Toffaletti¹**Co-authors:** Camilla Fiorello²; Eugenio Tufino³; Marco Di Mauro⁴; Massimiliano Malgieri; Pasquale Onorato⁴; Stefano Oss⁴; Tommaso Rosi¹ *Physical Science Communication Laboratory, Department of Physics, University of Trento, Via Sommarive, 38050 Povo (Trento), Italy*² *University of Trento, Department of Physics, Physical Science Communication Laboratory*³ *University of Trento, Physics department*⁴ *University of Trento*

The understanding of the anthropic greenhouse effect (GHE) rests on two key concepts, namely thermal emission and the interaction of different kinds of electromagnetic radiation with different kinds of matter. A survey of the existing Physics Education research concerning the GHE and climate change shows that students have in general a poor understanding of such concepts. In this work, we present some experiments designed to foster their learning. We shall moreover show how the

learning outcomes of the students have improved after the incorporation of these experiments in a pre-existing teaching-learning sequence focused on the physical bases of the GHE.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Poster session 2 / 104

Analysing students' drawings of the greenhouse effect: common features associated to the understanding of the phenomenon

Author: Camilla Fiorello^{None}

Co-authors: Marco Di Mauro ¹; Massimiliano Malgieri ; Pasquale Onorato ¹; Stefano Oss ¹; Stefano Toffaletti ²; Tommaso Rosi

¹ *University of Trento*

² *Physical Science Communication Laboratory, Department of Physics, University of Trento, Via Sommarive, 38050 Povo (Trento), Italy*

This contribution describes an analysis of student drawings concerning the topic of the greenhouse effect. We examined drawings from students at different levels of education before exposing them to a dedicated teaching-learning sequence. We also explored effective methods for analysing the drawings and looked for connections with the drawings and diagrams found in school textbooks and images available on the internet.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Poster session 2 / 105

To teach or not to teach Quantum Physics? Revisiting goals and practices of instruction in secondary schools

Author: Pasquale Onorato¹

Co-authors: Marco Di Mauro ¹; Massimiliano Malgieri ²

¹ *University of Trento*

² *University of Pavia*

We report on the results of a series of interviews conducted with some experts on quantum physics concerning aspects of its teaching at the secondary school level, specifically the overall appropriateness of this teaching, the historical approach, the needed mathematical background and the topics that should be included. Some foundational and controversial aspects of quantum physics, which concern potentially includable topics, are addressed as well.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session 1 / 108

The use of a spreadsheet in the experimental activities at secondary school

Author: Miriam Spodniakova Pfefferova¹

Co-author: Martin Hruška²

¹ *Faculty of Natural Sciences, Matej Bel University in Banská Bystrica*

² *Faculty of Natural Sciences, Matej Bel University in Banská Bystrica*

The spreadsheet is widely used in practice, not excluding the teaching of physics. One of the possibilities is to use it in the experimental activity of pupils. The aim of the paper is to show how to use quantitative simulated experiments created in a spreadsheet during the teaching of periodic motion at secondary school. Quantitative simulations make it possible to explore periodic phenomena from a different perspective and to analyze events with changed input conditions through graphs.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Poster session 2 / 109

Students' epistemological beliefs in understanding the 1-D wave equation

Author: Muhammad Aswin Rangkuti¹

Co-author: Ricardo Karam¹

¹ *Department of Science Education, University of Copenhagen*

Several studies have explored students' perspectives on understanding physics equations. This paper focuses on students' epistemological changes as they deal with the meaning of the wave equation. Prior to interventions, we assessed students' intuition about the wave equation and identified three epistemological beliefs related to this equation. We then designed tutorials that targeted specific aspects of the wave equation to aid students in making sense of it. While a few persistent views remained evident in the post-test, some students demonstrated an elevated level of understanding with regards to the wave equation.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Poster session 2 / 111

The theory of five pillars of the mind and physics education

Authors: Daša Červeňová^{None}; Peter Demkanin^{None}

Neurosciences significantly influence shifts in knowledge in many different fields nowadays. Results of neuroscientific studies help elucidate many phenomena, especially the ones occurring during the learning process. Neuroscientific subfield that transdisciplinary studies cognitive development is called educational neuroscience. Many theories proposing to promote education, in general, have been published. The theory of Five Pillars of the Mind, formulated by Tokuhamo-Espinosa, is one of them. This article proposes an example of applying this theory to Physics education. We aim to enhance Physics education to be more brain-friendly by proposing redesigning a series of educational activities concerning inclined plane.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Hybrid session - later / 112

Teaching the subtleties of entanglement via the delayed-choice two-slit experiment with polarizers

Author: James Freericks^{None}

Co-author: Leanne Doughty¹

¹ *Georgetown University*

Single-particle entanglement requires at least two degrees of freedom for the particle that is used to make a nonfactorizable superposition. Using a two-slit experiment with horizontal and vertical polarizers over each slit, respectively, we illustrate how one measures at the slits to create an entangled state, followed by a delayed-choice placement of a second polarizer (before the photons hit the screen) to control the particle-like, or wave-like nature of the final observed pattern. This approach is used to teach (both non-scientists and undergraduates) the subtleties of entanglement and how delayed-choice experiments actually work.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Hybrid session - later / 113

The Photoelectric Effect and the Electromagnetic spectrum learning through the study of the implementation of spectroscopy techniques in Art analysis.

Authors: Brenda Ixcuiname Saavedra¹; Cesar Mora^{None}; Mirna Villavicencio²

¹ GIREP 2023

² UNAM

This work presents the photoelectric effect and the electromagnetic spectrum topic from a Physics course in High School learned through the study of the implementation of spectroscopy techniques in Art analysis. In general, students have difficulties with Physics, especially when the topics are within the framework of contemporary Physics, either due to the complications inherent to the concepts involved or due to the difficulties involved in carrying out experiments that show the theory. In this way, we exposed the relation between Physics and spectroscopy techniques in Art analysis, showing them implementations of spectroscopy.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Contemporary and modern physics / 114

Students' hybrid perspectives about wave function and quantum measurement: A cross-national study

Authors: Nilüfer Didiş Körhasan^{None}; Italo Testa^{None}; Irene Marzoli^{None}; Giovanni Giuliana^{None}

In this research, we focus on undergraduate physics students' hybrid views in two specific cross-cutting concepts in quantum physics, namely, wave function and measurement, and examined them in an international context, Italy and Türkiye. Our results indicate a weak association with the country of origin, whereas hybrid views are independent of the targeted concepts.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Innovative strategies at University / 116

Challenges in Designing Basic Physics Course for Undergraduate Biologists - investigating difficulties with learning physics

Authors: Mirela Kaczmarek¹; Tomasz Greczyło^{None}

¹ *University of Wrocław*

This paper presents a preliminary reflection on the Physics with Elements of Biophysics course taught at the Department of Physics and Astronomy at the University of Wrocław for biology students. Preliminary research on biology students' motivation and attitude towards learning physics, as well as the results of the course evaluation are included. The analysis of the obtained results will help to propose a teaching strategy that addresses the emerging problems and challenges.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Interdisciplinary approaches / 118

Student's Conceptions of the Greenhouse Effect: Consistent ideas or fragmented pieces?

Author: Thomas Schubatzky¹

Co-authors: Carina Wöhlke²; Claudia Haagen-Schützenhöfer³; Rainer Wackermann²

¹ *University of Innsbruck*

² *Ruhr-University Bochum*

³ *University of Graz*

Corresponding Author: thomas.schubatzky@uibk.ac.at

This study examines students' conceptions about the greenhouse effect using multiple-choice questions and analyses student's answers from two perspectives: the "knowledge as theory" and "knowledge in pieces" perspectives. The former emphasizes coherence and stability, while the latter highlights context-dependency and fragmentation. Findings reveal that 30% of the 501 German A-level students chose an answer based on a reflection-based misconception, which correlated with other misconceptions concerning the greenhouse effect and increased in likelihood by holding those misconceptions. The study suggests that both perspectives may have validity, but coherence in students' ideas is less often present than it is.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Poster session 2 / 119

Students' conceptions of the scientific underpinnings of climate change: A systematic review of the literature

Author: Sarah Wildbichler^{None}

Co-authors: Claudia Haagen-Schützenhöfer ; Thomas Schubatzky

Corresponding Author: sarah.wildbichler@uibk.ac.at

To enable students to take responsible action in the context of anthropogenic climate change, learning about scientific concepts underlying its mechanisms is essential. In general, the progression of learning processes is influenced by learners' conceptions. Students' conceptions of the scientific underpinnings of climate change have been investigated in various studies. To provide a broad overview and profound insights into research findings, we conduct a systematic review following PRISMA-guidelines. The review includes literature published in peer-reviewed journals in English between 2013 and 2023 about the conceptions of the scientific underpinnings of climate change held by students aged six to 18.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at school / 121

Teachers' perspectives and practices on teaching the properties of matter

Authors: Ayçin Ünal¹; Lorenzo Santi^{None}; Marisa Michelini^{None}; Mehmet Fatih Taşar²

¹ *University of Udine*

² *Georgia State University*

This study aimed to investigate the practices, and perspectives of in-service elementary and middle school teachers in Italy (N=74) and Turkey (N=56) regarding the properties of matter. A new questionnaire was created and used to collect data. Results showed that teachers in both countries mainly focused on the temperature in change of state. Their least concern was on magnetic susceptibility and latent heat. In teaching Turkish teachers preferred giving examples, while Italian teachers preferred argumentation. The Likert-type questionnaire showed that Turkish teachers had a higher average score than Italian teachers on both their opinions and practices regarding teaching the subject.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at University / 125

Non-constant acceleration kinematics. University students' difficulties related to representation systems

Authors: Any Urrutia¹; Cristian Merino²; Kristina Zuza³; Jenaro Guisasola^{None}

¹ *(1) Department of Physical Sciences, Universidad Andrés Bello, Viña del Mar, Chile*

² *(2) Faculty of Sciences, Pontifical Catholic University of Valparaíso*

³ *UPV/EHU (Applied Physics Department)*

The aim of this work is to detect university students' difficulties in kinematics with variable acceleration in relation to different representation systems (graphical and algebraic) in order to define the Learning Demands. Thus, design bases of a TLS (Teaching-Learning Sequence) are laid. An open-ended questionnaire has been designed and validated in relation to the epistemological keys and the learning objectives to be achieved with the future TLS. In answering, the questionnaire students have to identify, relate, compare and analyse different systems of representation through verbal/written reasoning when elaborating explanations. The analysis of the questionnaire was carried out using phenomenography methodology.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Contemporary and modern physics / 128

Development of the mental models of wave and particle as basis for wave-particle duality

Authors: Rutger Ockhorst^{None}; Freek Pols^{None}

Wave-particle duality is included in many high school physics curricula as a concept central to quantum physics. However, whether wave-particle duality can be taught effectively depends on the students' notions of the classical concepts of waves and particles and the ability to apply these concepts in modelling the physical world. Using a questionnaire on these concepts, we investigate the development of the mental models of waves and particles from novice to expert. The outline of this study as well as the results will be presented at the GIREP conference.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Hybrid session - later / 129

Astronomy concepts in the primary education: a case Brazilian school

Author: Carlos Mometti¹

¹ *School of Education, University of São Paulo*

Recent studies on astronomy teaching, considering the Brazilian context, have pointed out problems that make it impossible for students to learn. Among those, the area of teacher training stands out above all, and its real difficulties in developing the teaching of Astronomy. In this way, we seek in this paper to present a study developed in a Brazilian school about the implementation of a project aimed at the study of astronomical concepts for children. To do so, we start with theoretical-methodological assumptions and present some of the results obtained in the three-year period of the project.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Pre-service teacher education

Informal and non-formal learning / 130

Quantum physics in the past, present and future of Finnish university students

Author: Daria Anttila¹

Co-authors: Antti Lehtinen²; Pekka Koskinen²

¹ *University of Turku*

² *University of Jyväskylä*

Corresponding Author: daria.anttila@gmail.com

Quantum boom has brought quantum physics to everyday life, e.g., to movies or newspaper articles. But do Finnish university students with different majors notice it? Here, we explore their perceptions about the presence of quantum physics in their lives (past), its importance (present), and a possible interest to study it (future). We find that noticing the word “quantum” in their free time and considering quantum physics being relevant to society and everyday life is independent of study major. In addition, if study credits can be provided, students express interest in studying different topics related to QP.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Outreach

Poster session 1 / 131

Learning physics with i-learning materials of the Erasmus project ARphymedes Plus

Authors: Milena Košak Babuder^{None}; Karmen Javornik^{None}; Janja Rihter^{None}; Katarina Susman^{None}; Saša Zihert^{None}; Jerneja Pavlin^{None}

Abstract. In the contribution we present i-learning materials for physics aimed at pupils in primary school. The material takes into account the guidelines for creating i-learning materials and recommendations for accessibility for pupils with special educational needs. Also, the results of the evaluation of the i-learning material on a group of pupils will be added and suggestions for optimization will be given.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at University / 132

Students' experiences of applying vector quantities to rotational motion

Authors: Sebastian Kilde Lofgren^{None}; Tobias Fredlund^{None}; Åke Fäldt^{None}

The development and trial of a laboratory exercise dealing with rotational motion using vector quantities such as angular momentum, torque, and moment of inertia have been evaluated through interviews with students. The lab consists of two parts, rolling cylinders down a slope, and exploring a rotating bicycle wheel. The second part allows the students to determine the wheel's moment of inertia in two ways. The results suggest that while the exercise works well as a learning opportunity for students who fluently use vector quantities, it needs to be revised for many students who cling to content learnt in high school.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Workshop Physics teacher education / 134

The “International Handbook of Physics Education Research”: Insights, Themes, and Future Directions

Author: Paula Heron¹

Co-author: M. Fatih Taşar²

¹ *University of Washington*

² *Georgia State University*

Abstract. The International Handbook of Physics Education Research is a comprehensive review of the literature that spans learning, teaching and special topics, such as research methodology. The IHPER is the first such resource for the field and is intended to serve newcomers, as well as established researchers entering new areas. The development of the Handbook also served as an opportunity for contributors to reflect on major themes, to develop new insights, and to speculate about the future. In this session, contributors will discuss the process of preparing chapters, as well as major findings and notable gaps in the literature.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Hybrid session - later / 136

Design and implementation of a mechanical balance using electromagnetism concepts and active learning

Author: Jorge Roblero¹

Co-authors: Arturo Pazmiño¹; Eduardo Montero¹; Erick Lamilla¹; Luis Rodríguez¹

¹ *ESPOL*

This work summarizes a project-based learning experience around electricity and magnetism at the university level. The challenge for students was to build a mechanical balance with the capacity of measure the mass of different objects using a relationship between voltage and mass without using a microprocessor. The typical solution of this project must be relied on mechanical and electromagnetic calculations and experimental tests to verify the data. The balance prototype was built using a solenoid enable to generate a magnetic force at one end of the balance arm, while the mass to be measured is placed on the other arm.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Innovative strategies at University / 137

Enhancing University First-Year Physics Education: Implementation of Interactive-Engagement Methods for Deeper Conceptual Understanding

Author: Zuzana Jeskova^{None}

Co-authors: Jozef Hanč ; Dominik Borovský

In this research a model of teaching and learning within the University introductory physics course was designed implementing selected interactive engagement (IE) methods within the original course format. This model has been used for 10 years within the study programme of future physicists and physics teachers and compared with the traditional lecture and problem solving methods. The results show higher impact on conceptual understanding of kinematics and dynamics concepts in favour of students that experienced IE methods.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Hybrid session - later / 138

Improving pre-service science teachers' mastery in designing and implementing inquiry experiments in physics concepts

Author: Beril Yilmaz Senem^{None}

The aim of this action research was to improve the mastery of pre-service science teachers in designing and implementing inquiry-based physics experiments. The implementation had three phases; i.theoretical information for inquiry, ii.implementation of teacher-prepared experiments, and iii.design and implementation of the participants' own experiments. Data was gathered through reflection papers, self-evaluation forms, peer observations, and interviews. Pre-service science teachers had difficulty in deciding about the variables to control and manipulate while designing their own experiments. Peer observation and interviews revealed that the main reason behind the difficulties they have was the lack of content knowledge for teaching physics.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Lower-secondary education

Workshop Contemporary physics and modern physics / 139

Teaching and learning quantum entanglement

Authors: Marisa Michelini^{None}; Gesche Pospiech^{None}; Sergej Faletic^{None}

Corresponding Authors: gesche.pospiech@tu-dresden.de, sergej.faletic@fmf.uni-lj.si, marisa.michelini@uniud.it

One of the central features of quantum mechanics is entanglement. It is crucial for understanding the theory, and its applications, especially in quantum technologies. At the 2023 GIREP meeting, an activity of the GTG "Teaching and learning in quantum physics" will address questions about this fundamental principle. The workshop organizers have invited interested parties to participate with their contribution to shed light on the specific challenges and solutions to address this aspect of quantum mechanics.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Poster session 1 / 140

STEAM-Active TLS design protocol

Authors: Kristina Zuza¹; José Gutiérrez Berraondo^{None}; Lorenzo TROMBETTI²; Ane Portillo-Blanco³; Edurne ITURBE-ZABALO⁴; Linda BARELLI²; Spiros SIRMEKESIS⁵; Alesio MORICONI²

¹ UPV/EHU (Applied Physics Department)

² University of Perugia

³ UPV/EHU

⁴ IMH Campus

⁵ University of Peloponnese, Department of Electrical and computer engineering

The STEAM-ACTIVE project (KA2-Erasmus+) aims to contribute to higher education innovation to train university students to produce meaningful learning, and to develop multiple competencies according to an interdisciplinary approach to solve socio-scientific-technical problems. As a result, a Protocol has been developed for Teachers to illustrate the STEAM project design methodology framework with active teaching methodologies, part of the project presented in this work. Moreover, an E-learning-based training course for engineering teachers is being designed. As a final result, a collection of STEAM-based Teaching-Learning Sequences (TLS) will be designed.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Hybrid session - early / 141

Developing scientific thinking in early childhood

Authors: Caterina Bembich^{None}; Valentina Bologna^{None}

Co-author: Paolo Sorzio

Corresponding Author: cbembich@units.it

Creating the conditions to foster the development of children's scientific thinking in early childhood education services is a very stimulating cultural project based on the most recent psychological research findings. According to these findings, we present a brief theoretical overview of the reference framework we used to promote the growth of scientific thinking in some Italian kindergartens. We engaged a group of early childhood teachers and educators in a training program focusing on the theoretical framework and guiding them to involve children in educational activities to improve scientific thinking. An example of these activities is reported here.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

Pre-school education

Target education level (secondary, optional):

In-service teacher education

Poster session 1 / 142

Building an Autonomous Car: A STEM Teaching/Learning Sequence by Project-Based Learning for the training of future secondary school teachers

Author: Ane Portillo-Blanco¹

Co-authors: Jenaro Guisasola²; Kristina Zuza¹

¹ UPV/EHU (Applied Physics Department)

² School of Dual Engineering. Institute of Machine Tool (IMH)

In recent years, the use of STEM educational methodology in the classroom has been increasingly promoted, but due to the heterogeneity of approaches and the lack of knowledge on the part of teachers, it is necessary to accompany this process through the design and implementation of research-based STEM projects. This study presents the design of a STEM project for secondary school that integrates the disciplines of physics and robotics with a PBL approach and its implementation and evaluation with future secondary school trainee teachers.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Hybrid discussion workshop / 143

Discussion Workshop on “Physics and Society”

Author: Aristotelis Gkiolmas¹

Co-authors: Aikaterini Benisi²; Alexandra-Triantafyllia Papanagiotou³; Anthimos Chalkidis²; Artemisia Stoumpa²; Constantine Skordoulis²; Gianna Katsiampoura²; Ilias Boikos²; Vasiliki Psoma²; Zografia Papanagiotou²

¹ Department of Primary Education, Aristotle University of Thessaloniki, Greece

² Department of Pedagogy and Primary Education, National and Kapodistrian University of Athens, Greece.

³ School of Applied Mathematical and Physical Sciences, National Technical University of Athens, Greece

Our group, in Athens and Thessaloniki, is researching issues related to the interconnection between Physics and society. We are also aiming at operating regularly the corresponding GIREP Thematic Group. Therefore, we call for such a Workshop Discussion, within the GIREP 2023 Conference. There, contributors who are interested in this field are asked to share their ideas, results, as well as to propose relative initiatives in the Context of GIREP. The outcomes of this Discussion Workshop would be of importance, we believe, towards the crucial scope of relating Physics' instruction to social issues and social problems, in all levels of education.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Primary school education

Poster session 1 / 144**Physics game as a stimulus for experimental activity****Author:** Tatiana Sukeľová^{None}**Co-author:** Klára Velmovská**Corresponding Author:** tatiana.sukelova15@gmail.com

In this contribution, we focus on physics play as a stimulus for experimental activity. Games and physical ones are already a common part of teaching. We conducted a survey in which we observed classrooms using a physics game we created and a standard-assigned experiment to judge whether the physics game is a suitable stimulus for experimental activity. The survey showed that the physics game is a suitable stimulus, even if the implementation of experiments without a procedure is difficult for the pupils.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Hybrid session - later / 145**Training Teachers on New Topics and New Tools in Physics Education****Authors:** Andrea Piccione¹; Anna Alessandra Massa¹; Matteo Luca Ruggiero²; Marina Serio³; Marta Rinaudo³; Tommaso Marino⁴¹ *Ufficio Scolastico Regionale per il Piemonte*² *Dipartimento di Matematica, Università di Torino*³ *Dipartimento di Fisica, Università degli Studi di Torino*⁴ *AIF - Torino***Corresponding Authors:** matteoluca.ruggiero@unito.it, piccione.eft@istruzioneepiemonte.it, marta.rinaudo@unito.it

We report the result of a collaboration among Universities, Schools, and Institutions to increase interest in new tools and learning environments. To address this issue, we provide scientific and didactic support to teachers through different kinds of training sessions to introduce innovative didactic methodologies for teaching and learning. The project involved a training course both in streaming and in carried out sessions with university staff as well as secondary school teachers. The five meetings focused on new technologies, weather data processing, space missions, image processing, and modern physics, with applications that can be integrated into civic education and dual training.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at school / 146**Teaching electric circuits using real-world contexts –effects on conceptual understanding, interest, and self-concept**

Author: Benedikt Gottschlich¹

Co-authors: Claudia Haagen-Schützenhöfer ; Jan-Philipp Burde ²; Lana Ivanjek ; Liza Dopatka ³; Martin Richard Hopf ; Thomas Schubatzky ; Thomas Wilhelm ⁴; Verena Spatz

¹ *Physics Education Research Group, University of Tübingen*

² *PER Group, University of Tübingen*

³ *PER Group, Technical University of Darmstadt*

⁴ *Goethe-University Frankfurt*

Corresponding Author: benedikt.gottschlich@uni-tuebingen.de

Learners tend to perceive electric circuits as abstract and uninteresting, and often fail to achieve a basic conceptual understanding. Therefore, we have developed a teaching concept for simple circuits with real-world contexts which is based on findings from research on students' interests and includes contexts that appeal to different interest types. Controlling for various covariates in an empirical evaluation, we find no significant differences between the conventionally taught group (n = 24 classes) and the context-based taught group (n = 11 classes) based on the preliminary data in terms of the development of conceptual understanding and affective variables.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):**Physics teacher education / 147****Developing Instrument to Study the Cross-Disciplinary Coherence of Energy Concept image**

Author: Yaron Lehavi¹

Co-authors: Avraham Merzel ; Fadeel Joubran ²; Fadi Sakran ³

¹ *The David Yellin Academic College of Education*

² *The Arab Academic College of Education, Israel*

³ *Beit Berl College, Israel*

Crosscutting concepts (CCCs) are meant to foster integration between topics belonging to different scientific domains and are considered one of the pillars of an integrated K–12 science education curriculum. CCCs are expected to provide learners with organizational frameworks for connecting knowledge from the various disciplines into a coherent and scientific view of the world. However, CCCs are often defined and operationalized incompatibly in different disciplines. Here we describe the development of a questionnaire to study the cross-disciplinary coherence of the Energy concept image.

The questionnaire was administered to teachers and students of different levels. A preliminary analysis will be presented.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Pre-service teacher education

Lab work and experiments / 148

Developing Augmented Reality (AR) teaching materials for undergraduate physics

Author: PHILIPPA PETTS¹

Co-authors: Ross Parker ¹; Helen Cramman ¹

¹ *Durham University*

Corresponding Author: p.l.petts@durham.ac.uk

Extended reality (XR) technology blends the physical and virtual worlds, and has significant potential to transform education. Augmented and virtual reality (AR and VR) provide an interactive learning experience that allows students to visualize and explore complex concepts. AR technology is particularly useful for physics as it can provide an immersive and interactive learning experience, making the invisible visible. This proof-of-principle project developed AR simulations for a virtual optical table and introductory electromagnetism. The simulations were evaluated by undergraduate students and academic staff members who found the tools to provide an engaging and immersive learning experience with great potential.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Poster session 1 / 149

The IPPOG Resource Database: Making particle physics outreach & education available worldwide

Authors: Barbora Bruant Gulejova¹; on behalf of International Particle Physics Outreach Group IPPOG Collaboration^{None}

¹ *Universitaet Bern (CH)*

Over a decade International Particle Physics Outreach Group (IPPOG) has been offering to scientific community, teachers and educators an online collection of high-quality engaging education and outreach materials in particle physics (PP) and related sciences, the Resource Database (RDB). After major revamp and curation a brand new RDB has been published as part of the newly developed IPPOG website, more open to students, teachers and general public. New RDB aims to offer a primary source of PP outreach material bringing PP closer to society. Important part “Talking to Society” helps to build bridge between science and society and its challenges.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Students' identity, inclusion and wellbeing / 150

The Effect of Introductory Physics Course on Life Sciences Students' Attitudes toward Physics

Author: Kübra Özmen¹

¹ *Assist. Prof. Dr.*

Physics education research has shown that attitudes and beliefs influence students' in-class performance. The study examined changes in undergraduate molecular biology and genetics (MBG) students' attitudes toward physics before and after their introductory physics course. A total of 24 first-year MBGE students (Female:18, Male:6) enrolled in the General Physics I course during the Fall Semester of 2019-2020 participated in the study. This study's findings indicate positive and negative changes in certain sub-dimensions of attitudes toward physics. Nevertheless, the current practices in introductory physics courses are not generally effective in positively changing life science students' attitudes.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Innovative strategies at University / 152

The relationship between degrees of freedom and the thermodynamic and Boltzmann entropies in complex thermal systems.

Author: David Sands^{None}

In complex thermal systems in which the heat capacity varies with temperature, such as a typical Debye solid like silicon, the effective number of active degrees of freedom at any temperature can be defined from the internal energy in combination with equipartition. This allows for a conceptual picture of thermal equilibrium as well as elucidation of the link between the Boltzmann and thermodynamic entropies. It is shown that, in general, thermodynamic entropy is not the same as the Boltzmann entropy but there are clear circumstances under which they are identical. The instructional benefits of this approach are emphasized.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Innovative strategies at school / 153

Heat and temperature in middle school: step by step towards complexity through experiments and a narrative approach

Authors: Leonardo Colletti¹; Soufiane Krik¹; Paolo Lugli¹; Federico Corni¹

¹ Free University of Bozen-Bolzano

Corresponding Author: federico.corni@unibz.it

As part of the AT-NE-ST project, which aims to bring children closer to complexity and sensors, we designed and tested an educational path for middle schools concerning the development of the concepts of heat and temperature. It is based on a narrative approach and the exploitation of basic mental schemes. A series of measurements are carried out using appropriate sensors on model buildings in which parameters can be varied. Results show that pupils are able to describe these experiments, but still struggle when it comes to developing a coherent abstract model for even the simplest thermal phenomena.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Pre-service teacher education

Poster session 1 / 154

Study of the free damped oscillations of an elastic rubber band by using a smartphone

Authors: Aurelio Agliolo Gallitto¹; Claudio Fazio²; Giulia Termini^{None}; Onofrio Rosario Battaglia¹

¹ *Department of Physics and Chemistry –Emilio Segrè, University of Palermo, 90100 Palermo - Italy*

² *Università degli Studi di Palermo*

In the last years, the use of smartphones as laboratory tools for school physics experiments has received attention for the possibility of carrying out a wide variety of didactic experiences with low-cost experimental equipment. In this contribution, we describe an experimental activity that can be carried out by using smartphones to investigate the oscillations of a damped oscillator made of an elastic rubber loop and a mass. This system allows one to obtain information on the viscoelastic properties of the rubber material.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Symposium / 155

Physics education in kindergarten: children learning and teachers training

Authors: Federico Corni¹; Stamatis Vokos²; Giorgos Peikos³; Anna Spyrtou³; Giorgos Antoniadis³; Katerina Karat-egou³; Maria Tzioli³; Olga Kremmyda³; Spyridoula Gkiremezi³; Angelika Pahl⁴; Hans U. Fuchs⁴; Sara Zanella⁴; Grzegorz Karwasz⁵; Katarzyna Wyborska⁶

¹ *Free University of Bozen-Bolzano*

² *Department of Physics, California Polytechnic State Univ.*

³ *University of Western Macedonia, Florina, Greece*

⁴ *Free University of Bozen-Bolzano, Faculty of Education*

⁵ *University Nicolaus Copernicus, Torun*

⁶ *University Nicolaus Copernicus, Toruń*

Corresponding Author: federico.corni@unibz.it

This symposium is proposed by the GIREP Thematic Group “Physics Preparation of Teachers in Grades K-6” and consists of a discussion on physics education in kindergarten from two interlaced perspectives: children teaching/learning and teacher training in physics. The three contributions suggest ideas to start a discussion on these challenging and multifaceted topics in view of the identification of innovative ways of teaching and learning physics in kindergarten.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-school education

Target education level (secondary, optional):

Hybrid session - later / 156

A Visual tour of Quantum Technologies

Author: Eleni Karydi¹

Co-authors: Jacob Sherson¹; Simon Goorney

¹ *Department of Management, School of Business and Social Sciences, Aarhus University, Denmark*

In Europe, there is a strong push for the development of an industry around Quantum Technologies (QT). To this end, it is crucial to develop a workforce consisting not only of Physicists, but also those able to create and market companies and products: engineers and businesspeople. We report on a novel course designed using the Quantum Competence Framework to provide transparency between learning outcomes and job requirements. We demonstrate how an interactive visualisation tool, the Quantum Composer, can be used to provide accessible education for both the Physics and non-Physics demographic, those who will compose the future Quantum industry.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

University education

Target education level (secondary, optional):

Hybrid session - later / 157

Deciding the future of Quantum Technologies

Author: Simon Goorney¹

Co-authors: Jorge YAGO MALO²; Laura GENTINI³; Jacob Sherson¹; MARILU CHIOFALO⁴

¹ *Department of Management, School of Business and Social Sciences, Aarhus University, Denmark*

² *Department of Physics "Enrico Fermi", Largo Bruno Pontecorvo 3, I-56126 Pisa, Italy)*

³ *Department of Physics "Enrico Fermi", Largo Bruno Pontecorvo 3, I-56126 Pisa, Italy)*

⁴ *Department of Physics, University of Pisa*

In this presentation we showcase a novel approach to interdisciplinary education in Responsible Research and Innovation (RRI), grounded in the field of Quantum Technologies (QT). We present the findings from a workshop undertaken with 40 PhD students, structured through the culturo-scientific storytelling. Using the interactive Quantum Decide Game, in which students debate the possible futures of a society enriched with QT, we demonstrate an original methodology for interactive design of educational material. By having participants grapple with deciding the future of QT, they are empowered with awareness of RRI, whilst simultaneously creating engaging storylines to engender the same in others.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Outreach

Target education level (secondary, optional):

University education

Innovative strategies at school / 158**Students' perceptions on the assessment in physics lessons****Author:** Katarína Kozelková^{None}

Assessment plays an important role in teaching and learning. Within the assessment, teachers and students interact to obtain the information needed to improve learning. As the learning can be supported by the quality assessment, the survey was conducted at the lower and upper-secondary schools to investigate the assessment and feedback students were given. The paper describes the results of the preliminary survey on the students' perceptions of the assessment in physics lessons and compared them to the teachers' ideas about how the students experience the assessment. The results will be used to conduct deeper research into the topic.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Poster session 2 / 160**Digital Enhancement of Courses in Physical Engineering****Author:** Peter Bokes^{None}**Co-authors:** Miroslava Zemanová Diešková ; Soňa Kotorová

The aim of our activity is to enhance courses of Physical Engineering at FEI STU with digital educational materials and problems that require numerical solution and/or processing of results using smartphones, tablets and/or laptop computers. This will engage students' creative approach to learning using practically oriented problems. The outcome of our activity consists of educational electronic materials, tutorials for usage of open source programs and libraries, templates for input files for these programs and spreadsheet programs relevant for the designed problems. All educational materials are freely available at a dedicated web page.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):**Poster session 2 / 161****Students' ideas on the weather phenomenon foehn and their conceptual understanding of p-V diagrams - An explorative study**

Authors: Ingrid Krumphals¹; Paula Fehlinger²; Michael Ganz²; Stefan Ropac¹; Bianca Watzka²

¹ *University College of Teacher Education Styria*

² *Otto von Guericke University of Magdeburg*

Although the weather accompanies our students every day and the technical basics are taught in various subjects, their understanding of weather phenomena is poorly developed. The difficulties students have in applying their knowledge of mathematics and physics to weather are complex. We would like to explore these difficulties and the reasons for this lack of understanding through various studies. For this purpose, we conducted two studies on students' learning difficulties related to the foehn weather phenomenon. The results show that despite thematic teaching in geography, mathematics, and physics, basic concepts are not known, and interpretive strategies are lacking.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Innovative strategies at school / 162

RPG-based Gamification in Physics Teaching

Author: Borbála Herendi^{None}

Nowadays in teaching physics in high school, one of the biggest problems is attracting and maintaining students' attention. Gamification can be a very easy and exciting way to get students involved in the class. In my research, I used an RPG (role-playing game) based online platform (Classcraft), where the students can have their own character that they can personalize and level up as they receive XP (experience points) if they turn in assignments or participate in class. This platform has several tools too to gamify each lesson. At the end of the chapter, I compared their results.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at school / 163

Elixir to Schools - Attracting and supporting the teachers of the youngest to take up science

Author: Jitka Houfková^{None}

Co-author: Petra Prošková ¹

¹ *Elixir to schools, Czech Republic*

Elixir to Schools started ten years ago as a project aimed at improving physics education in the Czech Republic. It soon became apparent that it was sensible to support teachers from the primary school, and over time the support was extended to preschool teachers as well. Therefore, for the last five years, Elixir to schools has also targeted these teachers. This contribution has two main aims. To introduce the structure of support Elixir offers to the teachers of the young children and to present in details some of the physics activities used.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Pre-school education

Contemporary and modern physics / 164

Designing and evaluating a questionnaire on the quantum physics measuring process

Author: Gesche Pospiech^{None}

Co-authors: Philipp Bitzenbauer ; Kristof Toth ; Marisa Michelini ; Sergej Faletic ; Alberto Stefanel ; Lorenzo Santi ; Antonella Archidiacono ; Luca Mogno ; Stefano Montagnani

One of the key points for understanding quantum physics is the measuring process. In the context of modern approaches to quantum physics via two-state systems, the question of tools for assessing students' understanding and identifying learning difficulties in quantum physics arises anew. As a first step towards a comprehensive concept inventory, a questionnaire to inquire the student's perspective and reasoning about the measurement process as a key concept in quantum physics is developed and presented. This contribution will describe first results of its evaluation.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Pre-service teacher education

Contemporary and modern physics / 165

Using Variation Theory to Understand How Students Relate an Idealised Model to a Paul Trap in the Physics Laboratory

Author: Sebastian Kilde Löfgren¹

Co-authors: Jonathan Weidow ; Jonas Enger ²

¹ *Department of Physics, University of Gothenburg*

² *University of Gothenburg*

Corresponding Author: sebastian.kilde.lofgren@gu.se

Using models in the physics classroom allows students to explore phenomena in ways that could help facilitate learning. A laboratory exercise was developed where upper secondary school students worked with a mechanical Paul trap and a simulation to understand how a real Paul trap works to investigate the usefulness of ideal models in the physics laboratory for learning. A design-based research approach guided by variation theory was adopted for the mixed-method study. The results identified successful patterns of variations and how models in the physics classroom can be both a blessing and a curse for conceptual understanding.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Innovative strategies at University / 166

Addressing the gap in Continuous Professional Development of Academic Teachers—a case study

Author: Dagmara Sokołowska^{None}

Continuous Professional Development (CPD) of school teachers is promoted worldwide and broadly researched. At the same time, academic teachers' CPD is rarely addressed. Usually, science faculty members prove themselves to be high-level researchers, but at the same time, their interpersonal skills, pedagogical knowledge, and attitude of self-reflection on teaching are very limited. To address these issues, we designed the course Introduction to Academic Didactics for first-year PhDs. The results of the course development as well as students' engagement and their perception of the current teaching formats, and their view of necessary changes, will be reported in a case study.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Hybrid session - early / 167

Visualizing Entanglement in multi-Qubit Systems

Author: Jonas Bley¹

Co-authors: Alda Arias¹; Anna Donhauser²; Artur Widera¹; Eva Rexigel¹; Jochen Kuhn²; Lars Krupp³; Maximilian Kiefer-Emmanouilidis⁴; Nikolas Longen⁵; Paul Lukowicz³; Stefan Küchemann²

¹ (1) *Department of Physics and Research Center OPTIMAS, University of Kaiserslautern-Landau, Germany*

² (4) *Faculty of Physics and Physics Education, LMU Munich, Germany*

³ (2) *Embedded Intelligence, German Research Center for Artificial Intelligence Kaiserslautern, Germany; (3) Department of Computer Science, University of Kaiserslautern-Landau, Germany*

⁴ (1) *Department of Physics and Research Center OPTIMAS, University of Kaiserslautern-Landau, Germany; (2) Embedded Intelligence, German Research Center for Artificial Intelligence Kaiserslautern, Germany; (3) Department of Computer Science, University of Kaiserslautern-Landau, Germany*

⁵ (2) *Embedded Intelligence, German Research Center for Artificial Intelligence Kaiserslautern, Germany*

Corresponding Author: jonas.bley@rptu.de

Visualizing multi-qubit systems is challenging due to their high complexity. We present the dimensional circle notation (DCN) as an extension of the so-called circle notation that is used in introductory quantum computing courses to reduce mathematical hurdles. By doing so, we reveal entanglement properties of such systems and make measurements and unitary operations in multi-qubit systems more intuitive. DCN can therefore be used in education and research alike. In this workshop, we discuss the possibilities and limitations of DCN as compared to other visualizations and show how to use our publicly available DCN python/web-tool.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

University education

Target education level (secondary, optional):

Poster session 2 / 168

E⁴: training science teachers on energy using imaginative forms of expression

Authors: Barbara Grazzini¹; Chiara Giacomini¹; Chiara Puecher²; Cliona Murphy³; Federico Corni⁴; Grzegorz Karwasz⁵; Hans Ulrich Fuchs²; Iliaria Giovannini⁶; Jerusalem Jaime Jahoz⁷; José Cantó Doménech⁸; Katarzyna Wyborska⁵; Leonardo Piccinetti⁹; Mauro Amoroso⁹; Tiziana Altiero⁶

¹ *InEuropa srl*

² *Free University of Bolzano*

³ *Dublin City University*

⁴ *Free University of Bozen-Bolzano*

⁵ *Nicolaus Copernicus University*

⁶ *University of Modena and Reggio Emilia*

⁷ *Esciencia Eventos Científicos, S. L.*

⁸ *University of Valencia*

⁹ *Sustainable Innovation Technology Services Ltd*

Corresponding Author: federico.corni@unibz.it

To face the current environmental and technological challenges, it is necessary to support and reform teacher training (for primary and lower secondary school teachers) at academic institutions in matters concerning energy. In this context we present the Erasmus project 'e⁴', which aims to (1) create a higher education course with innovative resources for teacher training in the field of

energy technologies, (2) establish a network of academic institutions and partners from (energy) industry, agriculture and public institutions dealing practically with these matters (from hereon called stakeholders). Lastly, we want to make these results available on a (3) web platform.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Pre-service teacher education

Poster session 2 / 169

A survey on conceptual aspects in implementing a teaching intervention module on light spectroscopy

Author: Danilo Catena^{None}

Co-authors: Italo Testa¹; Lorenzo Santi²; Marisa Michelini²

¹ *University of Naples*

² *University of Udine*

Corresponding Author: 164019@spes.uniud.it

A Teaching Intervention Module (TIM) on optical spectroscopy was designed in the theoretical framework of the Model of Educational Reconstruction. This study illustrates a proposal for a conceptual survey related to the TIM implemented in three classes of N = 50 high school students (17-18 years old). We focused the survey on the mechanism of colours' formation and the interpretation of spectra. The answers' categorization will provide the students' conceptual understanding of these topics, as well as the distractors for the reformulation with multiple-choice items. Data analysis is currently in progress, and the results will be presented at the congress.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Plenary talk / 170

From theoretical studies of liquid crystals to professional learning communities of teachers

Author: Mojca Čepič¹

¹ *University of Ljubljana, Faculty of Education*

Plenary lecture;

Marked as oral presentation.

It was impossible to choose the target level, as the content extends from lower secondary to university level and in service teachers.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Workshop Innovative strategies at school / 171

How a simple activity can open a door to serious inquiry: The boat competition

Author: Mojca Čepič¹

Co-author: Ana Gostinčar Blagotinšek ¹

¹ *University of Ljubljana, Faculty of Education*

The workshop is an illustration for my plenary lecture, where the mode of working in professional learning community of in-service teachers in Ljubljana, Slovenia, within the STAMPed project is also described. Here, the participants will carry out one of the activities developed in the project and discuss a plethora of possibilities for inquiry a very simple task offers when considered to more details.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Contemporary and modern physics / 173

Conceptual Understanding of Climate Change of German A-level Students

Author: Rainer Wackermann¹

Co-authors: Carina Wöhlke ; Thomas Schubatzky ; Claudia Haagen-Schützenhöfer

¹ *Physics Education, Ruhr-University Bochum, Germany*

This study examines the conceptual understanding of the scientific principles of climate change of German A-level students using the CCCI-422 climate change concept inventory. The sample under

investigation consists of 501 A-level students of five German upper-level secondary schools (Gymnasium) representing the complete A-level student body in their schools. Results show that the CCCI-422 seems difficult for the A-level students, because less than half the items were answered correctly. Alternative conceptions known from literature (e.g. ozone hole explanation) can be approved with this instrument and this sample. The self-assessment drops from pre to post strongly and becomes more realistic.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

174

Investigating pre-service physics teachers' understanding of functions, formulas and equations in lab courses: A pilot study

Author: Olga Gkioka¹

¹ *boğaziçi*

The focus of the study is on how pre-service teachers understand mathematical expressions (equations) when they analyse experimental measurements in physics lab courses. Sixteen pre-service physics teachers participated. Data sources were open-ended written tasks, semi-structured interviews and lab reports. The participants have had particular difficulties when they reason with mathematical expressions as they demonstrate a restricted understanding of them as formulas only. It is easy for them to calculate slopes of line graphs by applying the “formula” for slopes, when they process experimental data. However, they experience difficulties when they need to calculate rates at particular points of a curve.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Hybrid session - later / 175

Connecting physics teaching to sustainability challenges: The GREEN-EDU project experience

Authors: Dominique Persano Adorno¹; Iro KOLIAKOU²; Tharrenos BRATITSIS³; Joanna Komorek⁴; Nicola PIZZOLATO⁵

¹ *Dipartimento di Fisica e Chimica “E. Segrè”, Università di Palermo*

² *Anatolia College*

³ *Early Childhood Education Department, University of Western Macedonia*

⁴ *College of Business and Health Sciences*

⁵ *ICS Maredolce*

Empowering young learners to create a sustainable future is critical in educating future responsible citizens. Green education can also act as a vehicle to inspire the next generation of students to pursue a career in science. Under the umbrella of green education, difficult physics concepts can be introduced and explained within a more interesting context, relevant to the everyday (and future) life of the students. The EU GREEN-EDU project supported the development of new interdisciplinary approaches and teaching practices in science classrooms, enhancing the efficacy of teaching/learning physics through novel fields such as sustainable engineering, robotics and green biotechnology.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Digital technologies / 176

Open Data Science Tools and Artificial Intelligence in Physics Education & Research

Author: Jozef Hanč¹

Co-authors: Martina Hančová¹; Dominik Borovský¹

¹ *P. J. Safarik University*

The current data-driven era is rapidly transforming the world around us, including physics education research (PER) and education. Modern statistical, data science, and artificial intelligence (AI) methodologies enhance data processing, analysis, and visualization, enabling optimal data-driven decision-making. As PER increasingly adopts advanced methods and tools, there is still a lack of full openness, which provides a unifying framework connecting research practices, methods, data, and code for everyone in the PER community. Our key aim is to share our experience with open data science, encouraging broader adoption within the field. We also underscore the potential benefits of data science and AI in helping teachers adopt more effective blended learning.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

In-service teacher education

Hybrid session - later / 177

Astronomy and Arduino applications in Physics class

Author: Maria PETO^{None}

Abstract. In this poster, few school projects are presented which helps to combine theoretical knowledge and students' creative and innovative skills in STEM activities. The topic is applied in Physics classroom and in practical outdoor activities with the Science Club students. The activities are based on taking and analysis of astrophotos, designing of simple rovers and measuring devices controlled by an Arduino microcontroller. The goal is to develop students' competencies in a way that is interesting and stimulating to them.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session 2 / 178

Is the Revolutionary ChatGPT an Aristotelian Thinker?

Author: Dominik Borovský¹

Co-author: Jozef Hanč¹

¹ P. J. Safarik University

ChatGPT, a recently released revolutionary AI chatbot based on deep learning and artificial neural networks, enables highly proficient human-like conversations, translations, and reasoning. Our ongoing research aims to investigate ChatGPT's potential in physics education, including its capabilities, limitations, and impact on students in real conditions. Employing an exploratory sequential mixed-methods design, our preliminary results from the first phase reveal, for example, that while GPT-3.5 acts as an Aristotelian thinker with respect to FCI, GPT-4 achieves a Newtonian thinking level. The study will also present ChatGPT's performance in various physics tasks and its implications for enhancing students' physics understanding and engagement.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Innovative strategies at school / 179

Theatrical Activities on Magnetic Phenomena for the Scientific Learning in Primary School

Authors: Marisa Michelini¹; Irene Sualdin²

¹ *Physics Education Research Unit, University of Udine, via delle Scienze 206, 33100 Udine, Italy*

² *Primary school teacher and actress*

Corresponding Author: irene.sualdin@gmail.com

Scientific education needs to be started early, with explorative experiences of the physical world. This contribution presents the implementation of a Teaching Intervention Module (TIM) on magnetic phenomena, using integrated strategies of active learning and arts. A theatrical performance is designed, prepared and implemented by children, during and for their own learning of the main basic concepts on the magnetic phenomena, explored by an Inquiry Based Learning approach. This research, with 12 4th-5th grade children, uses in/out tests, tutorials and an observation grid to guide and monitor the children's learning through both the scientific inquiry and the theatrical activities.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at University / 181

Decision-making by students in lab courses: stimulating students' reasoning when choosing apparatus in experiments

Author: Paul Logman¹

Co-author: Matthijs Rog

¹ *Leiden University*

Making substantiated decisions is an important critical thinking skill. In this study we look at students substantiating their choice of apparatus for experiments. Students' choices were registered and they were asked about the reasoning behind their choice. About three quarters of our population reasoned only by intuition. However, having students choose from similar apparatus that differ only in technical details stimulated about a fifth of our students to come up with valid (technical) reasons for their preference. This is therefore recommended for other lab courses.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Poster session 2 / 182

Introducing quantum physics concepts through lesson materials on quantum technology

Authors: Freek Pols^{None}; Lodewijk Koopman^{None}; Rutger Ockhorst^{None}

We present examples of lesson materials on quantum technology, currently under development, to be used as an introduction to quantum physics in upper secondary school aimed at students with a general STEM background. We expect that introducing students to quantum technology and how its applications impact their daily environment can be a fruitful starting point for developing some intuition about quantum phenomena. Thus, the materials contain hands-on activities and demonstrations with a predict-observe-explain approach. Additionally, we wish to explicitly connect quantum physics to other fields of scientific study such as chemistry and biology.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

In-service teacher education

Innovative strategies at University / 184

Using peer-reviewed papers to design new type problems

Authors: Andreja Šarlah¹; Gorazd Planinsic¹

¹ *Faculty of Mathematics and Physics, University of Ljubljana*

Corresponding Author: andreja.sarlah@fmf.uni-lj.si

Problem solving is an integral part of teaching and learning physics, however, the research shows that by solving traditional problems students do not develop coherent knowledge. In the technological era there is a high demand for professionals of different areas with higher level thinking skills and scientific abilities characteristic for physicists. To help the students to learn to act and think like the physicists do, new type of problems have to be designed. We show how scientific papers can be used in the process and how such problems are seen by traditional physics educators.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Digital technologies / 185

Integrating Python data analysis in an existing introductory laboratory course

Authors: Eugenio Tufino¹; Micol Alemani²

Co-author: Stefano Oss¹

¹ *University of Trento*

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In this presentation we describe how we incorporated data analysis with Python in the first year laboratory course at the University of Potsdam. This transformation was implemented without considerably altering the course structure. We carefully designed Jupyter Notebooks with exercises and applied physics examples. We use these Notebooks to guide students through the fundamentals of data handling and analysis in Python while performing simple experiments. We present our approach and the developed materials. Finally, we discuss the effectiveness of our intervention based on quantitative empirical studies in the lab class.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Hybrid session - later / 186

Prospective primary teacher education on electric phenomena

Author: erik Pagnutti^{None}

Co-authors: Alessandra Mossenta ; Lorenzo gianni Santi ¹; Marisa Michelini ¹

¹ *University of Udine*

Prospective Primary Teachers (PPT) education requires activities to produce competence, crucially in producing conceptual change, from common sense ideas to a scientific vision of phenomena. Test -in/out and research-based proposals as formative tools seem useful to identify the learning knots of specific topics and to support professional development of PPT. An in-out test on electric phenomena was developed using the research outcomes on conceptual knots, administered to a group of PPT before and after a formative module. The learning gain of the formative module emerged in data analysis, offering guidelines for PPT pre-service education.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Innovative strategies at University / 187

Peer discussions with MCQs after immediate feedback

Author: Børge Irgens¹

¹ *UiT the Arctic University of Norway*

Students' being active in their approach to learning and learning from each other has been shown to lead to good learning outcomes. Several approaches use multiple-choice questions (MCQs) to achieve this. However, the discussions often proceed in ways unanticipated by the teacher, and we still do not understand how these discussions work in many contexts. Therefore, we videotaped discussions between students in a third-semester intermediate mechanics course while they answered MCQs and studied what happened when they got feedback that they answered incorrectly and had to try again.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Physics teacher education / 188

The influence of teacher's experience on students' argumentation

Author: Tünde Kiss^{None}

Co-author: Klára Velmovská¹

¹ *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, Slovakia*

Argumentation in solving physics problems is among the important aspects of teaching that contribute to the development of the students' personality. In the paper we gave a definition of argumentation in teaching of physics, and criteria for evaluating students' responses in terms of argumentation. As part of the research, we dealt with argumentation of students in solving physics problems in terms of the number of years of experience of their teachers. We found that students of more experienced teachers were not more successful in solving tasks focused on argumentation.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Lower-secondary education

Innovative strategies at school / 189

Promoting inquiry skills in lower secondary level. Physics from the suitcase

Author: Izabella Julia Benczik¹

¹ *Eszterhazy Karoly Catholic University Eger*

As a school-university collaboration, the Eszterhazy University Eger in Hungary has launched the Physics from the suitcase project in 2019, i.e. it established a lending library of classroom-sized experimental kits. Pre-service teachers designed inquiry-based activity sheets for the optics and the electricity kits, covering 12-14 weeks of teaching. The two, one-semester-long modules have been implemented among 7th and 8th graders in two controlled pilot experiments that demonstrated significant enhancement of the students' content knowledge, progressively improving inquiry skills, and a more positive study attitude in the members of the experimental group.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Primary school education

Symposium_hybrid / 190

New perspective in Physics education research and teaching & learning Physics in Latin-American Countries

Author: Gabi Lorenzo^{None}

This symposium addresses four aspects of Physics education research from Latin American perspective. Research outcomes, experiences and projects that are representative from the diverse lines of work in this multicultural region are presented here. The use of digital technologies, the critical challenges for the social and historical curricular design, the promotion of community participation and some training experiences of in-service teachers are presented and reflected in this work. In this way, this symposium will offer a clear vision of the efforts linked to the research and development of Physics education which are being made in this region of the world.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Students' identity, inclusion and wellbeing / 191

HoPE (Hands on Physics Experience): creativity and collaborative construction of knowledge develop lifelong learning competences

Author: Maria Cristina Trevisoi¹

Co-authors: Edward Moriarty ²; Elizabeth Cavicchi ²; Paola Rebusco ³; Roberto Calabrese ⁴

¹ *University of Ferrara*

² *MIT Edgerton Center*

³ *MIT- ESG*

⁴ *INFN and University of Ferrara*

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Traditional ways of teaching and learning Physics are usually led only by teachers. Students study historical discoveries. There is almost no space for creativity and interaction among students. How is it possible to raise a new generation of inventors and innovators that are able to work collaboratively, as they will be expected to do in the future society? This is the story of a high school STEM program run collaboratively with MIT Edgerton Center. Students are actively engaged in their learning process by creating, researching, designing, building collaboratively with peers their own STEM projects and by developing lifelong learning skills.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Hybrid session - early / 192

Speaking the Unspeakable 2023 –an exhibit on quantum entanglement and Bell's inequality

Author: Valentina DE RENZI^{None}

Co-authors: Alessia Allevi ¹; Andrea Smirne ²; Guido Goldoni ³; Lorenzo Maccone ⁴; Marco Genoni ²; Maria Bondani ⁵; Olindo Corradini ³

¹ *DIPARTIMENTO DI SCIENZA E ALTA TECNOLOGIA, Università dell'Insubria*

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³ *Dipartimento di Scienze Fisiche, Informatiche e Matematiche dell'Università di Modena e Reggio Emilia e Istituto CNR-NANO, Via Campi 213/A Modena, Italy*

⁴ *Dipartimento di Fisica Università di Pavia*

⁵ *CNR - Institute for Photonics and Nanotechnologies*

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We present a possible route to introduce the key concepts of quantum superposition and entanglement to secondary school students and to the general public avoiding mathematical difficulties. Our narrative is based on the description of key experimental findings, starting from Stern-Gerlach and Feynman double-slit experiments to the experimental proof of the violation of Bell's inequalities by 2022 Nobel prize winners. Furthermore, we exploit carefully chosen analogies and custom-made models to help visualisation and understanding. The narrative and the models have been successfully exploited in a public exhibition.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

Outreach

Target education level (secondary, optional):

Higher-secondary education

Poster session 1 / 193**Teaching and learning physics through augmented reality: Erasmus+ KA201 Project ARphymedes****Authors:** Jerneja Pavlin^{None}; Katarina Susman^{None}; Sasa Zihel^{None}

The biggest challenge for teachers nowadays is to raise students' motivation for learning. In this contribution the novel technology, augmented reality (AR), in teaching physics will be presented. In the workshop participants will be actively engaged, testing teaching materials from teachers' perspective. Materials including AR has been previously tested among pupils, students and teachers within the Arphymedes project. The results will be discussed and compared with impressions of workshop participants, which were developed during the Erasmus project ARphymedes.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Primary school education

Target education level (secondary, optional):

In-service teacher education

Hybrid session - early / 194**Facilitating the understanding of quantum mechanics: risks and benefits of Artificial Intelligence in an African context****Author:** Baudouin DILLMANN^{None}**Co-authors:** Alvin NYANDEJE¹; Dhanushi SALVA¹; Eric Ouma JOBUNGA²; Nicola PIZZOLATO³; Dominique PERSANO ADORNO⁴¹ *Strathmore University*² *Technical University of Mombasa*³ *ICS Maredolce*⁴ *University of Palermo*

The present communication aims at proving the benefit of an open inquiry approach of physics instruction for college students, as compared to traditional lecture-based teaching strategies. The challenges presented by the emergence of Artificial Intelligence, are major societal issues to the academic culture. We propose to demonstrate that higher levels of thinking abilities can be achieved by "driving" the students to personally experience the world and struggle for finding solutions to real problems. We have proven it can be done by involving them in highly interesting learning projects and strongly motivating them to actively participate in the scientific endeavour.

How would you like to present your contribution?:

Hybrid from my own country (early in the conference day, best for Asia, Australia ...)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Poster session 2 / 195**Awakening a sense of belonging to the professional community in pre-service physics teachers**

Author: Viera Haverlikova¹

Co-author: Klára Velmovská²

¹ *Comenius University in Bratislava, Faculty of mathematics, Physics and Informatics*

² *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, Slovakia*

The shortage of physics teachers is nowadays reality in many countries. It leads to the need for changes in pre-service teacher education. To support professional identity and building a professional community, a new experiential camp is offered to pre-service teachers. The contribution presents initial research focused on identifying students' expectations, relevance of content and applied methods, as well as on satisfaction of participants. Building a sense of belonging to the professional community is a long-term process, nevertheless first effect was observed.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):**School - university collaboration / 197****School-University Collaborations: an exploration of issues and possible solutions.**

Authors: David Sands^{None}; Mattia Ostinato¹; Sarah Zochling²

¹ *University of Barcelona*

² *CERN*

Corresponding Author: dsandsrb025@gmail.com

This EPS-sponsored symposium follows on from a Round Table conducted at the EPS frum in Paris in 2022. We consider physics teaching in schools from a Europe-wide perspective and examine issues in teacher professional development ranging from enhancement of knowledge of the curriculum content, laboratory skills and pedagogy. We present views from the Physics Education Division of the

European Physical Society, the Young Minds initiative of the European Physical Society, various sections of which actively work with schools around Europe and the Teacher and Student Programmes section at CERN. We explore the possibility of a European initiative in school-university collaboration.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

In-service teacher education

Workshop Innovative strategies at university / 198

Conceptual Approaches To Teaching

Authors: David Sands^{None}; Katarína Kozelková^{None}

The nature of concepts and conceptual understanding is discussed in relation to approaches to teaching which enhance conceptual understanding. The role of qualitative relationships, mental models, discussion, team work and the use of different kinds of representations are all discussed with reference to their use in scientific reasoning and, by extension, learning to reason in science. Participants will have the opportunity to put these ideas into practice by, first, explaining or discussing difficult concepts and then bringing the ideas together in the design of teaching sequences that emphasize the conceptual approach. Both university and school teachers are welcome.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Hybrid session - later / 199

The Kaleidoscope : a case of the reflection of light

Author: Ruth MARTINEZ VICTORIA¹

¹ UNAM

One of the basic concepts to understand several topics of optics is the reflexion of light. The design of experiment related to reflection of light contribute to understand the physics in a specific case the study and construction of a kaleidoscope is a funny, interesting and easy activity for the students in basic levels or high school. In this contribution we can understand the process of the construction and the analysis of the variety of patterns that will produces with every movement of the kaleidoscope. This experiment is one of a serie of experiment related with the topic.

How would you like to present your contribution?:

Hybrid from my own country (later in the conference day, best for Americas ...)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Higher-secondary education

Poster session 1 / 200**Fidget spinner –a simple experiment and Java applet**

Authors: Arpad Bordas^{None}; Peter Farago^{None}

Fidget spinner is a cheap toy which can be used as a teaching tool to demonstrate rotational motion. The goal of our study is to present simple fidget spinner experiment and a Java applet developed for theoretical investigation of the problem.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Poster session 1 / 201****Non-Formal Physics Educational Activities Impact on Secondary School Students**

Author: Ivan Tronov^{None}

Co-author: Marian Kires¹

¹ *Institute of Physics Faculty of Science UPJS in Košice, Slovakia*

The article is devoted to the investigation of impact of the non-formal physics related activities on the target group of Lower and Upper-Secondary school students. Research was conducted on the basis of physics competitions, that run in Slovakia during the period 2022 –2023 with the application of the questionnaires based on the Informal Education and Outreach Framework.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Physics teacher education / 204**Supporting physics teachers in the implementation of innovative teaching methods and inspiring learning environments****Authors:** Antonia Juhasova¹; Marian Kires¹¹ *Falutly of Science, Pavol Jozef Safarik University in Kosice*

In this paper we focus on education aimed at developing students' skills and competencies by building scientific literacy, which requires teachers to implement innovative teaching methods. Digital technologies and the wide availability of information make it possible to combine formal education with self-study at home. We strive for teachers to gain a personal conviction in the suitability and effectiveness of blended learning and to gain confidence in its implementation. We present a mapping of the current state of teachers' attitudes towards the introduction of innovative teaching methods and the needs for their connection to the learning environment.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):**Workshop Digital technologies / 206****Surprising and interesting projects with Coach****Authors:** Ton Ellermeijer^{None}; Peter Demkanin^{None}

This workshop aims to make participants familiar with the power of tools like Measurement with sensors, video measurement and modelling (computational science) to enable more realistic and challenging Physics Education. With these tools students can experience the Modelling Cycle and carry-out authentic projects. The Coach Authoring and Learning environment is unique because it offers these tools in one environment, enabling combining these tools and making the learning curve for as well teachers as students very efficient. A number of projects will be introduced to inspire participants who will receive a free 1-year license and these examples to continue the experience.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Plenary talk / 207**Unexpected trajectories into higher education physics: Perspectives on gender, identity and culture****Author:** Anna T. Danielsson¹¹ *Stockholm University, Sweden*

This talk will explore a diverse set of trajectories into higher education physics, zooming in on what has made physics studies possible for minoritised students. In doing so, mechanisms of in/exclusion will be highlighted, with a focus on how gender and social class are made relevant in students' stories about their trajectories to higher education physics. The talk will also zoom out to explore how cultural traits of the discipline of physics contribute to in/exclusion of students, demonstrating how an analytical perspective focused on gender, identity, and culture can nuance and deepen the understanding of students' physics learning experiences.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Plenary talk / 208**Physics Teacher Professional Learning: innovative models for promoting culture and addressing societal issues****Author:** Eilish McLoughlin¹¹ *School of Physical Sciences & CASTeL, Dublin City University, Ireland*

Two of the major challenges facing physics education internationally is the shortage of qualified physics teachers and an increased focus on the use of integrated STEM learning experiences at primary and second level. Firstly, this talk discusses the design and influence of a professional learning programme to upskill second-level teachers of mathematics, chemistry, biology to become qualified as physics teachers. The programme design includes principles that are fundamental to effective physics teacher education, i.e., strong physics knowledge is essential for good teaching, and teachers carrying out a practitioner inquiry (PI) on their own practice as part of a professional learning community (PLC) will enhance their content knowledge for teaching physics. Secondly, this talk shares the experiences and influences of a STEM Teacher Internship (STInt) programme that has provided paid summer placements for over 250 pre-service and novice in-service STEM teachers across 60 host organizations across Ireland. The influence on teachers' personal and professional learning, awareness of equity and societal issues, use of 'real world' contexts and integrated STEM learning approaches, inspired by their own immersive learning experiences in industry, is discussed. This talk shares recommendations for the design and implementation of immersive and collaborative learning experiences for enhancing physics teacher professional learning and influencing classroom practice.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):**Plenary talk / 209****The importance of laboratory instruction in the physics curriculum****Author:** Ian Barden¹¹ *Niels Bohr Institute, University of Copenhagen, Denmark*

Laboratory instruction in physics is often justified with the claim “physics is an experimental subject.” While this claim is certainly true, we can make much better and—one hopes—more convincing arguments for laboratory instruction in physics. This discussion is particularly important for many reasons. Among the reasons is that students are often unclear on why they have to spend time in the lab and thus feel the time would be more optimally used doing other course activities. A convincing argument for why we include “labs” in our curriculum could be helpful in obtaining student buy-in. Another reason is that there is little hard evidence that laboratory work helps students understand the subject, at least to the extent that end-of-term exams measure understanding. Finally, in many educational institutions, labs are under budgetary pressure since they often require a larger investment in both equipment and time. In this talk, I will give my views on why hands-on experience in the lab is important and how laboratory work can be tuned to give students meaningful educational experiences in the laboratory.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Plenary talk / 210**Use of quantitative methods in Physics Education Research: searching for new perspectives to inform theory and practice****Author:** Italo Testa¹¹ *University of Naples Federico II, Naples, Italy*

Starting November 2022, Physical Review Physics Education Research, the flagship journal in physics education research community, has announced the establishment of a Statistical Modeling Review Committee to assess the quality of statistical modeling techniques in submitted papers. The establishment of this committee reflects the increasing number of submissions that exploit techniques such as structural equation modeling, linear regression and Rasch analysis. While the declared aim of this committee is to relieve the reviewers’ burden to delve into technical details of papers, it also clearly signals that the physics education research community is increasingly acknowledging the

need to support its claims through suitable quantitative methods, going beyond the old-fashioned motto Education is not Measurement. In the first part of this talk, I will briefly review the main statistical techniques used nowadays in physics education research and call for a better interaction with the statistical and educational psychology communities. Lack of such an integration, I will argue, is the main impediment to finding consensus about the obtained results even within the physics education research community itself. In the second part of the talk, I will try to envisage possible new research avenues for physics education research building on the possibilities offered by advanced statistical methods.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Plenary talk / 211

Challenges in AI-generated physics education

Authors: Gabriel Semanišin¹; Lubomír Antoni¹

¹ *Faculty of Science, Pavol Jozef Šafárik University in Košice, Slovakia*

Artificial Intelligence (AI) is one of the fastest-growing fields dealing with understanding and building intelligent machines that can compute how to act effectively and safely in a diversity of novel challenges. Today, generative AI is applied in a varied collection of applications, from creating art to helping in education and improving healthcare. Generative AI has the potential to bridge the gap between the current state of knowledge and the knowledge of graduates by generating educational content that is tailored to the needs and interests of individual learners. Generative AI can form personalized learning paths for students on their learning history and preferences, can generate simulations and scenarios that simulate real-world situations, or can help to analyze big data and identify patterns and hidden information that are difficult to detect by humans. Automated AI assessment, machine learning, or learning analytics can boost the learning and instruction quality in STEM education. Several types of AI applications in STEM education were investigated, for example, educational programming or social robots, intelligent tutoring systems, student behavior detection, learning prediction, automation, or AI textbooks. The applications of AI in innovative physics education can enhance the experience for both students and teachers. For example, the visualization and evaluation techniques can help to find hidden patterns in the students' solutions which allow to prevent student mistakes or misconceptions. We present an example of the application of AI in innovative physics education with the help of several machine learning methods and algorithms.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Teachers' best practices / 212**PHYSICS KALEIDOSCOPE - From Simple Tools to Inspirative Physics Education****Author:** Antonia Juhasova¹¹ *Faculty of Science, Pavol Jozef Safarik University in Kosice*

It is a challenge to engage and develop the talents of lower secondary school students who have minimal knowledge of physics but are interested in why and how the world around them works. By making physical toys and conducting simple experiments with readily available materials, students are introduced to selected physical phenomena through play. In the physics club, we discuss physical principle and look for answers to curious questions. A great advantage for the pupils is that they can present their own toys and explain their physical nature to their parents and siblings. Every year, new exhibits are added to the physics club gallery, which motivates the followers.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):**Teachers' best practices / 213****Conducting a STEM career information day for the 8th grade in the form of a digital congress during the Corona pandemic****Author:** Sebastian Bauer¹¹ *Humboldt-Gymnasium Vaterstetten*

An annual STEM career information day, organized by students for their classmates, was transformed into a digital congress format during the Corona pandemic. The face-to-face presentations were replaced by video conferences using the school's digital platforms. This subsequently allowed to invite foreign speakers, a German YouTube influencer as well as several HGV alumni, who shared their experiences from their first semesters at University. In the contribution we will give an overview of the activities of our Humboldt Academy for Science and Engineering course and show in particular the procedure of our digital STEM career information day.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

The UDCiencia Teaching Innovation Group and its role in promoting scientific dissemination

Author: Carlos Damián Rodríguez-Fernández¹

Co-authors: Ana M. González Tizón²; David Ausín²; Esther Rilo²; Luisa Segade²; Montserrat Domínguez-Pérez²; Oscar Cabeza²

¹ *Departaments of Física e Ciencias da Terra, and Bioloxía, Universidade da Coruna, Spain*

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UDCiencia is a multidisciplinary group composed by professors and students from different scientific branches, focused on educational innovation and scientific outreach. Our aim is to create appealing materials and methodologies for teaching physics (and other sciences) to undergraduates, but also to students from schools, high schools, or special education centres. Our approach is based on the Serving-Learning (SL) philosophy: professors provide mentoring to undergraduates, and they develop multidisciplinary hands-on workshops to address specific topics. We present here “Under Pressure”, our recent workshop for exploring the concept of pressure and the reasons behind the morphology of some (abyssal) marine species.

How would you like to present your contribution?:

Live in Košice (time slot to be allotted based on the programme)

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education