

GIREP 2022, Ljubljana, Slovenia

Monday, 4 July 2022 - Friday, 8 July 2022

Faculty of Education, University of Ljubljana

Book of Abstracts

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Contemporary Physics and Modern Physics / 137**(V) Radiolab: Interdisciplinary Paths of Nuclear Physics****Author:** Vera Montalbano¹¹ *University of Siena***Corresponding Author:** montalbano@unisi.it

Health effects of radon, most notably lung cancer, have been investigated for several decades. Therefore, indoor radon monitoring is a great way for considering the problem of natural radioactivity but also a way to insert phenomenological elements in physics education useful in understanding the crisis of classical physics and for introducing to modern physics. The RADIOLAB project allowed to explore the possibility of a rapid introduction of elements of modern physics for younger students. The methodological changes made necessary by the need to continue activities during the pandemic have made learning paths even more versatile, especially towards distant schools.

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 Physics and Modern Physics / 50****Upper-secondary physics students' expression of representational competence when interacting with a GeoGebra simulation****Author:** Lorena Solvang¹**Co-author:** Jesper Haglund ¹¹ *Karlstad University***Corresponding Author:** lorena.solvang@kau.se

The present study provides a new model that can be used to characterize students' representational competence. By using this model, we explore upper secondary school students' interaction with a GeoGebra simulation of friction by analyzing in which ways students express different aspects of their representational competence. The results show that by using the provided simulation in conjunction with provided set of instructions, students were able to express four of five aspects of representational competence.

How would you like to present your contribution?:

Live in Ljubljana (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 Physics and Modern Physics / 67**The Energy Field Approach****Authors:** Manuel Becker¹; Martin Richard Hopf^{None}¹ *University of Vienna***Corresponding Author:** manuelbecker@unitybox.de

Energy is an important crosscutting concept across middle and high school grades. However, studies show that students struggle comprehending this concept. To address this problem, we started a design-based research project called “the energy field approach” (EFA). This project develops a teaching learning sequence (TLS) for high schools (grades 10-12) building on knowledge about students’ misconceptions and the model of educational reconstruction. As a key feature, it combines traditional energy forms to only kinetic energy and field energy. This TLS is cyclically evaluated and re-designed by conduct and qualitative analysis of teaching experiments according to the method of probing acceptance.

How would you like to present your contribution?:

Live in Ljubljana (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 Physics and Modern Physics / 11**Designing an open-ended simulation tool for special relativity education at the secondary level****Author:** Paul Alstein¹**Co-authors:** Kim Krijtenburg-Lewerissa¹; Wouter van Joolingen¹¹ *Utrecht University***Corresponding Author:** p.alstein@uu.nl

We report the design and first evaluation of an open-ended simulation tool for special relativity education at the secondary level. The simulation tool, named Relativity Lab, is aimed at supporting students in performing and evaluating thought experiments, by constructing simulations from scratch and viewing the outcomes from different frames of reference. We performed a usability test (N=11) in which students were asked to perform thought experiments in a predict-observe-explain format. Preliminary findings indicate that students are able to construct simulations correctly and that the session helped them to imagine thought experiments more clearly.

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Contemporary Physics and Modern Physics / 103**Mathematical tools to explore quantum technologies****Authors:** Filippo Pallotta^{None}; Maria Bondani¹¹ *CNR - Institute for Photonics and Nanotechnologies***Corresponding Author:** maria.bondani@uninsubria.it

We designed and implemented learning activities to teach Quantum Physics in the context of Quantum Technologies by exploiting the necessary mathematical formalism and interactive activities necessary to stimulate students' reflection on the principles of quantum theory.

How would you like to present your contribution?:

Live in Ljubljana (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

Contemporary Physics and Modern Physics / 97**An approach to the Second Quantum Revolution: the case of the random walk algorithm****Authors:** Sara Satanassi^{None}; Ercolessi Elisa¹; Levrini Olivia¹¹ *UNIBO***Corresponding Author:** sara.satanassi3@unibo.it

The teaching of quantum technologies has now become a leading topic and is at the heart of numerous international programs.

In the contribution, we present an approach for teaching the second quantum revolution to secondary school students that Bologna's research group in physics education has developed in recent years. The approach and activity that we are going to present contribute to shed light on the potential that quantum computation and its interdisciplinary nature have both to introduce some quantum physics basic concepts and to reflect on the differences between the classical and quantum rational structures.

How would you like to present your contribution?:

Live in Ljubljana (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 Physics and Modern Physics / 75**Student Intuitions in Statistical Mechanics****Authors:** Ebba Koerfer^{None}; Bor Gregorcic¹¹ *Uppsala University, Sweden***Corresponding Author:** ebba.koerfer@gmail.com

This exploratory case study aimed to investigate patterns in student reasoning in statistical mechanics, in order to identify difficulties and develop ideas for future research. Upper-division undergraduate students, taking a course in statistical mechanics, were interviewed in groups. Here we present observed patterns of student reasoning about a simple, discrete system in contact with a heat bath. Our findings reveal problematic student intuitions of the high temperature limit. Several students were, however, able to transfer knowledge from a similar problem involving spin to improve their reasoning.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):**Contemporary Physics and Modern Physics / 66****Avoiding the Use of Complex Numbers: Didactic Problems Regarding the Uncertainty Principle?****Author:** Kristóf Tóth^{None}**Corresponding Author:** tothk0711@gmail.com

The uncertainty principle can be interpreted via different approaches to QM. In this presentation consequences for the general uncertainty principle are shown in an approach avoiding the use of complex numbers. These are strange to students who are familiar with the position-momentum relation. If we deal with real vector spaces, like most of the two-state-approaches do in secondary schools, there is no sense to talk about any uncertainty inequality, even if the two quantities do not have common eigenstates. This presentation provides a form of the uncertainty principle valid in two-state problems, too, and also presents misconceptions and didactic proposals.

How would you like to present your contribution?:

Live in Ljubljana (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 Physics and Modern Physics / 46**Particle Physics Concepts in High-School Physics Education****Author:** Anja Kranjc Horvat¹**Co-authors:** Jeff Wiener¹; Sascha Schmeling¹; Andreas Borowski²¹ CERN² University of Potsdam**Corresponding Author:** anja.horvat@cern.ch

Elementary particle physics is entering high-school education. However, many argue that particle physics is often introduced in a reductionistic and informative way. This study analyses how particle physics content in high-school physics curricula compares to experts' expectations. The expectations of 13 experts were elicited through an expert concept mapping study on what high-school students should learn about particle physics. The resulting expert concept map was compared to the outcome of a curricular review of particle physics content in 27 countries worldwide. The comparison shows that the curricula cover significantly fewer concepts than experts expect students to learn about particle physics.

How would you like to present your contribution?:

Live in Ljubljana (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 Physics and Modern Physics / 160**(V) Introducing General Relativity in High Schools: a Teaching-Learning Module****Authors:** Adele Naddeo^{None}; Marco Di Mauro¹¹ *Physical Science Communication Laboratory, Department of Physics, University of Trento***Corresponding Author:** adele.naddeo@na.infn.it

A novel teaching-learning module is here presented, aimed at introducing basic concepts of general relativity to students attending the last year of scientific high schools. Emphasis is on conceptual rather than technical aspects, and only familiarity with simple calculus is required. Part of the module is devoted to the discussion and the reproduction (or simulation), of key real or gedanken experiments, such as the Eötvös experiment and the Einstein elevator. The starting point is a critical overview of the principles of Newtonian mechanics and gravity, in particular the role of fictitious forces, as well as the limits of special relativity.

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):

Pre-service teacher education

Contemporary Physics and Modern Physics / 141**Elementarizing quantum algorithms: clarification of the internal structure and preliminary learning outcomes****Author:** Giacomo Zuccarini^{None}**Co-authors:** Chiara Macchiavello ; Claudio Sutrin¹; Massimiliano Malgieri¹¹ *University of Pavia***Corresponding Author:** giacomo.zuccarini@unipv.it

We describe a tentative elementarization scheme for the information processing phase of quantum algorithms and report on a preliminary evaluation of its effectivity on Italian self-selected secondary school students in distance learning. While the test was conducted on a small sample in very special conditions, this work of clarification promoted a consistent understanding of the algorithmic structure in informational terms and, at least partially, in physical ones.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Contemporary Physics and Modern Physics / 119**Exploring students' views about basic concepts in introductory quantum mechanics through factor and cluster analysis****Authors:** Giovanni Giuliana^{None}; Irene Marzoli¹; Italo Testa²; Umberto Scotti di Uccio³¹ *Università di Camerino*² *University Federico II Naples*³ *Università Federico II***Corresponding Author:** giogiuli@unina.it

Literature in physics education shows that students still experience difficulties learning quantum mechanics, although it is part of the high school curriculum and many research-based proposals are available. Prior works mostly focused on specific misconceptions and a clearer picture of students' ideas on general quantum concepts is still lacking. We addressed these issues by inspecting, through factor and cluster analysis, the responses given by 408 Italian K-12 students to a Likert scale questionnaire on quantum physics. Our preliminary results show that when standard teaching is suitably supported by extracurricular activities, students may achieve a fully quantum view.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Contemporary Physics and Modern Physics / 136**Agent-based perspectives on epidemiological models: analysis of interviews with upper high-school students**

Authors: Eleonora Barelli¹; Olivia Levrini¹

¹ *Department of Physics and Astronomy “Augusto Righi”, Alma Mater Studiorum – University of Bologna*

Corresponding Author: eleonora.barelli2@unibo.it

One of the most popular models for the spread of diseases is constituted by a system of differential equations describing the evolution of susceptible, infectious, and recovered populations over time. However, agent-based epidemiological models can also be formulated based on interaction models from physics of complex systems. In this contribution, we discuss how upper high-school students, interviewed at the end of a teaching-learning module on computational simulations, develop their agent-based models for the spread of the virus, and how they construct analogies with agent-based models of complex systems previously encountered.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**CUR Workshop / 104****Exoplanets: Classroom Experimentation with Arduino**

Author: Dorottya Schneider^{None}

Co-author: Mihály Hömöstre¹

¹ *ELTE University, Faculty of Science*

Corresponding Authors: schniderdorottya@gmail.com, hmisko83@hotmail.com

Abstract. We offer a workshop for teachers to provide examples of designing Arduino-based students' experimentation for regular physics classes. Participants will engage in an enjoyable experiment: modeling the transit method of exoplanet research. The process of educational development and the changing curricula require the use of new ideas in addition to traditional methods. Our competence-based methodology – classroom experimentation with the application of Arduino in

the topic of exoplanets – gives the opportunity for students to participate actively in the lessons, use digital devices and develop specific competencies.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

GIREP / 198

Medal ceremony

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Closing ceremony

Informal and Non-Formal Learning / 133

(V) “Astronomy for Sailors” A Web Game to Learn Physics Using a Clock and the Sun

Authors: Chiara Righi^{None}; Francesco Chirico^{None}; Gaia Verna^{None}; Simone Iovenitti^{None}; Elena Santopinto^{None}; Riccardo Sgarro^{None}; Silvano Tosi^{None}; Stefano Orsenigo^{None}

Corresponding Author: simone.iovenitti@inaf.it

If you were on a sailing boat, far from the coast, could you tell your position on Earth using just a clock and the Sun? This is the challenge for hundreds of students at our interactive astronomy workshop in the context of the “Genova Science Festival” (Italy, 2021). Visitors played on a web application that we developed from scratch, with the help of trained scientific animators. However, that was not just a matter of applying formulas: they must estimate errors, make considerations, find approximations, and... do not suffer from seasickness! The best way to learn physics is to use it.

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):

Primary school education

Target education level (secondary, optional):

Lower-secondary education

Informal and Non-Formal Learning / 142**Astronomy and telescope courses as after school activities****Authors:** Filip Hložek^{None}; Jitka Houfková^{None}**Corresponding Author:** fil.hlozek@gmail.com

In this contribution the research of astronomical courses in the Czech Republic is presented. It has been focused on the activities organized by the observatories and lecturers of the courses. Inspired by these we developed other activities and manuals that can be used by teachers or other people interested in astronomy.

How would you like to present your contribution?:

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

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Primary school education

Informal and Non-Formal Learning / 40**Development of a RIASEC-based model to analyse students' perceptions of the work of nuclear- and astrophysicists****Author:** Moritz Kriegel¹**Co-author:** Verena Spatz¹¹ *Technical University of Darmstadt***Corresponding Author:** moritz.kriegel@physik.tu-darmstadt.de

There are stereotypical beliefs about the work of scientists among students. These can lead to a lack of interest and ill-considered occupational choices. We aim at developing a model to represent a comprehensive overview of the work of physicists, based on the RIASEC+N-model of vocational interest types [1]. We focus on the work of researchers in a Collaborative Research Centre in the field of nuclear-/ astrophysics. We have conducted an interview- and a questionnaire study to identify occupational activity profiles among them. This will be used to design an outreach program to give students an authentic insight in modern physics.

How would you like to present your contribution?:

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

Target education level (primary):

Outreach

Target education level (secondary, optional):

Higher-secondary education

Informal and Non-Formal Learning / 183**(Cancelled) Paving the way for fostering scientific civic literacy: an Italian national study on how primary school children perceive scientists****Authors:** Giacomo Bozzo^{None}; Peppino Sapia^{None}

Fostering the public understanding of science and technology is widely recognized as a crucial issue in order to develop appropriate skills for 21st century citizenship. The development of policies aimed to this needs a clear picture of how the public feels about science and technology and the people making them (i.e., scientists and engineers). The perception acquired during childhood, conditions the future attitudes towards science and scientists, and the educational choices of future adult citizens.

In this context, we present the design and some preliminary results of an Italian national survey on the perception of scientists by primary school pupils.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Outreach

Lab work and Experiments / 29**(V) How pupils proceed in creating their first graph of experimental data - preliminary results****Author:** Karolína Šromeková^{None}**Co-author:** Viera Haverlikova¹¹ *Comenius University in Bratislava, Faculty of mathematics, Physics and Informatics***Corresponding Author:** karolina.sromekova@fmph.uniba.sk

Several studies point to pupils and students having problems working with graphs. However, only a few studies address this at the level of 11-12 year olds. It is during this period that pupils begin to attend Physics classes, where they construct their knowledge and skills including data collection and processing. The focus of this study is how students proceed when creating graphs and which of their competencies need to be improved. The grounded theory approach is used in this work. The paper presents the first results obtained by analyzing students' solutions and individual interviews with students.

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):

Primary school education

Lab work and Experiments / 117**Development of digital experimental tasks for distance learning****Author:** Bruno Tomrlin¹**Co-authors:** Simon Z. Lahme²; Pekka Pirinen³; Ana Susac¹; Antti Lehtinen³; Pascal Klein²¹ *University of Zagreb, Croatia*² *University of Göttingen, Germany*³ *University of Jyväskylä, Finland***Corresponding Author:** simon.lahme@uni-goettingen.de

Development of tasks suited for both in-person and distance learning for university students is needed since the sudden COVID-19 pandemic. We have prepared several experimental tasks for university students which are focused on experimental skills and the use of digital technologies to prepare students and instructors for remote assignments. Each task was designed following the framework we developed. Some tasks can be used in high school to help students develop experimental skills. We have tested the developed experimental tasks with first year students and used interviews and questionnaires for evaluation.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Pre-service teacher education

Lab work and Experiments / 37**Do various groups involved in physics education appreciate the same aspects of physics demonstrations? – Ongoing research****Author:** Alexandr Nikitin¹**Co-authors:** Dana Mandíková ; Isabella Pavelková ; Marie Snětinová ; Martin Chvál ; Petr Kácovský¹ *Department of Physics Education, Charles University***Corresponding Author:** alex.nikitin@seznam.cz

This contribution presents the research design of an ongoing study of parameters influencing perception of physics demonstrations by different communities of people involved in the upper secondary school (SS) education. Its aim is to determine such parameters in various groups of people (SS teachers, SS students, pre-service physics teachers, pre-service physics teacher trainers) and to compare these parameters between different groups. The research design comprises of a video-study using high-inference rating scales. Item response theory (IRT) will be employed to analyse the data.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Lab work and Experiments / 58**

Creating Consistency Across Online and In-Person Labs Using the Investigative Science Learning Environment

Author: Chris Moore¹

¹ *University of Nebraska Omaha*

Corresponding Author: jcmoore@unomaha.edu

We have used the Investigative Science Learning Environment (ISLE) as a framework for reforming the introductory physics laboratory sequence at a university in the Midwest USA. Lab experiences have been reformed to focus on science abilities and experiment design, in contrast to “cook-book” content-verification labs. Furthermore, labs were designed to use accessible sensors (ioLab sensor carts) and everyday items to create consistency across our online and in-person lab sections. We report on a multiple-group quasi-experiment comparing groups completing traditional labs and the reformed labs. Student views and scores on the Physics Lab Inventory of Critical thinking (PLIC) will be compared.

How would you like to present your contribution?:

Live in Ljubljana (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 / 113

Evaluation of the effectiveness of an introductory mechanics Lab with Arduino and smartphone

Authors: Eugenio Tufino¹; Giovanni Organtini²

¹ *University of Trento, Physics department*

² *Sapienza Università e INFN, Roma I (IT)*

Corresponding Author: eugenio.tufino@unitn.it

This communication describes the design and implementation of a mechanics laboratory at Sapienza Università di Roma. Due to the pandemic, most of the practicals in 2021 were held remotely. The lectures were held by a single lecturer, while for the lab part the students were divided into two

sections, in one of which digital techniques were introduced, allowing them to carry out experiments from home in an active and collaborative approach. To assess the impact of the new format, the E-CLASS survey, translated into Italian, was proposed in both sections (before/after the course), the results of which are presented.

How would you like to present your contribution?:

Live in Ljubljana (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 / 17

Towards inquiry: Redesign of a first year physics lab course

Author: Freek Pols^{None}

Corresponding Author: c.f.j.pols@tudelft.nl

Recently, calls for a shift in focus for physics lab courses have been made. It is recommended for introductory lab courses to aim at teaching students how to plan, conduct and evaluate a rigorous experimental physics inquiry. However, transforming lab courses is a difficult task. I elaborate on the road I have been walking the past three years in redesigning our first year physics lab course. The theoretical framework on which the design is based is elaborated, and subsequently show how the ideas are operationalized in a lab course for ~ 250 students.

How would you like to present your contribution?:

Target education level (primary):

University education

Target education level (secondary, optional):

Lab work and Experiments / 93

Project for physics teaching, making elementary particles visible and study their properties

Authors: Erik H M Heijne¹; Daniel Parcerisas Brossa^{None}

¹ CERN & IEAP-CTU

Corresponding Author: d.parcerisas@safagava.edu

This project's aim is to make elementary particles visible in order for students to study their properties within the classroom.

Over the last 15 years, efforts have been made to use the Minipix for educational purposes and by so doing, it is now possible to view and easily distinguish several types of these elementary radiation quanta, on the screen of a laptop.

Now is a good time for the proposal of a European-wide use of the Minipix-Edu, since the Medipix

team at CERN could provide a considerable number of Minipix educational kits to interested entities at no charge for the users.

How would you like to present your contribution?:

Live in Ljubljana (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 / 9

Experiments in Electricity and Magnetism for Future Teachers: From Lectures to Teaching Labs

Author: Leoš Dvořák^{None}

Co-authors: Irena Dvořáková¹; Věra Koudelková¹; Stanislav Gottwald¹

¹ Charles University, Faculty of Mathematics and Physics

Corresponding Author: vera.koudelkova@mff.cuni.cz

The paper will report on an improved approach to pre-service physics teacher training in electricity and magnetism at our faculty. It starts with an experiment-based lecture in the first year, complemented by an optional seminar that emphasizes experiments students will be able to use in their future teaching. Three years later, it culminates in teaching labs dedicated to this field. Motivation for changing the previous traditional teaching of this topic, important features of the state of the art, and lessons learned will be presented, illustrated by examples of experiments that have proved useful and attractive to students.

How would you like to present your contribution?:

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

LAB Workshop / 153

Particle camera based on the pixel detector Timepix serving as a powerful tool in making physics more attractive to the young generation via possibility of personal hands-on experience in micro-cosmos experiments

Authors: Michael Holik¹; Stanislav Pospisil²; Vladimír Vichá³

¹ IEAP CTU in Prague; FEE UWB in Pilsen (CZ)

² Czech Technical University in Prague (CZ)

³ *IEAP CTU in Prague (CZ)*

Corresponding Authors: michael.holik.cz@gmail.com, vladimir.vicha@utef.cvut.cz

The particle camera based on the pixel detector Timepix in the form of the educational kit represents a progressive tool in physics teaching. It greatly profits from a combination of advanced detection technology, real-time data analysis and result visualisation. A high level of interactivity in performing of micro-cosmos experiments brings deep engagement of students while resulting in their motivation and future interest in science study. The workshop contribution is conceived in the form of a live demonstration. Several exemplar experiments will be performed in order to present the performance of the particle camera and its numerous benefits.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

LAB Workshop / 94

Making elementary particles visible and study their properties

Author: Stanislav Pospisil¹

Co-authors: Michael Holik²; Vladimir Vicha³

¹ *IEAP-CTU in Prague*

² *IEAP CTU in Prague, FEE UWB in Pilsen*

³ *IEAP CTU in Prague (CZ)*

Corresponding Authors: stanislav.pospisil@utef.cvut.cz, michael.holik.cz@gmail.com, vladimir.vicha@utef.cvut.cz

Demonstration session with Minipix instruments in operation

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Physics Curriculum Materials / 21

(V) Conceptual understanding of microscopic models in thermodynamics

Author: Nataša Erceg^{None}

Corresponding Author: nerceg@phy.uniri.hr

Misconceptions about molecular systems in interaction reveal difficulties in understanding macroscopic phenomena at the microscopic level. It is recommended that the existing misconceptions be addressed along with the comparative construction of correct thermodynamic models to make teaching more effective. Following the above, the conceptual understanding of molecular kinetic theory (MKT) of solids is investigated, as a continuation of the previously conducted research on the understanding of MKT gases and liquids. The main results are presented.

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):

Physics Curriculum Materials / 55

Methodological Suggestions for Creating Subquestions for the Force Concept Inventory (and Other Research-based Assessments)

Author: Michael M Hull¹

Co-authors: Jun-ichiro Yasuda ²; Naohiro Mae ³

¹ *University of Vienna, Austrian Educational Competence Centre, Division of Physics*

² *Yamagata University, Institute of Arts and Sciences*

³ *Osaka University, Research Center for Nuclear Physics,*

Corresponding Author: michael.malvern.hull@univie.ac.at

The Force Concept Inventory (FCI) is a research-based assessment that is used internationally to assess student understanding of Newtonian mechanics. The assessment has been investigated from a number of perspectives and many suggestions have been made for its improvement. One suggestion is the creation of subquestions. Subquestions are a tool to reduce false positives (answering a survey item correctly without correct understanding) and false negatives (answering incorrectly despite correct understanding). In this presentation, we will discuss how we created subquestions for two items on the FCI, informed by survey-based interviews with students and the original intended targets of the items.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Physics Curriculum Materials / 16**An introduction to the Assessment Rubric for Physics Inquiry****Authors:** Freek Pols^{None}; Peter Dekkers¹¹ *Delft University of Technology***Corresponding Author:** c.f.j.pols@tudelft.nl

Assessment and feedback are essential in learning to engage in physics inquiry. However, assessment regularly focusses only on the quality of the presentation of the results rather than the adequacy of the decisions made during the investigation and students' ability to justify these. To acknowledge both aspects of inquiry, we developed and validated the Assessment Rubrics for Physics Inquiry using so-called Understandings of Evidence: insights and views that an experimental researcher relies on in constructing and evaluating scientific evidence. In the presentation we elaborate on the construction, validation and implementation of the rubric.

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Physics Curriculum Materials / 180**Investigating university students' visual strategies when solving spectroscopy problems****Authors:** Lana Ivanjek^{None}; Jeremias Vahle¹; Stefan Küchemann²; Sergey Mukhametov²; Jochen Kuhn³; Marie-Annette Geyer¹¹ *TU Dresden*² *TU Kaiserslautern*³ *LMU München***Corresponding Author:** lana.ivanjek@tu-dresden.de

Previous studies have demonstrated that students have difficulties in connecting spectral lines in discrete spectra with the transition between energy levels. In this study, we investigate how this connection is influenced by different representation of discrete spectra and how novices and experts differ in their problem-solving strategies. Therefore eye movements of university students were measured while they were answering questions containing representations of discrete spectra before and after one hour tutorial on discrete spectra. In this talk, preliminary findings will be presented.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Pre-service teacher education

Physics Curriculum Materials / 20**Effect of context on students' understanding of basic vector concepts****Authors:** Damjan Klemencic¹; Maja Planinic¹; Zeljka Milin Sipus²; Filip Tusek¹; Andreja Bubic³; Marijan Palmovic⁴¹ *Department of Physics, Faculty of Science, University of Zagreb*² *Department of Mathematics, Faculty of Science, University of Zagreb*³ *Chair for Psychology, Faculty of Humanities and Social Sciences, University of Split*⁴ *Laboratory for Psycholinguistic Research, Department of Speech and Language Pathology, University of Zagreb***Corresponding Author:** ana.susac@fer.hr

We used isomorphic mathematics and physics items in paper-and-pencil and eye-tracking testing to investigate the effect of context on students' understanding of vector concepts without the step of translation from physics to mathematics. We found no significant difference between overall scores on mathematics and physics items and the time that students spent attending physics and mathematics items. These findings suggest that the translation from physics to mathematics is the key step that introduces additional cognitive load and difficulty on physics problems.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Physics Curriculum Materials / 52****Productive epistemic games in an Investigative Science Learning Environment****Authors:** Christopher Robin Samuelsson¹; Bor Gregorcic¹; Maja Elmgren¹; Jesper Haglund²¹ *Uppsala University, Sweden*² *Karlstad University, Sweden***Corresponding Author:** robin.samuelsson@physics.uu.se

We have studied what epistemic games students employ to formulate observations, hypotheses and design experiments within an investigative learning environment. The students participated in an activity based on ISLE (Investigative Science Learning Environment) focused on the melting of ice when some table salt is added to it. Two pairs of students were compared: a pair of engineering students and a pair of physics teacher students. Finally, two types of epistemic games were identified that made the physics teacher students more successful in their engagement with the activity than the engineering students.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Pre-service teacher education

Physics Curriculum Materials / 82**Diagnosing the source of students' difficulties within the Physics-Mathematics interplay context**

Author: Hadas Levi¹

Co-authors: Avraham Merzel²; Yaron Lehavi³; Baruch Schwarz²

¹ *the Hebrew University of Jerusalem, Lev Academic Center*

² *The Hebrew University of Jerusalem*

³ *The David Yellin Academic College of Education*

Corresponding Author: hnlevi@gmail.com

The interrelationships between mathematics and physics in the context of teaching and learning physics are attributed in the literature to a distinct domain, hereinafter referred to as “PhySmatics”, that encompasses unique skills and modes of thinking. Students exhibit difficulties with respect to this domain which are seldom get attention in the literature. Based on antecedent categorization of students' phymatic difficulties we present a diagnostic questionnaire that aims at identifying the cognitive source for these difficulties. We describe four possible cognitive sources based on their paired responses to questions with and without physics context.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Physics Curriculum Materials / 89****Design and validation of a two-tier questionnaire on basic astronomical phenomena**

Author: Silvia Galano^{None}

Corresponding Author: silvia.galano@posta.istruzione.it

Abstract. In this study we developed a new two-tier questionnaire to investigate students' understanding of astronomical phenomena (change of seasons, Moon phases and eclipses). We submitted this questionnaire to a pilot sample of 152 students of the first year of secondary school in order to validate the instrument. We present results from this pilot submission.

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

Physics Curriculum Materials / 71**Addressing complexity in primary school through basic physics observations and metaphorical narrative**

Author: Leonardo Colletti¹

Co-authors: Federico Corni ¹; Paolo Lugli ¹; Soufiane Krik ¹

¹ *Free University of Bozen-Bolzano*

Corresponding Author: lcolletti@unibz.it

Physics deals with complexity by reducing it to a limited number of universal principles. Since we live in a world characterised by an increasing complexity in all fields, an indispensable educational challenge arises for basic science education. Here we describe the outcomes of the first stage of a two-year project on complexity we have been developing for schools. It exploits the use of primary metaphors already available in the language of children and applied to the description of the characteristics of a circuit, whether it be the movement of marbles inside a tube or the flowing of electric current.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):**Physics Curriculum Materials / 171****Determination of a car speed – analysis of projectile motion from a muddy puddle**

Author: Aleš Mohorič^{None}

Corresponding Author: ales.mohoric@fmf.uni-lj.si

Students were given a task to determine the speed of a car from a muddy pattern on the car door. Students were able to give two explanations for the pattern formation. Using different representations of the data they were able to decide in favour of one of the explanations.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Physics Curriculum Materials / 110****Design of context-based teaching resources for simple electric circuits****Author:** Benedikt Gottschlich¹**Co-authors:** Jan-Philipp Burde²; Thomas Wilhelm³; Liza Dopatka⁴; Verena Spatz⁵; Thomas Schubatzky; Claudia Haagen-Schützenhöfer⁶; Lana Ivanjek; Martin Richard Hopf¹ *Physics Education Research Group, University of Tübingen*² *University of Tuebingen*³ *Goethe-Universität Frankfurt am Main*⁴ *TU Darmstadt*⁵ *Technical University of Darmstadt*⁶ *University of Graz***Corresponding Author:** benedikt.gottschlich@uni-tuebingen.de

Despite the enormous importance of electricity for today's industrial societies, teaching of simple circuits is often perceived by learners as abstract and unappealing. In addition, learning objectives are often not achieved. Therefore, a context-based teaching concept for simple electric circuits has been developed. Considering results from studies investigating the interests of students, the concept explicitly includes contexts which are appealing to both girls and boys. Currently, the concept is empirically evaluated as part of a field study in order to investigate the effects of context-based teaching on students' conceptual understanding, interest, and physics-related self-concept.

How would you like to present your contribution?:

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

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):**Physics Curriculum Materials / 72****DBR based Redesign cycle of a TLS on Dynamics for High School****Authors:** Leire Olazabal¹; Garazi Leturiondo-Uriona¹; Paulo Sarriugarte¹; Peio Garcia-Goiricelaya¹; Kristina Zuza¹¹) *Donostia Physics Education Research Group (DoPER), Department of Applied Physics, University of the Basque Country (UPV-EHU), Spain***Corresponding Author:** kristina.zuza@ehu.eus

Abstract.

The redesign process of the TLSs (Teaching Learning Sequence) is needed in DBR (Design Based Research) methodology as the last step of every cycle we implement the sequence. In this work, we implement and analyse the results obtained for a TLS on dynamics for high school (16-17) in two different schools in the Basque Country in 2020-2021. The obtained data seems to show that although experimental groups performed better control groups, there is room to improve the TLS.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Physics Teacher Education / 164

Examining the relationship between teacher self-efficacy and teaching out-of-field in physics

Authors: Kyla Smith¹; Judith Hillier¹; Sibel Erduran¹

¹ *University of Oxford*

Corresponding Author: kyla.smith@education.ox.ac.uk

Out-of-field teaching has been shown to negatively impact teachers' wellbeing and retention in the profession. This paper investigates the teacher self-efficacy of physics teachers alongside the extent to which they feel they are out-of-field. A theoretical framework of social cognitive theory places teachers' capabilities, agency, and ability to develop at the centre of the study. Data was collected via an online questionnaire from teachers of secondary-level physics across the four western provinces of Canada. The extent to which teachers felt out-of-field in physics and their teacher self-efficacy with instructional strategies when teaching physics were moderately negatively correlated ($r(69) = -.457, p < .001$).

How would you like to present your contribution?:

Live in Ljubljana (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 / 98

Measurement uncertainty: a lever for the professional development of out-of-field physics teachers

Authors: David Perl Nussbaum^{None}; Ofek Sivan¹; Zehorit Kapach^{None}; Zeev Krakover^{None}

Co-author: Edit Yerushalmi²

¹ *Weizmann Institute of Science*

² *Weizmann institute*

Corresponding Author: davidper@weizmann.ac.il

This study examines the negotiation of epistemological approaches between out-of-field teachers (with training in biology) and in-field physics teachers as they engage in an argumentative activity on measurement uncertainty. The activity was designed along the lines of the Knowledge Integration theory so that the biology teachers' disciplinary knowledge can serve them in constructing knowledge in physics. We report on a case study that reveals the different epistemologies of the teachers and highlight the opportunity that argumentative activities, designed to bring forward participants' disciplinary backgrounds, hold for the professional development of out-of-field as well as in-field physics teachers.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 62

Concept of Force Representations of Prospective Primary Teachers

Authors: Alberto Stefanel¹; Marisa Michelini¹

¹ *University of Udine*

Corresponding Author: alberto.stefanel@uniud.it

The representation of physical concepts is essential to support teaching and to activate learning in primary school. Investigating how future teachers represent the physical concepts has great importance. A research was carried out on concepts of force representations of 274 prospective teachers, enrolled in the Primary Education Sciences degrees. Rubrics were designed and used to analyze different dimensions involved in drawing, descriptions, didactic and disciplinary motivations. It emerged that most of the representations do not include the representation of the involved forces, but rather implies a precise didactic approach to the force concept.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Pre-service teacher education

Physics Teacher Education / 42**Creation of an evaluation rubric for the assessment of written preparation for teaching physics****Author:** Barbora Gejdošová^{None}**Co-author:** Klára Velmovská**Corresponding Author:** barbora.krajmerova@gmail.com

In this paper, we present a proposal for an evaluation rubric for the evaluation of preparations for physics lessons. We describe the method of creating an evaluation rubric and its subsequent use in practice. A well-conducted lesson by the teacher supposes quality preparation for the lesson. Therefore, we believe that it is important that teacher students are able to develop thoughtful preparation also in written form. We plan to improve it by providing feedback based on the evaluation tool we propose.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):**Physics Teacher Education / 54****Design and implementation of a STEAM Teaching/Learning Sequence by Project-Based Learning for the training of future secondary school teachers****Author:** Ane Portillo-Blanco¹**Co-authors:** Paulo Sarriugarte¹; Kristina Zuza¹; Jenaro Guisasola¹¹ UPV/EHU**Corresponding Author:** ane.portillo@ehu.eus

In high school teacher education, although work on didactic units for teaching the curriculum of science disciplines is common, they rarely include multidisciplinary STEAM viewpoint. In this project, we show the design and implementation of a teaching/learning sequence (TLS) to show STEAM projects in High School with a project-based learning approach, with students of the Master's Degree in Secondary Science Teacher Training. The TLS designed integrates content and skills from various STEAM disciplines, with physics and biology being the main ones and adding the PBL character through the search for the best way to protect oneself from the sun.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Physics Teacher Education / 92**How do teachers interpret and respond to students' explanations?****Author:** Danijela Kuvezdic¹**Co-authors:** Eugenia Etkina²; Gorazd Planinsic³¹ *Josip Juraj Strossmayer University of Osijek, Department of Physics*² *Rutgers University, New Brunswick, New Jersey, USA*³ *Faculty of Mathematics and Physics, University of Ljubljana***Corresponding Author:** dkuvezdic@fizika.unios.hr

We present the findings of the study of teachers' ability to interpret student explanations and respond to them productively. We use the framework of the content knowledge for teaching energy (CKT-E), specifically its component common for all physics topics – the Tasks of Teaching to analyse teachers' responses to a survey that asks them to comment on student answers and explanations for a non-traditional problem involving momentum and energy. The survey contained the text of the problem and student written explanations of their answer and asks the teacher to comment on student's strengths/weaknesses, and to provide response to the student.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 36**Improving the effectiveness of Physics teaching****Author:** Valentina Bologna^{None}**Co-authors:** Francesco Longo ; Francesca Antoci ; Simon Peter Leban ; Maria Peressi ; Paolo Sorzio**Corresponding Author:** valentina.bologna@phd.units.it

Physics teachers need to understand subject matter knowledge tailored specifically to teaching. It can be reached by extending the teachers' background with in-service training activities and professional development. We report the results of a recent experience involving some Physics teachers engaged in a profound revision of their Pedagogical Content Knowledge (PCK). This allowed investigating the standard features in their instructional practices to identify their specialised Content Knowledge for Teaching (CKT). Two representative stories are reported here, selecting a younger and a more expert teacher. They revised their specific way of Physics teaching, encouraging the students' development of argumentation skills.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 100**Students' Critical Thinking skills in relation to climate change****Authors:** Lana Ivanjek^{None}; Magdalena Micoloi^{None}**Corresponding Author:** magdalena.micoloi@tu-dresden.de

It is widely known by now that Critical Thinking (CT) is a skill that students should obtain during their education. Especially in the climate change debate young people need to distinguish between facts and 'fake news' because the effects of climate change concern them in particular. CT skills are measured in general-domain but also assessed for topics in the physics context, hence for domain-specific. In order to connect the two topics, CT and climate change, semi-structured interviews were conducted to assess students' reasoning patterns and CT skills in relation to climate change.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 76**Quantum Technology PCK for Teachers****Authors:** Erica Andreotti¹; Lise Verbraeken¹**Co-authors:** Renaat Frans¹; Maria Bondani²; Bart Folkers³; Leon JURČIĆ⁴; Massimiliano Malgieri⁵; Filippo Pallotta⁶; Henk Pol⁷¹ *University Colleges Leuven-Limburg*² *CNR - Institute for Photonics and Nanotechnologies*³ *University of Twente*⁴ *University of Ljubljana*⁵ *University of Pavia*⁶ *University of Insubria*⁷ *University of Twente***Corresponding Authors:** erica.andreotti@ucll.be, lise.verbraeken@ucll.be

For many years quantum physics has been introduced in European secondary schools. However, quantum physics, and even more quantum technology, is not sufficiently part of present physics teachers' Pedagogical Content Knowledge (PCK). For this reason, the QTedu pilot project 'Quantum Technology PCK for teachers' wants to put together the expertise of several educational researchers in order to i) pre-research the Pedagogical Content Knowledge (PCK) teachers need to

teach Quantum Technology (QT) and ii) Synoptic PCK Map of practical use for teachers and teacher educators.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 43

Collaborative Reflection on the Integration of "Deliberation Labs" into Teachers' Practice – Large-Scale PD Perspective

Authors: Adi Noga¹; Smadar Levy¹; Edit Yerushalmi¹; Zehorit Kapach¹

¹ *Weizmann Institute of Science*

Corresponding Authors: adinoga12@gmail.com, smadarlevy@gmail.com

The "Flag Person Framework", structuring collaborative reflection on practice, was introduced in a national network of Professional Learning Communities (PLCs) to support physics teachers implementing "Deliberation Labs" to increase students' agency in the lab. We examined how PLC leaders perceived, as teachers and as leaders, the affordances and limitations of the "Flag Person" framework. The analysis showed that the framework allowed them to redefine lab goals and collaboratively examine ways to reorient instruction to achieve them. While the "Flag Person" framework was useful in fostering change, it placed a high workload on the PLC participants and leaders.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 112

Supporting Teaching Assistants in a Community of Practice

Author: Vira Bondar¹

Co-authors: Jonas Nuber²; Manuel Zeyen¹; Guillaume Schiltz¹; Klaus Kirch³; Günther Dissertori¹

¹ *ETH Zurich, Department of Physics, Switzerland*

² *Paul Scherrer Institute (PSI), Switzerland*

³ *ETH Zurich, Department of Physics, Switzerland / Paul Scherrer Institute (PSI), Switzerland*

Corresponding Author: bondarv@phys.ethz.ch

We are presenting a framework that supports teaching assistants in their teaching duties during exercise classes and that fosters their professional teaching development. The framework relies on the concept of Communities of Practice and combines pedagogy together with strategies and support for social interaction. We are discussing the challenges of this novel approach and its positive effects on teaching and learning.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

In-service teacher education

Physics Teacher Education / 135

Science students' experience of spatial scales: A phenomenographic pilot study

Authors: Elias Euler¹; Jenny Sullivan Hellgren²; Urban Eriksson¹

¹ *Lund University*

² *Umeå University*

Corresponding Author: elias.euler@fysik.lu.se

We report on the initial findings of a pilot study from a larger project investigating the teaching and learning of spatial/temporal scales in science. Pre-service science teachers from physics and biology were interviewed over Zoom while completing a ranking task for objects ranging from a proton to animal cells to the Universe. A phenomenographic analysis was carried out to determine the qualitatively different ways in which science students experience spatial scales.

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):

Pre-service teacher education

Physics Teacher Education / 102**Teaching Physics through Astronomy: an object-based approach****Author:** Alessio Mattia Leonardi¹**Co-authors:** Marta Carli ¹; Stefano Ciroi ¹; Fanny Marcon ¹; Ornella Pantano ²; Sofia Talas ¹; Monica Zagallo ¹¹ *Department of Physics and Astronomy, University of Padua, Italy*² *Department of Physics and Astronomy, University of Padova, Italy***Corresponding Author:** alessiomattia.leonardi@unipd.it

Astronomy is disappearing from Italian high-schools. The latest reform of the school removed its teaching from the upper secondary curriculum but, nevertheless, fundamental contents about Astronomy are required by the Italian National Standards. ATENA, a training course for in-service high-school teachers aims to investigate the possibility of introducing Physics concepts by the means of Astronomy. We present the results of the two activities that introduce the course, constructed according to an object-based learning approach, involving two different astronomical instruments. The aim is to explore the ways in which this approach can favor the integrated learning of Astronomy and Physics.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 126**Exploring the experiences of undergraduate physics students on a 'Teaching Physics in School' module and the effects on their intentions to become physics teachers****Author:** Daniel Cottle¹¹ *University of Birmingham***Corresponding Author:** dan@greencushion.co.uk

Physics undergraduates undertaking a 'teaching in schools' module describe how their skills, perceptions of physics teaching and intentions to train as a teacher are affected by their school experiences.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

University education

Physics Teacher Education / 18**Utilizing physics teachers' epistemological and pedagogical conceptions on thermodynamics to develop training programs****Authors:** Kalliopi Meli¹; Dimitrios Koliopoulos¹; Konstantinos Lavidas¹¹ *University of Patras***Corresponding Author:** kmeli@upatras.gr

In this research, we used a traditional theoretical framework for physics teachers' training as a starting point to develop a new research instrument (online questionnaire) for exploring teachers' conceptions on the epistemology and pedagogy of thermodynamics. Our goal was to validate the original framework to make informed decisions on the design of future training programs based on teachers' ideas. Our analysis ($N=42$ in-service Greek physics teachers) indicated four factors that suggested restructuring the given theoretical framework. As a future step, we aim to address larger populations and adapt additional physics fields to generalize our results.

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Physics Teacher Education / 120**Co-designing rich tasks in physics as a model of deepening teacher professional learning****Authors:** Eilish McLoughlin^{None}; Tandeep Kaur¹; Paul Grimes¹¹ *Dublin City University***Corresponding Author:** eilish.mcloughlin@dcu.ie

Teacher collaboration has been promoted as essential to supporting teachers' learning and motivation. A key feature of models of teacher collaboration is that they support teachers in changing their classroom practices with the aim of enhancing student learning. This study reports on the design and implementation of a novel approach to teacher collaboration - the SAMRII model (Solve, Anticipate, Modify, Reflect, Implement, Inquire) - a systematic approach supporting teachers to co-design rich tasks in Physics. Findings from the initial implementation suggest that this model can support teachers in designing classroom rich tasks for enhancing student learning in physics.

How would you like to present your contribution?:

Live in Ljubljana (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

Physics Teacher Education / 39

Evaluation of a university seminar on the use of digital media in the physics classroom

Author: David Weiler¹

Co-authors: Jan-Philipp Burde ²; Rike Große-Heilmann ³; Andreas Lachner ⁴; Josef Riese ³; Thomas Schubatzky

¹ *University of Tübingen - Physics Education Research Group*

² *University of Tuebingen*

³ *RWTH Aachen*

⁴ *University of Tuebingen - School Education*

Corresponding Author: david-christoph.weiler@uni-tuebingen.de

Fostering “digital competences” is an important aspect of university education for pre-service physics teachers. Therefore, a research-based seminar on the effective use of digital media in physics teaching was developed, implemented and evaluated. Our analyses indicate that the seminar leads to an increase in motivation to use digital media in physics lessons. The findings are the basis for re-designing the original seminar using the design-based research approach. For example, the topic of modelling software in physics teaching is included in the new seminar concept.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Physics Teacher Education / 88

Developing a blended programme of professional development during the Covid lockdowns

Author: Alessio Bernardelli¹

¹ *Institute of Physics*

Corresponding Author: alessio.bernardelli@iop.org

The Institute of Physics (IOP) has been leading rich programmes of professional development (PD) across school in UK and Ireland for over a decade. The need to support and develop non-specialist teachers of physics subject matter knowledge (SMK) and pedagogical subject knowledge (PCK) has been a focus of the IOP. During the lockdowns our style, means of delivery and content had to

quickly adapt to remote learning. This oral presentation aims to share the underpinning research, the process and the outcomes the IOP developed in this challenging period and environment

How would you like to present your contribution?:

Live in Ljubljana (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 / 130

Digital Competencies for Science Teaching: Adapting the DiKoLAN Framework to Teacher Education in Switzerland

Authors: Lars-Jochen Thoms¹; Christina Colberg²; Johannes Huwer¹

¹ *Thurgau University of Education, Switzerland / University of Konstanz, Germany*

² *Thurgau University of Education*

Corresponding Author: lars.thoms@uni-konstanz.de

Teacher training institutions are currently facing the great challenge of having to integrate the promotion of digital teaching competencies into established training programmes. To do this, it must first be possible to name the sub-competencies to be implemented. The aim of this research is the transfer and adaptation of the German DiKoLAN framework for the training programmes at the Thurgau University of Education. For this purpose, expert interviews were conducted. As a result, we present three new competence frameworks specific to the canton of Thurgau as well as the procedure, which can serve as a blueprint for similar projects.

How would you like to present your contribution?:

Live in Ljubljana (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

Plenary talk / 193

Topology with Liquid Crystals

Corresponding Author: igor.musevic@ijs.si

Plenary talk / 194

Conceptual Model of Physics Teacher Preparation: Developing Habits of Mind and Practice through Apprenticeship in a Community

Corresponding Author: eugenia.etkina@gse.rutgers.edu

Plenary talk / 192

What is difficult in learning physics and what we can do about it: The case of wave optics

Corresponding Author: maja@phy.hr

Plenary talk / 190

Inquiry to Learn

Corresponding Author: ufd Sokol@cyf-kr.edu.pl

Plenary talk / 191

Research on designing Teaching/Learning Sequences: Accomplishment and challenges

Poster session: CUR & INF & PTE / 15

Development of digital competencies of pre-service physics teachers (DiKoLeP)

Authors: Thomas Schubatzky^{None}; Jan-Philipp Burde¹; Rike Große-Heilmann²; Josef Riese²; David Weiler¹

¹ University of Tuebingen

² RWTH Aachen

Corresponding Author: thomas.schubatzky@uni-graz.at

The digital transformation of the education system is seen as a central challenge. Prospective physics teachers should therefore also develop “digital competences” during their studies. This requires learning opportunities that address the development of pedagogical content knowledge (PCK) and beliefs regarding digital media alike. In the project DiKoLeP, a university seminar concept is therefore being developed, implemented, and evaluated. The evaluation is carried out regarding the development of pre-service teachers’ digital media PCK. In addition, the development of digital media related beliefs will be investigated. The overall aim is to derive hypotheses for learning opportunities in university education.

How would you like to present your contribution?:

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 186

(V) Prospective Quebec Elementary Teachers' Conceptual Representations of the Light's and Matter's Colors

Author: Abdeljalil Métioui¹

¹ *Université du Québec à Montréal*

Corresponding Author: metioui.abdeljalil@uqam.ca

The present research focuses for the first time on the survey of the conceptual representations of 132 prospective Quebec elementary teachers regarding the phenomena of the formation of the colors of light and matter. For it, a paper and pencil questionnaire was constructed and managed. The data analyses show that most have conceptual difficulties in explaining light-matter interaction.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 123

(V) When Physics Meets Philosophy again: the “Gravitas” project

Authors: Matteo Tuveri^{None}; Walter Bonivento¹

Co-author: Viviana Fanti²

¹ *INFN Cagliari*

² *Dipartimento di Fisica Università di Cagliari e INFN Sezione di Cagliari.*

Corresponding Author: matteo.tuveri@ca.infn.it

The “Gravitas” project is a multidisciplinary outreach and educational program devoted to high school students (17-19 years old) that mixes contemporary physics and philosophy of science. Co-ordinated by the Cagliari Section of the National Institute of Nuclear Physics, in Italy, “Gravitas” offers an informal learning environment where students learn about contemporary physics, philosophy, and the history of science. They also create material such as posts to foster their learning. In 2022, 250 students from 16 Sardinian high schools attended the project. We present it and discuss its possible multidisciplinary outcomes and the implementation of informal learning strategies in high schools.

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):

University education

Poster session: CUR & INF & PTE / 107

(V) From the Colloquial to the Scientific Story: the use of Classroom Dialogue in the Development of Conceptual Understanding of Physics

Authors: Jan Van der Veen¹; Patrick Diepenbroek^{None}; Wouter Van Joolingen²

¹ *Eindhoven School of Education*

² *Freudenthal Institute for Science and Mathematics Education*

Corresponding Author: patrick.diepenbroek@istwente.org

The importance of drawing upon the daily-life views of students during colloquial classroom dialogue in physics education is widely recognised. Switching to the scientific jargon is important, but when and how to make this transition is not clear. Equally unclear is how many transitions are effective. A better understanding of what constitutes effective implementation of these transitions during classroom dialogue is achieved by means of collaborative designing lesson materials and implementing these in the classroom. This talk will present the outline for my study which will take place in the next four years.

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: CUR & INF & PTE / 44

(V) Educational Physics Talks, a space for collective learning and professionalization for teachers and researchers

Author: Mario Humberto Ramírez Díaz¹

Co-authors: Fabiola Escobar Moreno ¹; José Gilberto Castrejón Mendoza ¹

¹ *Instituto Politécnico Nacional*

Corresponding Author: mramirez@ipn.mx

The results of an investigation are presented, whose objective has been to describe dialogic learning between participants and researchers, in a discussion space called Educational Physics Talks (EPT), which revolves around the products of inquiry in the framework of Didactics of Physics. Likewise,

the research has tried to answer the question: what is the contribution of dialogic learning in the Educational Physics Talks? The conclusion is that the evidence shows that the EPT turn out to be an effective space for collective dialogic learning, around Educational Physics.

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):

Poster session: CUR & INF & PTE / 33

(V) The reasonable ineffectiveness of Physics in teaching: the example of Thomson's atomic model

Authors: Luisa Lovisetti¹; Marco Giliberti²

¹ *University of Milan, Department of Physics*

² *Università degli Studi di Milano*

Corresponding Author: luisa.lovisetti@unimi.it

Thomson's atomic model - as a name - is familiar to teachers and students. However, when asked about its structure, they usually only say that it is a "plum pudding" in which a positive charge is uniformly distributed and electrons are randomly arranged, not realising that it should rather be described by a precise mathematical model. The situation highlights how there is often a lack of critical mind in putting together previous knowledges in a coherent way. This proves a widespread ineffectiveness of physics education in creating the fundamental mental structures necessary to critically analyse what is taught and learned.

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):

Pre-service teacher education

Poster session: CUR & INF & PTE / 114

Identification of the Factors Influencing Game-Based Learning in a Game "The Tournament of J. C. Maxwell"

Authors: Ladislav Janiga^{None}; Viera Haverlikova¹

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

Corresponding Author: ladislav.janiga@fmph.uniba.sk

The paper presents educational game „The Tournament of J. C. Maxwell“ and results of pedagogical survey realised among 55 students. The goal of the survey was to identify factors influencing successful usage of games in education and to map students' attitude to game-based learning. In questionnaire and interview students expressed their positive attitude to the game they played. Competitiveness, external motivation (rewards, valuation), teamwork, using different types of tasks and activities, time stress and physical motion were identified as factors that might affect attitudes to the game-based learning and the effectiveness of the game as a learning method.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 163

The Science Cup – A competition to enhance children's interest in STEAM

Authors: Jitka Houfková¹; Kateřina Vágnerová¹

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

Corresponding Author: jitka.houfkova@gmail.com

In this contribution, we introduce a STEAM-focused team competition for kids aged three to eighteen and an invitation to join. The competition has a tradition of more than twenty-five years and aims to awaken children's interest in science and technology and develop their research skills and creativity. The competition is available online after registration and there is always an English version of the assignment. The authors of this contribution create the assignments and evaluate the solutions in the two youngest categories, so selected assignments, examples of solutions from these categories and difficulties related to this age groups will be presented.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Pre-school education

Poster session: CUR & INF & PTE / 170

Non-formal learning on an example of Aviation Education Centre Krakow Airport

Authors: Daniel Dziob^{None}; Hanna Koscielny^{None}; Jolanta Rokosz^{None}; Monika Trojanowska^{None}; Natalia Krawczyk^{None}; Natalia Zapart^{None}

Corresponding Author: daniel.dziob@uj.edu.pl

Flying and aviation successfully draw people's attention for more than 100 years, being a complex connection of science and humanities. Our Aviation Education Centre (CEL) brings solid professional knowledge to visitors, showing the connection between science and everyday life in the affordable way. Here we present the methods utilized in CEL to teach and entertain our guests using particular examples of scientific experiments performed by guides and visitors, focusing on the perspective of informal learning.

How would you like to present your contribution?:

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

Target education level (primary):

Outreach

Target education level (secondary, optional):

Lower-secondary education

Poster session: CUR & INF & PTE / 181

Does the weather matter in aviation? Physics explains!

Authors: Hanna Koscielny^{None}; Daniel Dziob^{None}; Jolanta Rokosz^{None}; Monika Trojanowska^{None}; Natalia Zapart^{None}; Natalia Krawczyk^{None}

. Weather has an enormous effect on aviation, and the impact is explained by physics. However, few know about it. After all, it is not an element of school education. That is why, among others We explain this dependence at the Kraków Airport Aviation Education Centre, using, inter alia, an original meteorological station and an original board game.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Lower-secondary education

Poster session: CUR & INF & PTE / 182

Knowledge or fun? You can both at once! An example of summer camps from the Aviation Education Centre.

Authors: Natalia Krawczyk^{None}; Daniel Dziob^{None}; Hanna Koscielny^{None}; Jolanta Rokosz^{None}; Monika Trojanowska^{None}; Natalia Zapart^{None}

Curiosity about the world is natural for children, but the trick is not to make it disappear when you pass on scientific knowledge to them. During the summer camps at the Aviation Education Centre, we dressed (not only) physical knowledge in a detective scenario. Through the elements of competition and fun, we tried to convey to students not only knowledge, but also the method of inquiry through discovery and experimentation.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-school education

Target education level (secondary, optional):

Primary school education

Poster session: CUR & INF & PTE / 27

PER-Based Curricula for Middle and High Schools

Author: Martin Richard Hopf^{None}

Co-authors: Thomas Wilhelm¹; Horst Schecker²

¹ *Goethe-Universität Frankfurt am Main*

² *Universität Bremen*

Corresponding Author: martin.hopf@univie.ac.at

Curricula contain detailed information on how to teach (physics) topics. It is amazing and surprising, how differently curricula for the middle and high school physics classroom can be designed, how the sub-topics can be arranged and which explanations and visualisations can be used. On the poster, we give a brief introduction to curriculum development and its history as well as short examples from German language PER-based curricula.

How would you like to present your contribution?:

Live in Ljubljana (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: CUR & INF & PTE / 51

Projects based Approach for Implementing a STEM-Focused Engineering Curriculum

Authors: Arrue Mario¹; Gutiérrez-Berraondo José¹; Guisasola Jenaro²

¹ *Escuela de Ingeniería Dual-IMH*

² *Escuela de Ingeniería de Gipuzkoa, Univesidad del País Vasco (UPV/EHU)*

Corresponding Author: jgutierrez@imh.eus

The STEM education movement has emerged as an alternative, to ensure science-technical learning and increased student interest in science and technology-related careers.

The development of the project is carried out in three phases; the contextualisation, where the identification of the necessary knowledge of the different disciplines is worked on with scaffolding questions and the establishment of steps to carry out the project. All of this is worked on using different activity sheets; during the classroom teaching of the subjects; and finally the results obtained in each of the subjects are grouped together to give traceability to develop the report

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 56

The Interplay of Curricular Knowledge and Perceived Agency of Pre-Service Physics Teachers in Vienna and Tokyo

Author: Mike Hull^{None}

Co-authors: Haruko Uematsu¹; Andrew Elby²

¹ *Tokyo Gakugei University, Department of Physics*

² *University of Maryland, Department of Teaching and Learning, Policy and Leadership Division: STME*

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Teacher educators and education researchers have argued for the importance of responsive teaching. To teach responsively, however, requires more than creativity. It requires also a perception of agency, that one has the freedom to deviate from the lesson plan when needed. Effective responsive teaching requires also an understanding of why the textbook and other curricular materials were designed the way they were. In this paper, we investigate the interplay between this last factor (“curricular knowledge”) and perceived agency in the context of an opportunity for pre-service teachers earning a MS degree to learn about and use Open Source Tutorials.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 63

STEM Digitalis project: STEM Digital Distance Learning in University Teaching

Authors: Eilish McLoughlin^{None}; Gunnar Friege¹; Argyris Nipyrakis²; Priit Reiska³; Dimitris Stavrou²

¹ *Gottfried Wilhelm Leibniz Universitaet Hannover, Germany*

² *University of Crete, Greece*

³ *Talinn University, Estonia*

Corresponding Author: eilish.mcloughlin@dcu.ie

The Erasmus+ project STEM Digitalis is a cooperation of five Universities for improving digital education readiness in tertiary education of prospective science teachers. The project foresees the development of at least five digital scenarios for primary and secondary prospective teacher training in blended and distance learning contexts. Furthermore, the project aims to foster teaching methodologies for making meaningful and effective use of technology, as well as open educational platforms for sharing the digital materials.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

University education

Poster session: CUR & INF & PTE / 78

The Structure of Students' Sign Networks in Mechanics

Author: Richard Taylor¹

Co-authors: Judith Hillier¹; Ann Childs

¹ *University of Oxford*

Corresponding Author: richard.taylor@education.ox.ac.uk

This research uses a snowball sampling method to measure the structure of word (sign) networks formed by students learning mechanics (physicists) and students who are likely to have a more basic understanding (psychologists). The networks of physics and psychology students have similar structures but connect to different signs. All networks contain highly connected hub-words. There are common hub-words (e.g., force, energy, time) in both groups of students, despite differences in understanding. This suggests connects between words develop before students have a fully coherent conceptual understanding of mechanics.

How would you like to present your contribution?:

Live in Ljubljana (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: CUR & INF & PTE / 84

Physics Teachers and use of Sensors by Pupils Themselves, Preliminary Ideas of Typology of Physics Teachers

Authors: Silvia Novotná^{None}; Peter Demkanin^{None}

Corresponding Author: novotnasilvia1@gmail.com

Sensors for use in schools within physics education have a firm place in many educational systems. However, even in these educational systems, some teachers do not use them. In this contribution, we offer preliminary ideas leading to preparation of typology of physics teachers. We start with the model of personality developed by C. R. Cloninger and proceed with preliminary work by the team from the University of Wisconsin-Madison, focused on Teachers on the Market: A Typology of Teachers' Philosophy, Mission, Vision, and Values. Finally, we try to ground our work on the neuroscience view of teachers formulated by T. Tokuhama-Espinosa.

How would you like to present your contribution?:

Live in Ljubljana (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: CUR & INF & PTE / 86

How to efficiently communicate evidence-based curricula?

Author: Markus Obczovsky^{None}

Co-authors: Thomas Schubatzky¹; Claudia Haagen-Schützenhöfer¹

¹ *University of Graz*

Corresponding Author: markus.obczovsky@uni-graz.at

To support student learning a common approach in physics education research is to develop evidence-based curricula for certain topics. However, those curricula and corresponding curriculum materials often do not find their way into broad school practice or if they do, the didactic ideas guiding the development are often not sufficiently identified by teachers. To support teachers in identifying those didactic underpinnings the concept of Essential Features of curricula is introduced and discussed. The development of this concept of Essential Features – including a validation by 5 experts for relevance and consistency – will be presented on the poster.

How would you like to present your contribution?:

Live in Ljubljana (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

Poster session: CUR & INF & PTE / 106**An analysis of students' misconceptions on Special Relativity****Author:** Alessio Mattia Leonardi¹**Co-authors:** Settimio Mobilio²; Claudio Fazio³¹ *Department of Physics and Astronomy, University of Padua, Italy*² *Department of Science - University Roma Tre*³ *Università degli Studi di Palermo***Corresponding Author:** a.m.leonardi@hotmail.it

Special Relativity is one of the key theories of our description of reality but its accommodation among students at different level is still a critical issue. Even after instruction, student's answers continue to be biased by Classical Mechanics.

We present the analysis of high-school students' answers to open questions concerning topics on Classical Mechanics and Special Relativity showing the persistence of pre-relativistic reasoning. This study is part of an experimentation on the teaching of Special Relativity with the use of a mechanical instrument that allows students to explore by hands the effects of a change of reference frame.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Poster session: CUR & INF & PTE / 118****Physical Computing with Arduino in Mathematics and Science Teacher Education – Development of a Master's Course on Digital Transformation****Author:** Angelika Mandl¹**Co-authors:** Thomas Schubatzky¹; Claudia Haagen-Schützenhöfer¹; Philipp Spitzer¹¹ *University of Graz***Corresponding Author:** angelika.mandl@uni-graz.at

Digital competences are increasingly important to participate in today's society. To professionalise future mathematics and science teachers for the implementation of digitally transformed teaching, a master's course is developed and researched at the University of Graz in the paradigm of Design-Based Research. The first version of the research-informed course design is implemented in the current semester. Research on students' learning processes will guide the redesign of the course and generate local learning theories as well as design knowledge and design methodology. The

development of the first part of the course and results of the accompanying research are presented here.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 131

Developing second-level physics students' energy literacy

Authors: Eilish McLoughlin¹; Suzan Gunbay¹

¹ *Dublin City University*

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At second level, the concept of energy is commonly taught as a cross-cutting concept in science and students build their knowledge about energy around four central ideas: energy transfer, transformations, dissipation, and conservation. We present the findings of a pilot study carried out as part of the Energizing Education to Reduce Greenhouse Gas Emissions (ENERGE) project. This study presents the design and implementation of teaching and learning materials with two cohorts of second level physics students. The findings from the piloting showed that the activities (1) successfully developed student energy literacy in multiple domains and (2) promoted good curricular alignment.

How would you like to present your contribution?:

Live in Ljubljana (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: CUR & INF & PTE / 134

A review of the Greenhouse Effect and Climate Change in the High School Textbooks

Authors: Stefano Toffaletti¹; Marco Di Mauro¹; Pasquale Onorato¹

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Corresponding Author: s.toffaletti@unitn.it

The recent reintroduction of civic education, especially concerning sustainable development, opened the field to the design, implementation, and evaluation of teaching-learning sequences (TLS), focusing on the greenhouse effect and climate change, in high schools. These themes have gained weight

in the student curriculum and, consequently, more space is being dedicated to them in high school textbooks. In this poster, we report on a critical analysis we performed, concerning the actual presence of improvements in the treatments dedicated to these topics in current textbooks, and the effectiveness of such improvements, starting from the results of previous studies.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 140

Eyes light and colors: a short laboratory learning path for primary school prospective teachers

Authors: Francesca Monti^{None}; Claudia Daffara¹; Adele La Rana¹

¹ *University of Verona*

Corresponding Author: francesca.monti@univr.it

We present a short laboratory learning path on optical phenomena centered on human eye vision both in terms of image formation and colors that was recently proposed to a class of Prospective Primary school Teachers (PPTs). The activities were organized as a free guided exploration and investigation after a brief description of the main experimental facts and of the available instrumentation. We investigated through worksheets how and to what extent PPTs would utilize the proposed activities in projecting a learning path on these subjects for their future primary school students.

How would you like to present your contribution?:

Live in Ljubljana (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

Poster session: CUR & INF & PTE / 167

Teaching physics for non-physics students: the case of Jagiellonian University Medical College, Faculty of Pharmacy

Authors: Daniel Dziob^{None}; Jan Kobierski^{None}; Michal Swiatek^{None}; Sebastian Bozek^{None}; Wojciech Jawien^{None}

Corresponding Author: daniel.dziob@uj.edu.pl

To understand the surrounding world one needs to know at least the basic physical principles, like Newton's laws. Our experience shows that biophysics laboratory is an effective way of introducing basic physical concepts (both theoretical and experimental) into curricula of pharmaceutical and

cosmetologist professionals. The poster presents selected exercises together with students' opinions as well as general observations on the effective and ineffective ways of introducing physical concepts to curriculum.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 184

Bringing physics closer to students: Erasmus+ KA201 Project ARphymedes

Author: Jerneja Pavlin^{None}

Co-authors: Sasa Zihlerl ; Katarina Susman

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Physics is often mentioned in the school environment in connection with less preferred subjects. The reason for this could be the abstractness of physics concepts and the quantitative descriptions of physics concepts. Students and teachers report that they have little time for experiments for a variety of reasons. One interactive method that could help overcome this limitation to some extent is the use of augmented reality. The aim of this paper is to present the project AR Physics made for students (acronym: ARphymedes), which addresses the above problem.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Poster session: CUR & INF & PTE / 151

Explanatory videos as a support mechanism for internship mentors in physics

Author: Milan Nemling^{None}

Co-authors: Markus Obczovsky ; Thomas Schubatzky ; Claudia Haagen-Schützenhöfer¹

¹ *University of Graz*

During school internships, Austrian pre-service teachers (PSTs) are accompanied by a mentor from their internship school. To jointly reflect upon lesson plans and lessons held, an understanding of the underlying ideas from physics education research is necessary for the mentor and mentee. To support the development of this basis, a project was set up to provide mentors information about core contents of the physics teacher education program in Graz. To evaluate explanatory videos as

a possible support mode, a first video was produced and a survey was conducted among 13 mentors. The results will be presented on the poster.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 174

Semiotic model for learning physics in high school

Author: Guillermina Ávila García¹

Co-authors: Fabiola Escobar Moreno ²; Liliana Suárez Téllez ²

¹ *Instituto Politécnico Nacional*

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The work's objective is to identify, from the perspective of the high school student, the relationship between applied mathematics and tangible computation for the understanding of physical phenomena, based on the semiotic model, a principle of construction and reconstruction that articulates the representation and interpretation of physical phenomena. via computer. The study is qualitative and exploratory in nature, implementing a didactic sequence where students make use of physical objects, use tangible computation for the model and analyse its different states over time, derived from this, student elaborations are 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):

Upper-secondary education

Target education level (secondary, optional):

Higher-secondary education

Poster Session: LAB & MDR / 169

Intracellular joystick - from doing to teaching science

Authors: Bartosz Lisowski^{None}; Daniel Dziob^{None}

Corresponding Author: daniel.dziob@uj.edu.pl

Physics from the lab and taught to students are from two different worlds. This is even more pronounced as scientists often focus on working in the laboratories, forgetting to communicate their results to the public. Here we show how, by involving students in research projects, one can bring these two worlds closer together.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Outreach

Poster Session: LAB & MDR / 34

(V) “The Elegance of Quantum Mechanics”: a didactic path for high school

Authors: Ester Melli¹; Luisa Lovisetti²; Marco Giliberti³

¹ *Università degli studi di Milano*

² *University of Milan, Department of Physics*

³ *Università degli Studi di Milano*

Corresponding Author: ester.melli@studenti.unimi.it

This paper describes the work of design, testing and evaluation of the effectiveness of a pilot Teaching-Learning Sequence on quantum mechanics presented to high school students and teachers. The experimentation consisted of 10 Zoom meetings, between October 2021 and January 2022. At the end of the first nine meetings, each student was given a form aimed at bringing out the reasoning used, and the level of understanding achieved. At the end of the course a satisfaction survey was also given. The effectiveness of the activity was assessed by means of all homework and interviews with 13 students and 6 teachers.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 177

Introducing Quantum Physics with low-cost quantitative experiments

Authors: Luigi Gratton¹; Marco Di Mauro¹; Pasquale Onorato¹

¹ *University of Trento*

Corresponding Author: marco.dimauro@unitn.it

We present two quantitative low-cost experiments aimed at introducing students to quantum physics from a phenomenological point of view. These experiments could be used to discuss quantum measurements and the collapse of the wave-function, analysing the light transmission by 3 polaroids, and using the latter to set-up a quantum eraser. The experiments were tested with master students in mathematics and physics, who aim at becoming high school teachers. Some controversial aspects of how these experiments should be understood in terms of quantum physics will be also discussed.

How would you like to present your contribution?:

Live in Ljubljana (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

Poster Session: LAB & MDR / 176

Mystery Boxes and the Higgs Boson Discovery: Exploring the Nature of Science

Authors: Anja Kranjc Horvat¹; Daniele Molaro^{None}; Gernot Werner Scheerer^{None}; Guillaume Durey¹; Jeff Wiener¹; Julia Woithe¹; Margherita Boselli¹; Merten Nikolay Dahlkemper¹; Niklas Herff²; Patrick Georges Thill¹; Sarah Maria Zoechling³; Panagiota Chatzidaki⁴; Ruadh Duggan⁵

¹ CERN

² Technische Universitaet Dresden (DE)

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⁵ Freudenthal Institute, Utrecht University, Utrecht

Corresponding Author: anja.horvat@cern.ch

Nature of Science is featured in all science curricula. However, science in schools typically only features examples from the early 1900s. Often, those examples no longer reflect contemporary scientific practices. Meanwhile, modern discoveries, such as the Higgs boson discovery in 2012, provide a prime example of science in the making and a great opportunity to discuss the Nature of Science. Our activity connects steps in discovering the Higgs boson to the Nature of Science aspects. The activity is further supported by mystery boxes which enable students also to experience the nature of scientific discovery.

How would you like to present your contribution?:

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

Target education level (primary):

Outreach

Target education level (secondary, optional):

Higher-secondary education

Poster Session: LAB & MDR / 12**Development of printed single and double slits and optical gratings for students' wave optics experiments**

Authors: Katarina Jelacic¹; Antun Lovro Brkic²; Lana Ivanjek^{None}; Karolina Matejak Cvenic^{None}; Maja Planinic³; Ana Susac⁴

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

² *Institute of Physics*

³ *Department of Physics, Faculty of Science, University of Zagreb*

⁴ *Department of Applied Physics, Faculty of Electrical Engineering and Computing, University of Zagreb*

Corresponding Author: kjelacic@phy.hr

As a part of a larger project, printed slits and optical gratings were developed for students' high school experiments in wave optics: interference on a double slit and optical grating and diffraction on a single slit. These printed single and double slits are very cheap and easily accessible for teachers. The patterns they produce show clear differences between single slit diffraction and double slit interference patterns that can help students investigate and discuss the differences necessary for a better conceptual understanding of these wave optics phenomena.

How would you like to present your contribution?:

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 65**The Scientific Graphic Organizer for Practical Work**

Authors: Freek Pols^{None}; Patrick Diepenbroek¹

¹ *International School Twente*

Corresponding Author: c.f.j.pols@tudelft.nl

To better align assessment and learning goals for practical work, without increasing the teacher's workload, we developed the scientific graphic organizer (SGO). The SGO can be considered a pre-structured but simplified lab journal that in many cases allows to replace the practical's worksheet as well as students' written report. We elaborate on the educational value of the SGO, discuss its elements, and report on the practical implementation and preliminary results of research into, and with the SGO.

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

Poster Session: LAB & MDR / 68**Similarities and differences between professions and countries of key-concepts in teaching quantum physics and their illustrations****Author:** Avraham Merzel¹**Co-authors:** Erica Andreotti ; Daria ANTILLA ²; Philipp Bitzenbauer ; Maria Bondani ³; Marilu Chiofalo ⁴; Mieke De Cock ; Sergej Faletic ; Caterina Foti ⁵; Renaat Frans ; Aurél GÁBRIS ⁶; Simon GOORNEY ⁷; Franziska GREINERT ⁸; Leon JURČIČ ⁹; Zdeňka Koupilová ; Kim Krijtenburg-Lewerissa ¹⁰; Massimiliano Malgieri ; Rainer MÜLLER ⁸; Pasquale Onorato ¹¹; Gesche Pospiech ; Kirsten Stadermann ; Malte UBBEN ¹²; Andreas WOITZIK ¹²; Henk Pol ¹³¹ *The Hebrew University of Jerusalem*² *University of Turku*³ *CNR - Institute for Photonics and Nanotechnologies*⁴ *University of Pisa*⁵ *Aalto University*⁶ *QWorld Association*⁷ *Aarhus University*⁸ *Technische Universität Braunschweig*⁹ *University of Ljubljana*¹⁰ *Utrecht University*¹¹ *University of Trento*¹² *Westfälische Wilhelms-Universität*¹³ *University of Twente***Corresponding Author:** avraham.merzel@mail.huji.ac.il

This study compares the views of high-school teachers, physics educators at the university level, and physics education researchers from different countries, about the key concepts to be used in teaching quantum physics in secondary education and their illustrations. We analyzed responses to a Delphi study prompted by the QTEdu group, in the attempt to portray the illustrations for each key concept and to map for each illustration, what are the key concepts it involves. This might help in the effort to canonize these concepts for making sound curricula of quantum physics in high-school.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 79**Analyzing high school students' difficulties with wave optics using a knowledge-in-pieces approach****Authors:** Karolina Matejak Cvenic¹; Lana Ivanjek²; Maja Planinic¹; Ana Susac³; Katarina Jelacic¹; Martin Hopf⁴¹ *Department of Physics, Faculty of Science, University of Zagreb*² *Faculty of Physics, Physics Education Research, Technische Universität Dresden*³ *Department of Applied Physics, Faculty of Electrical Engineering and Computing, University of Zagreb*⁴ *University of Vienna, Austrian Educational Competence Centre Physics***Corresponding Author:** karolina@phy.hr

A series of semi-structured demonstration interviews about the basic phenomena of wave optics were conducted with Croatian high school students after their regular school instruction on this topic. We analyze the identified students' difficulties with the interference and diffraction of light on double-slit, single-slit and optical grating from the knowledge-in-pieces perspective.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Poster Session: LAB & MDR / 80****Two experiments to support learning of surface phenomena****Authors:** Onofrio Rosario Battaglia^{None}; Giulia Termini^{None}; Claudio Fazio¹¹ *Università degli Studi di Palermo***Corresponding Author:** onofriorosario.battaglia@unipa.it

We present two different experiments aimed at supporting the understanding of surface phenomena. Set-ups are a low budget. Materials and experimental apparatuses are available even in ordinary school didactic laboratories. In the first experiment, we use, as experimental apparatus, a simplified custom-built version of the well-known Du Noüy ring. It allows us to measure the surface tension of several common liquids, like water, oil, alcohol, etc. In the second experiment, we use two glass plates to build a sort of variable-section capillary to estimate the interfacial tension at the water-glass interface.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 83**“Quantum Physics is difficult because my teacher says so.”****Author:** Henk Pol¹**Co-authors:** Bart Folkers¹; Kirsten Stadermann¹¹ *ELAN Department of Teacher Development***Corresponding Author:** h.j.pol@utwente.nl

Abstract. We will present the results of an analysis of Dutch secondary school students' and teachers' perceptions of Quantum Physics (QP) in comparison to their perception of Classical Physics. First, data on teachers' perception of QP teaching and their students' understanding of QP were collected. Secondly, we analyzed students' self-efficacy concerning the subject of QP and related this to their teachers' perceptions of teaching QP.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Poster Session: LAB & MDR / 90****Using infra-red camera in the activities that help students construct basic knowledge of thermal radiation****Author:** Gorazd Planinsic¹**Co-author:** Eugenia Etkina²¹ *Faculty of Mathematics and Physics, University of Ljubljana*² *Rutgers University, New Brunswick, New Jersey, USA***Corresponding Author:** gorazd.planinsic@fmf.uni-lj.si

The availability of infra-red (IR) cameras changes the way we teach many topics: energy, thermodynamics, electricity, optics, and modern physics. As an IR camera is a complex device that functions based on the physics beyond the introductory level, in order to fully use its pedagogical potential, we need to integrate it into an introductory physics course without compromising course coherence and overloading the curriculum. We share activities in which we used IR cameras following the framework for using modern devices in introductory physics courses developed earlier. Activities follow the ISLE approach and were tested with physics education students.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 95

Special relativity at Czech schools: a half-century comparison

Author: Lukáš Richterek^{None}

Co-authors: Patricie Kočišová¹; Lukáš Slaměník¹

¹ *Faculty of Science, Palacký University Olomouc*

Corresponding Author: lrichterek@gmail.com

In this contribution, we present the results of one bachelor and one master theses both devoted to the teaching of special relativity at an upper-secondary or intro-university level in the Czech Republic. We compare the test results of the grammar-school students in the school years 1976/1977 and 2021/2022, which are close to average and very similar in both cases, so the level of understanding has not changed in the meantime. We also present a set of interactive spacetime diagrams used in the preparation of future physics teachers within our relativity course.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 99

(V) Build a colorimeter: a final assignment for an electronic instrumentation course

Author: Margreet Docter^{None}

Co-author: Jeroen Bastemeijer¹

¹ *Delft University of Technology*

Corresponding Author: m.w.docter@tudelft.nl

As a final project for our electronic instrumentation practical course, students were challenged to build their own colorimeter to measure their own biochemical reaction, requiring them to apply all recently acquired theoretical knowledge and practical skills. They developed their electronic circuit on our recently developed Advanced Learning Platform for Analog Circuits and Automation, which allowed them to perform most measurements at home, though supervision was offered at the university. Their written reports show great understanding and application of all they have learned, with good grades. In feedback, students appreciate this assignment as the most enjoyable part of our course.

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: LAB & MDR / 108

Competence through Authenticity - CMS Open Data in Education

Author: Peitsa Veteli¹

Co-author: Kati Lassila-Perini ¹

¹ *Helsinki Institute of Physics (FI)*

Corresponding Author: peitsa.veteli@gmail.com

The modern world is a very data-driven place, bristling with repositories of openly available information, yet these resources are seldom used in education below university levels. In this talk we present the case for secondary school level use of open, authentic “real world” data and easily accessible programming as cross-disciplinary tools for advancing the students’ scientific literacy and broader subject knowledge. Feedback from teacher trainings, student workshops and school courses between 2016-2022 indicates a very positive reception with topics ranging widely from analysis of particle physics data from the CMS experiment at CERN to climate questions or sociological problems.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 115

Changing the narrative in Climate Change: design of a storyline based approach for PER

Author: Lorenzo Miani^{None}

Co-author: Olivia Levrini ¹

¹ *University of Bologna - ALMA MATER STUDIORUM*

Corresponding Author: lorenzo.miani2@unibo.it

Climate change is the greatest threat to mankind and the biosphere. It is essential to understand how to deal with this problem, discover its causal mechanisms and find the best way to narrate it. The literature has shown that using a probabilistic risk-based approach does not allow for a full understanding of the causal mechanisms linked to one’s actions and leads to inaction on climate change. This work aims to design a storyline approach to be implemented in a physics course for secondary students that aims at developing skills such as systemic thinking, future vision and agency.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 116**Case study on winching rope as an example of multidisciplinary teaching example****Authors:** Antti Rissanen¹; Kalle Saastamoinen¹¹ *National Defence University***Corresponding Author:** antsa.rissanen@gmail.com

In this article we present STEM-related master level education. Here we go through an example on the way how to teach risk of damage connected to helicopter winching. We were teaching this case study through the method called group-based learning. Moreover we observed skill and reasoning ability development due the early research methodological education during the two last years of master level education. From the point of science we present shortly basic cable physics and probability of their failure by practical examples.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 121**First results using a Home-Kit designed in the COSID-20 project: teaching physics laboratory at a distance****Authors:** Tommaso Rosi¹; Giuliano Zendri²; Eugenio Tufino¹; Stefano Toffaletti¹; Stefano Oss¹; Pasquale Onorato¹¹ *University of Trento*² *Level Up***Corresponding Author:** pasquale.onorato@unitn.it

We designed and tested a personalized home-kit that was distributed to students in a Physics Education course during the pandemic as part of the COSID-20 project. A goal of the design of the kit was to be inexpensive enough to be attractive to schools and universities: a collaboration with a local startup has proven very valuable in this sense. In this work we will present our kit, which we will physically bring to the conference, showing the solutions we found and discussing how to be able to perform many different experiments with low-cost, easy to find materials and tools.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Poster Session: LAB & MDR / 122**A framework for design principles of experimental tasks in contemporary physics laboratory courses**

Author: Simon Z. Lahme¹

Co-authors: Bruno Tomrlin²; Pekka Pirinen³; Ana Susac²; Antti Lehtinen³; Andreas Müller⁴; Pascal Klein¹

¹ *University of Göttingen, Germany*

² *University of Zagreb, Croatia*

³ *University of Jyväskylä, Finland*

⁴ *University of Geneva, Switzerland*

Corresponding Author: simon.lahme@uni-goettingen.de

While laboratory courses are an integral part of physics studies aiming a huge variety of learning objectives, research has shown that typical lab courses do not reach the desired goals. While diverse approaches by lab instructors and researchers try to increase the efficiency of lab courses, the experimental tasks remain the key elements of each lab. As it gets more and more difficult to keep an overview of these developments, we present a literature-derived framework for design principles of experimental tasks in contemporary physics labs which can be utilized to characterize existing or to develop new experimental tasks.

How would you like to present your contribution?:

Live in Ljubljana (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: LAB & MDR / 125

Designing learning material for teaching particle physics with Feynman diagrams

Authors: Andreas Müller¹; Jeff Wiener²; Merten Nikolay Dahlkemper²; Pascal Klein³; Sascha Schmeling²

¹ *Université de Genève*

² *CERN*

³ *Universität Göttingen*

Corresponding Author: merten.dahlkemper@cern.ch

This research project aims at developing learning material for teaching particle physics with Feynman diagrams to high school students. We take a design-based research approach to find possible educational uses for Feynman diagrams to be beneficial in the learning about particle physics. We incorporate these uses into the learning material with design principles derived from multimedia learning theories and test the material in teaching experiments with high school students. At the conference we present the educational uses as well as an approach on how to implement them.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 149

Using Smartphones to Innovate Laboratories in Introductory Physics Courses

Authors: Andrea Ferrogli¹; Chiara Sirignano²; Darya Krym¹; Elisa Bernardini²; Francesca Soramel²; Giovanni Ossola¹; Henrik Jessen Munch²; Jake Postiglione¹; Juan Sebastian Poveda Correa¹; Lucia Gabelli²; Marta Carli²; Miguel Fiolhais³; Mohamed Yousry Elkhatab²; Ornella Pantano²; Pierpaolo Mastrolia²

¹ *Physics Department, New York City College of Technology, The City University of New York*

² *Department of Physics and Astronomy, University of Padua*

³ *Science Department, Borough of Manhattan Community College, City University of New York*

The SmartPhysics project involved two higher education institutions, one in Italy and one in the US, with the aim of exploring the use of smartphones to perform laboratory experiments in introductory physics courses at university. Here we present and discuss two experiments that were tested during the project: the 'pendulum' experiment, consisting in the measurement of g using a pendulum and a proximity stopwatch, and the 'bouncing ball' experiment, aimed at measuring the energy lost by a bouncing ball going through a series of inelastic collisions with a hard surface.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 152

The Role of Experiment in Physics Education: Attitudes of Upper Secondary School Students

Author: Jana Marounová^{None}

Co-author: Petr Káčovský

Corresponding Author: jana@machalicka.cz

This contribution aims to introduce research on the attitudes of upper secondary school students to experiments in physics lessons. The research instrument has three logical parts – the metadata about respondents is the first one. The second part is focused on describing the current state regarding experimental work in physics lessons at upper secondary schools. In the third part, respondents are asked about their view of the “ideal state” concerning experimenting in their physics lessons. More than 1300 students participated in this research. The main goal of this study is to determine the perception of including experiments in physics lessons.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 158

Digital Image Processing in Physics Classroom

Authors: Akos Ruzsa^{None}; Arpad Bordas^{None}

Corresponding Author: bordas.arpad@gmail.com

Digital image processing is a very useful method to analyse photographs and videos. The idea behind the image investigation is to recognize different shapes and colours. In our study we analyse videos of free fall and projectile motion by software written in Python programming language employing OpenCV libraries.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 159

Using action research to improve laboratory activities in secondary school

Author: Lucia Gabelli¹

Co-author: Marta Carli¹

¹ *University of Padova*

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We report the results of an action-research activity conducted in the framework of the in-service teacher training programme CoLLABORA, developed at the University of Padova between 2018 and 2020. During the programme, teachers were encouraged to identify a problem relevant to their context and to formulate a research question as a guide for the design of new laboratory activities. Here we present the results of an experimentation in which the teacher aimed to verify whether an inquiry-based approach could enhance the involvement of students and make their knowledge more durable compared to traditional laboratory activities.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 165

Investigating students' views about experimental physics in a transformed laboratory course in Germany

Authors: Micol Alemani¹; Heather J. Lewandowski²; Erik Teichman³

¹ *(1) Institute of Physics and Astronomy, University of Potsdam*

² *(2) JILA, National Institute of Standards and Technology and Department of Physics, University of Colorado*

³ *Institute of Physics and Astronomy, University of Potsdam,*

Corresponding Author: alemani@uni-potsdam.de

In this presentation, I will first describe the process of our laboratory course transformation at the University of Potsdam and show exemplary activities to foster students' acquisition of scientific skills. In the second part of the talk, I will describe how we have adapted the Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS) to the German context and set up an automated web-based system for instructors. I will present the first results using this German version of the E-CLASS at the University of Potsdam and compare them with those from the larger E-CLASS data set.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Poster Session: LAB & MDR / 45

MACROBITS, a teaching tool for quantum cryptography

Author: Joao Pereira¹

¹ UNIRIO

One amazing characteristics of quantum algorithms is how they can deliver results with 100% certainty despite their structure are based on the probabilistic interpretation of quantum mechanics. These types of algorithm require a different way of thinking and sets a challenge for science educators. A routine to emulate quantum cryptography protocols for high school students, is 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 usefull to illustrate quantum mechanics concepts such as superposition, change of basis and quantum measurement.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Outreach

Poster Session: REM & STR / 7

Inquiry-based learning and STEM conception in pedagogical practice at secondary and high school levels in the Czech Republic

Authors: Jakub Ivanic^{None}; Roman Kubínek^{None}

Corresponding Author: jakub.ivanic01@upol.cz

This paper deals with the issue of inquiry-based learning and its conception integrating science, technology, engineering, and mathematics into one whole ("STEM conception" in the text below) and their use in education in the Czech Republic. In the first part, we describe our experience with the usage of inquiry-based learning and STEM conception in the informal education of gifted children in the science centre Pevnost poznání and our motivation to perform research. The second theoretical part focuses on the definitions of inquiry-based learning and STEM conception. The last part contains the description of the research as well as research questions.

How would you like to present your contribution?:

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

Poster Session: REM & STR / 189

Physics Teaching Methods and How to Grade Ukrainian Students in the Czech Republic

Author: Nataliya Kazachkova¹

Co-author: Irena Dvořáková²

¹ *Institute of Physics of the Czech Academy of Science, Czech Republic, and V. N. Karazin Kharkiv National University, Ukraine*

² *Charles University, Faculty of Mathematics and Physics, Prague*

Corresponding Author: nataliyakazachkova@gmail.com

The poster is devoted to the problems which the Czech teachers had been faced working with the secondary school students who escaped from Ukraine due to the Russian aggression. The main problems have been mentioned and some ways of the decision have been proposed. One of the way is using the educational video Nezkreslená věda. Selected parts of the cycle have been supplemented with additional methodical materials in Ukrainian language, adapted and added by multiple choice questions, crosswords and experimental problems. The detailed guidelines for the Czech and Ukrainian teachers are being prepared.

Target education level (secondary, optional):

Higher-secondary education

Target education level (primary):

Lower-secondary education

How would you like to present your contribution?:

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

Poster Session: REM & STR / 178

Transforming Informal Education Programs for High School Students and Teachers at CERN into Virtual Alternatives: Challenges and Opportunities

Authors: Niklas Herff¹; Uta Bilow¹; Sascha Schmeling²; Moritz Springer¹

¹ *Technische Universitaet Dresden (DE)*

² *CERN*

Corresponding Author: niklas.herff@cern.ch

Netzwerk Teilchenwelt is a German particle physics education and outreach program. Among other activities, it offers highly attractive visit programs at CERN for high school students and teachers. During the pandemic, these informal education programs at CERN could not be carried out in the usual way. Therefore, instead of the regular on-site programs for students and teachers, virtual alternatives were developed and implemented. This paper explores the challenges and opportunities created by the transformation.

How would you like to present your contribution?:

Live in Ljubljana (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: REM & STR / 32**(V) Principles and Equations of Physics: a multidisciplinary laboratory****Authors:** Flavio Albanese¹; Marco Giliberti²; Luisa Lovisetti³¹ *Compagnia del Sole, Bari*² *Università degli Studi di Milano*³ *University of Milan, Department of Physics***Corresponding Author:** marco.giliberti@unimi.it

In the last two Academic Years, as part of the Scientific Degree Plan, some interdisciplinary and transversal online meetings have been proposed. They regarded the three principles of dynamics, the law of universal gravitation and Maxwell's equations. "Variations" on the themes were also presented - of historical, philosophical and also musical nature - to make the cultural setting of what has been discussed deeper and make it meaningful in the present. At the end of the course, the students produced a video of few minutes with a personal reworking and rethinking of the meaning of one of the topics discussed.

How would you like to present your contribution?:

Live in Ljubljana (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: REM & STR / 13**Understanding and addressing in-service teachers training needs in the digital era****Authors:** Anastasia Spanou¹; Kalliopi Meli²; Sofoklis Goulas³¹ *University of Piraeus*² *University of Patras*³ *Stanford University***Corresponding Author:** kmeli@upatras.gr

In this research, we give prominence to in-service teachers' questions posted in the context of a constructivist training program in Greece. The program's scope was to facilitate teachers (N=232,

including 104 STEM teachers) meeting distance education needs by using an asynchronous Question & Answer (Q&A) platform. Our results indicate that technology issues and pertinent remote lecture-based teaching challenges prevailed, psychological factors, alternative strategies, and assessment issues were also prominent. The content and the form of the program can inform future training programs in remote settings.

How would you like to present your contribution?:

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Higher-secondary education

Poster Session: REM & STR / 188

Remote Inquiry Based Learning, methods, assessment and examples

Authors: Mojca Čepič¹; Ana Gostinčar Blagotinšek¹; Eilish McLoughlin^{None}; James Lovatt²; Paul Grimes³; Jan De Lange⁴; Dagmara Sokolowska^{None}

¹ *University of Ljubljana, Faculty of Education*

² *School of Physical Sciences & CASTeL, Dublin City University*

³ *Dublin City University*

⁴ *artevelde university of applied sciences*

Corresponding Author: mojca.cepic@pef.uni-lj.si

The poster discusses methodology of inquiry based learning under remote conditions that was developed and tested within the ERASMUS+ project Remote Inquiry in Science Education. We focus on work with students, the assessment of their activities and present some examples. Besides, we present the framework for two remote training courses, which introduce and advance the inquiry based learning experience to teachers remotely but are adapted to use in teaching in person as well.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Poster Session: REM & STR / 185

(V) Elementary Pre-service Teachers' Alternative Conceptions on the Electric Current Distribution in Simple Electrical Circuits

Author: Abdeljalil Métioui¹

¹ *Université du Québec à Montréal*

Corresponding Author: metioui.abdeljalil@uqam.ca

The present qualitative research focuses on surveying the alternative conceptions of one hundred and seventy-seven ($N = 177$) elementary pre-service teachers from Quebec in Canada regarding the current distribution in simple electric circuits. For it, a questionnaire composed of xx statements was constructed and managed. They must choose if it is true or false for each statement following their justification. The data analyses show that their alternative conceptions are profoundly different from those advanced in the circuit theory, mainly related to the amount of current passing through lamps.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Poster Session: REM & STR / 10

Guided Discovery Teacher Training Online

Authors: Irena Dvořáková¹; Věra Koudelková¹

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

Corresponding Authors: dvorak.irena@gmail.com, vkoudelkova@gmail.com

We will show our experience with online seminars for teachers led by the method of guided discovery. We will give concrete examples of various activities that we have tried in the years 2020–2021 and show several experiments. We will also present teachers' reactions to these seminars.

Target education level (primary):

In-service teacher education

Target education level (secondary, optional):

Poster Session: REM & STR / 19

Physics Textbooks - as an important tool for learning and teaching

Authors: Marika Kapanadze¹; Gabriela Jonas-Ahrend²

Co-authors: Alex Mazzolini³; Fadeel Joubran⁴

¹ *Ilia State University, Georgia*

² *Paderborn University, Germany*

³ *Swinburne University of Technology, Australia*

⁴ *Arab Academic College for Education*

Corresponding Authors: marika_kapanadze@iliauni.edu.ge, jonas.ahrend@web.de

Physics textbooks are traditionally viewed as primary resources for the implementation of physics curricula throughout the world. While print-based physics textbooks evolved slowly over the centuries, the advent of new inquiry-based approaches (based on physics education research), and the development and use of online resources, have led to a substantial broadening in the “physics textbook” landscape (both at secondary schools and universities). Assessment of textbooks (including content, pedagogy and presentation) have been widely reported in physics textbook evaluation literature, but there is little evidence that it has influenced textbook development. This paper reviews the development and assessment of physics textbooks.

How would you like to present your contribution?:

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

Target education level (primary):

Outreach

Target education level (secondary, optional):

Poster Session: REM & STR / 28

Trialling two Teaching/Learning Sequences on Surface Phenomena based on Active-Learning Methodologies

Authors: Claudio Fazio¹; Giulia Termini²; Onofrio Rosario Battaglia²

¹ *Università degli Studi di Palermo*

² *University of Palermo*

Corresponding Author: claudio.fazio@unipa.it

We present the results of the trial of two teaching/learning sequences on surface phenomena for High School students. The sequences have been trialled with a sample of students divided into two groups. The first follows an approach, based on macroscopic models of surface tension. The second focuses on the discussion of mesoscopic models implemented in Smooth Particle Hydrodynamics simulations. Both approaches are based on active learning methodologies and hands-on experiments. We discuss the points of strength and weakness of both approaches in promoting student description/reasoning skills, on the basis of an analysis of student answers to questionnaires and interviews.

How would you like to present your contribution?:

Live in Ljubljana (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: REM & STR / 30**The Use of Computational Modelling and Video Motion Analysis Software in the Field of Newtonian Dynamics – a Mixed-Methods Study****Author:** Jannis Weber¹**Co-author:** Thomas Wilhelm²¹ *Goethe University Frankfurt*² *Goethe-Universität Frankfurt am Main***Corresponding Author:** weber@physik.uni-frankfurt.de

Computational modelling and video motion analysis software are programs that help the user focus on the relations of physical quantities by taking care of the complex maths. They differ in their approach towards Newton's second law. These two approaches are compared in a pre-test post-test study (N = 274 students). The results show that both are similarly successful in improving the conceptual understanding with large effect sizes even after lessons in school. Differences regarding other variables are discussed in the presentation. Furthermore, an analysis of audio and screen recordings of the working phase of 45 students is discussed.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Poster Session: REM & STR / 38****School-leaving Examination in Physics at the end of Upper Secondary School in the Czech Republic – Current State****Author:** Petra Pschotnerová¹**Co-author:** Dana Mandíková¹¹ *Charles University***Corresponding Author:** petra.pschotnerova@gmail.com

The paper presents selected results from a questionnaire survey conducted at Czech upper secondary schools. We focused mainly on the form of the school-leaving examination in physics, on the proportion of students who choose to take this exam in physics, and also on why students choose physics as one of the subjects, how they prepare for the examination in physics, and which topics in physics

are, in their opinion, the easiest or, on the contrary, the most difficult in terms of preparation for the school-leaving examination in physics.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: REM & STR / 48

Analysis of Force Concept Inventory (FCI) in two different approaches to learning physics

Authors: Mirko Marušić^{None}; Jelena Ružić^{None}; Luka Gujinović^{None}

Corresponding Author: jrusic@oss.unist.hr

This paper presents the results of a six-year project aimed at observing how two different methods of teaching university physics (traditional and active method) affect the conceptual understanding of Newtonian mechanics. The study included 826 first-year university students. The FCI instrument was used for Pre and Post testing. For the traditional method of learning physics in all studies, the Hake's normalized gain (g) is in the range of 0.04 to 0.06. With the active learning method, characterized by experimentation and discussion, students of all studies performed with significant g values in the range of 0.30 to 0.40.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Poster Session: REM & STR / 59

Teaching uniformly accelerated motion with the help of robotics

Author: Peter Stubljár^{None}

Corresponding Author: peter.stubljjar@gmail.com

During physics lessons in primary school, we teach students the laws of uniformly accelerated motion. The presented example of good practice describes uniformly accelerated movement with the help of programming Lego robots Mindstorms EV3. Pupils implement the laws of uniformly accelerated motion in the programming of robotic vehicles. They observe the movement of robotic vehicles, which they programmed themselves beforehand, analyze how the speed changes over time, and compare the measured values with the theoretical ones. By doing so, students are able to achieve learning objectives faster and more successfully. Furthermore, they test physical laws with help of ICT technology.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Poster Session: REM & STR / 60

The Human-centered design framework as a means of bridging the research-practice gap

Authors: Fabian Bernstein¹; Sascha Schmeling²; Thomas Wilhelm³

¹ CERN, Johann-Wolfgang-Goethe Univ. (DE)

² CERN

³ Goethe-Universität Frankfurt am Main

Corresponding Author: fabian.bernstein@cern.ch

The transfer of innovation from physics education research to practice has been a major challenge in recent decades. While design-based research projects aim at achieving higher ecological validity, widespread adoption does not follow automatically. The Human-centered design framework – as used in industry and codified in ISO standards – opens up pathways to increase the probability of adoption of research products and raise acceptance amongst practitioners. To this end, 3D-printed LowCost-HighTech interferometers, developed at CERN's S'Cool LAB, have been subjected to comparative usability testing with high school teachers to investigate how the Human-centered design framework can help overcome implementation issues.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: REM & STR / 77

The Solvay Education Programme at CERN Science Gateway

Authors: Guillaume Durey¹; Julia Woithe¹; Sascha Schmeling¹

¹ Science Gateway Education Team, CERN

Corresponding Author: guillaume.durey@cern.ch

CERN attracts attention from students around the world yet can only welcome a very small fraction of applicants through its residential programmes. To capitalize on this unaddressed demand for immersion in a STEM environment, we have developed the Solvay Education Programme at CERN Science Gateway, which combines the unique advantages of both on-line and on-site learning. The first level of the programme aims at triggering STEM interest via video shorts. The second level develops this interest through online interactive courses. The third level targets students' STEM career interests with a week-long stay on site, featuring workshops, projects, visits and lectures.

How would you like to present your contribution?:

Live in Ljubljana (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: REM & STR / 91

Some Aspects of Relevance of Science and Physics Education

Author: Marika Kapanadze¹

Co-authors: Nino Javakhishvili¹; Ekaterine Slovinsky¹; Lia Dzagania¹

¹ *Ilia State University, Tbilisi, Georgia*

Corresponding Author: marika_kapanadze@iliauni.edu.ge

The Relevance of Science Education is one of the important issues studied during the last decades by the researchers from many countries. There are many attempts to change the philosophy of learning and implement new approaches at schools. Education researchers have been actively discussing and studying what pedagogical methods work more effectively. It is very important to take into account the country context and to determine what teaching approaches are effective in country specific cases. This paper presents some aspects of relevance of science and physics education studied in the frame of international project ROSES.

How would you like to present your contribution?:

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

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):**Poster Session: REM & STR / 105**

Analysing audio recorded peer discussions

Author: Eliane Merki¹

Co-authors: Andreas Vaterlaus¹; Andreas Lichtenberger¹

¹ *ETH Zürich*

Corresponding Author: merkie@student.ethz.ch

Using peer instruction to foster concept learning in physics is an established method in physics education. We analysed audio-recorded discussions during clicker sessions covering questions on kinematics. In this presentation we are describing our methodology to transcribe and to code audio recordings. In addition, we are discussing some preliminary results of our analysis.

How would you like to present your contribution?:

Live in Ljubljana (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: REM & STR / 129

Prospective primary teacher education on magnetic phenomena

Author: Emanuela Vidic^{None}

Corresponding Author: marisa.michelini@uniud.it

Prospective Primary Teachers education require integrated activities to produce competence in building learning environments to be competent in producing conceptual change, from the common to scientific ideas. In-out test on magnetic phenomena was developed using the research results on conceptual knots and an open text administered to a similar group of PPT in the first year of research and a more complex test before and after a formative module based on research based paths. The test-in stimulated reflection on the conceptual knots and the learning gain of the formative module emerged in test-out data analysis offering guidelines for PPT education.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Poster Session: REM & STR / 132

Group Formation for Two-stage Collaborative Exams

Authors: Greg Kestin¹; Kelly Miller¹; Olivia Miller¹

¹ *Harvard University*

Corresponding Author: kmiller@seas.harvard.edu

Two-stage collaborative exams are an increasingly popular form of formative assessment which have shown promising results in promoting student learning. Despite this, there is no clear consensus on the best way of forming student groups. We report on a controlled experiment conducted during a two-stage collaborative exam in an introductory physics course. For the group-stage of the exam, half of the groups were instructor-selected and the other half were student-selected. We compared performance on both stages of the exam for both types of groups. We found female students perform better on two-part collaborative exams when they are in student-formed groups.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Poster Session: REM & STR / 139

(V) Active Learning Proposal for teaching the system of the double linear spring in the High School

Authors: Cesar Mora^{None}; Rubén Sánchez Sánchez¹

¹ *Instituto Politécnico Nacional*

Corresponding Author: rbnsnchz@yahoo.com.mx

In this work we present a methodology based on Active Learning of Physics with the use of Information and Communication Technology resources applied for the students of the High School in Mexico. A teaching methodology is shown considering the steps of Prediction, Observation, Discussion and Synthesis, with the aid of a simulation of a system of the double linear spring using Easy Java Simulations, which is a software tool that facilitates the use of the potential of the Java programming Language in a simple and illustrative way.

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):

Poster Session: REM & STR / 146

Physics Quantitative Literacy of US and Belgian STEM Teachers: a Preliminary Study

Authors: Charlotte Zimmerman¹; Mieke De Cock^{None}; Suzanne White Brahmia¹

¹ *Department of Physics, University of Washington*

Corresponding Author: mieke.decock@kuleuven.be

Quantitative Literacy (QL) is an important outcome of college education and plays an essential role in (introductory) physics. We report on a preliminary study on Physics Quantitative Literacy (PQL) of STEM Teachers in the US and Belgium. Using a pilot version of the Generalized Equation-based Reasoning inventory for Quantity and Negativity (GERQN), we explore PQL similarities and differences between US and Belgian in-service and pre-service STEM teachers.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Poster Session: REM & STR / 150

How do scientists explain basic concepts in quantum physics?

Authors: Stina Scheer^{None}; Gunnar Frieger¹

¹ *Gottfried Wilhelm Leibniz Universitaet Hannover, Germany*

Corresponding Author: scheer@idmp.uni-hannover.de

Quantum physics is often perceived as complicated, unintuitive and hard to explain. In a study in the form of an expert novice dialogue we asked young scientist doing research in quantum metrology to explain such concepts to an interested first year university student. Here we report our findings on content structure and explanatory elements used within these explanations.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Outreach

Poster Session: REM & STR / 155

From Thinking to Doing Through Dialogue: Designing a Pedagogical Strategy for STEM Teachers

Authors: Christel Balck¹; Jelle De Schrijver¹; Wim Temmerman¹; Annelies Pil¹; Jan Sermeus²

¹ *Odisee*

² *KU Leuven*

Corresponding Author: jan.sermeus@kuleuven.be

STEM education emphasizes hands-on activities, sometimes set in a pure discovery learning setting. In this work we present the result of a design-based research project to develop a teaching approach that aims to stimulate students' thinking skills (thinking about research and making, reflection and doubting, questioning and argumentation) by giving dialogue a prominent place. We discuss how this approach is appreciated by the teachers, how it affected the teachers teaching style and how it impacted the ability of the teacher to recognize students' thinking skills (a prerequisite to be able to stimulate them).

How would you like to present your contribution?:

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

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Poster Session: REM & STR / 161

Experiences of undergraduate engineering students in laboratory exercises of core courses during COVID-19 pandemic

Author: Ivana Štibi^{None}

Co-authors: Željka Mioković ; Danijela Kuvezdic¹

¹ *Josip Juraj Strossmayer University of Osijek, Department of Physics*

Corresponding Author: istibi@fizika.unios.hr

Specific epidemiological conditions caused by COVID-19 pandemic required sudden and necessary changes in the conditions for conducting lab work in university engineering education and university education in related STEM areas. The online survey examined the experiences and attitudes of students of the Croatian University (Josip Juraj Strossmayer University of Osijek) towards lab work in pandemic conditions. The results of the research indicate the application of a hybrid model of laboratory exercises, which includes implementation of experiments in and out of the laboratory with the use of ICT (mobile / web applications, computer simulations, ...)

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Poster Session: REM & STR / 162

Concept Learning in Electricity Enhanced by Virtual Reality

Author: Roman Schmid^{None}

Co-authors: Andreas Lichtenberger ; Andreas Vaterlaus

Corresponding Author: roschmid@phys.ethz.ch

Virtual Reality (VR) is a promising technology for enhancing concept learning in physics. A learning tool for VR about electric potentials and electric fields represented with vectors has been developed and tested on 26 high school students. Using pre- and posttests, we evaluated how students progressed on different types of items.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Poster Session: REM & STR / 175

Analyzing the pan flute: a strategy for understanding sound

Author: Ruth Paulina Martínez Victoria¹

¹ UNAM

Corresponding Author: ruthmartinezvictoria@gmail.com

The present didactic strategy generates in students a relationship between a topic of their interest such as music and the physical concepts treated in the waves theme and their characteristics, specifically the sound. Intellectual skills will be stimulated in students.

The main objective is to establish the relationship between terms related to sound and air columns from the construction of a musical instrument specifically the pan flute. An “inquiry methodology” was used. Following this methodology, the students carried out research on how to make a pan flute, encouraging their curiosity and reaching viable solutions that would allow pleasant sounds.

How would you like to present your contribution?:

Live in Ljubljana (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: REM & STR / 74

The influence of early physics education on development of rational thinking

Author: Alicja Wojtyna-Jodko¹

¹ *The (Polish) Association of Teachers of Natural Sciences and Technology*

Corresponding Author: awjodko@wp.pl

The COVID-19 pandemic has demonstrated that societies aren't prepared to unknown dangers. At least two have recently appeared: the SARS-CoV-2 virus and too low level of rational thinking of significant parts of populations. As a result, intense protests of anti-vaccines pose a significant threat to others.

Physics education is an appropriate and acceptable area to develop rational thinking.

Early physics education should focus on conscious observations of physical phenomena noticed by children in their surroundings, oral description, active experimenting and making reports (from

drawing pictures to developing more sophisticated forms).
Some examples of workshops and private lessons will be presented.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-school education

Target education level (secondary, optional):

PTE Workshop / 6

Problem Solving Seminar for Future Physics Teachers

Authors: Irena Dvořáková¹; Marie Snětinová¹

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

Corresponding Authors: dvorak.irena@gmail.com, snetinova.m@gmail.com

We present a seminar for future physics teachers focused on problem solving and creativity in problem solving. In this seminar, students are encouraged to find effective strategies to various problems on their own, to use multiple representations, and to be aware of barriers as well as possible clues to solving problems. Students and their teachers reflect together on the goal of each activity or problem, and look for ways to bring them into the regular classroom. The seminar is aimed not only at developing students' problem-solving competencies, but more importantly to draw them towards thinking like a future teacher.

How would you like to present your contribution?:

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

PTE Workshop / 156

Study and Discussion of examples of best practice of practitioners inquiry as a professional learning method for physics teachers.

Author: Wim Peeters^{None}

Corresponding Author: wim.peeters.int@gmail.com

This workshop uses at least 6 examples of practitioners inquiry as resources to discuss this methodology as a method of professional learning of (physics) teachers. Participants will be informed about each of the examples, the background and the learning needs the teachers expressed in their inquiry question. Following the inquiry cycle as proposed by N.Dana-Fichtman, the teachers set up an inquiry. They gather data about the impact on the learners, the class, the discipline group or even the school. Participants of the workshop will be able to reflect on the examples and exchange ideas about the professional learning method.

How would you like to present your contribution?:

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

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Higher-secondary education

PTE Workshop / 157

What Professional Training in Physics Education Should We Provide to Future Primary Teachers?

Authors: Federico Corni¹; Marisa Michelini²; Stamatis Vokos³

¹ *Free University of Bozen-Bolzano*

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This workshop is proposed by the GIREP Thematic Group “Physics Preparation of Teachers in Grades K-6” and consists of a discussion oriented to shared principles and guidelines for the achievement of competencies by student teachers at Kindergarten and primary school levels.

The discussion will be stimulated by three presentations that will introduce the salient issues. Participants will also work on the results of a questionnaire completed by researchers in the field of physics education.

How would you like to present your contribution?:

Live in Ljubljana (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

Remote Teaching and Learning / 145

A home-lab to study uncertainties using smartphone sensors

Authors: Cecilia Stari^{None}; Martin Monteiro^{None}; Arturo Marti^{None}

Corresponding Author: marti@fisica.edu.uy

We present a novel approach based on state-of-the-art technologies to teach error analysis and uncertainties to science and engineering students. In the last decade the appearance of smartphones considerably affected our daily life. Thanks to their builtin sensors, this revolution has impacted in many areas and, in particular, the educational field. Here we show how to use smartphone sensors to teach fundamental concepts for science students such as any measurement is useless unless a confidence interval is specified or how to determine if a result agrees with a model, or to discern a new phenomenon from others already known.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Remote Teaching and Learning / 61

An online teaching learning sequence with home experiments on relativity of motion and the equivalence principle in classical mechanics

Authors: Alessio Marzari¹; Massimiliano Malgieri^{None}; Pasquale Onorato¹; Tommaso Rosi¹

¹ *University of Trento*

Corresponding Author: massimiliano.malgieri@unipv.it

We designed a teaching-learning sequence on relative motion in classical mechanics, based on the fundamental design principle of highlighting those conceptual elements which could be valuable in the future learning of special and general relativity. In order to highlight selected key concepts and motivate students in their exploration, we used a series of experiments based on video analysis and interactive simulations, which can be modified on the fly by the students.

The sequence of activities was tested with a group of 24 undergraduate students in an online laboratory course during the COVID-19 pandemic.

How would you like to present your contribution?:

Live in Ljubljana (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

Remote Teaching and Learning / 144

Smartphones as partners to adapt labs to virtuality

Authors: Cecilia Stari¹; Arturo Marti²; Martín Monteiro³

¹ *Universidad de la República*

² *Instituto de Física, Universidad de la República, Montevideo, Uruguay*

³ *Universidad ORT*

Corresponding Author: ceciliastari@gmail.com

The COVID pandemic imposed a challenge on lab courses that had to quickly adapt to virtual modalities methodologies and experimental proposals. In this context, the use of smartphones, being precise and reliable, was an ally to implement experimental activities at home. Here we show examples of activities that can be done at home involving the students in the experimental design and in the choice of materials available at home. This has an impact on motivating further discussion and critical thinking, taking into account the physical model, the hypothesis and the best way to design the experimental setup.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Remote Teaching and Learning / 128

Students' use of different representations while communicating in a remote setting

Authors: Gregor Brumec^{None}; Bor Gregorcic¹; Gorazd Planinsic²

¹ *Uppsala University, Sweden*

² *Faculty of Mathematics and Physics, University of Ljubljana*

Corresponding Author: gregor.brumec14@gmail.com

In this study, we investigate how students in small groups in a remote setting communicate between each other while solving an activity based on the framework of the Investigative Science Learning Environment (ISLE). The activity is based on the video of pre-recorded surprising electroscope experiment, which was shown to the students. We documented students' use of different representations when searching for possible explanations of the observations. Using a social semiotic framework, we show how a simultaneous use of different representations by different students enabled them to provide explanations of the observations.

How would you like to present your contribution?:

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

Target education level (primary):

Pre-service teacher education

Target education level (secondary, optional):

Remote Teaching and Learning / 96

Analysis and evaluation of inquiry-based tasks in online learning scenarios

Authors: Despoina VALSAMOULI¹; Ioannis Lefkos²

¹ *Laboratory of informatics and Robotics in Education and Society, University of Macedonia*

² *University of Macedonia, Greece*

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The purpose of this research was to analyze and evaluate inquiry-based tasks found in online Inquiry Learning Scenarios on the Go-Lab platform, in terms of understanding of the scientific concepts they offer, the scientific process skills involved and their contribution in understanding the scientific inquiry. Inquiry-based tasks of 16 Example Inquiry Learning Scenarios were analyzed using the Inquiry-Based Tasks Analysis Inventory. Our findings suggest that these scenarios promote a high degree of understanding of scientific concepts and scientific inquiry process and that the degree of scientific process skills promoted, depends on internal characteristics of the scenarios.

How would you like to present your contribution?:

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

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Primary school education

Remote Teaching and Learning / 109

Evaluation of Croatian students' physics knowledge during the Covid-19 pandemic

Author: Ivana Štibi^{None}

Co-authors: Mojca Čepič¹; Jerneja Pavlin

¹ *University of Ljubljana, Faculty of Education*

Corresponding Author: istibi@fizika.unios.hr

The paper presents the results of the study on physics learning during the pandemic in Croatian schools. Data were collected using an online questionnaire and knowledge tests for each level of pre-university education (two testing cycles: school year 2020/2021 and 2021/2022). The data from questionnaire shows how physics teaching was conducted from the students' point of view and what problems the students had with online teaching and learning. The knowledge tests results show the difference in the level of physics knowledge in the pre-pandemic period, during online and hybrid teaching.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Remote Teaching and Learning / 173**Physics final matriculation exam in Slovenia 2020 - impact of Covid-pandemic****Authors:** Aleš Drolc¹; Aleš Mohorič^{None}¹ *National Examinations Centre***Corresponding Author:** ales.mohoric@fmf.uni-lj.si

Covid pandemic has caused disruption to pedagogical process. Schooling was moved on-line and resumed after a while in a limited extent in classrooms. It was feared this might have a significant impact on the matriculation exam. The preparations for the 2020 matura were disrupted for two months, from mid-March to mid-May and the matura was held in June. The analysis of the exam results shows only limited consequences, with signs of lenient grading by teachers. Less students than usual opted for the field modern physics with astronomy, as this is usually lectured in the last year.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Social event / 195****Social excursion to Bled****Social event / 196****Conference dinner****STR Workshop / 187****Similarities and Differences between Inquiry Based Learning and Practitioner Inquiry: Experiences from ERASMUS+ project 3DIPhE on the case of Cartesian diver****Authors:** Mojca Čepič¹; Ana Gostinčar Blagotinšek¹¹ *University of Ljubljana, Faculty of Education***Corresponding Author:** mojca.cepic@pef.uni-lj.si

ERASMUS+ project Three Dimensions of Inquiry in Physics Education (3DIPhE) investigated three levels of inquiry: inquiry based learning of students, practitioner inquiry for teachers and coaching professional learning communities of teachers.

In this workshop we present the first two dimensions and how they are connected with two practical examples: a special case of Cartesian diver, which introduces a cognitive conflict to students and how it can be studied by inquiry based learning and how it could be connected to practitioner inquiry.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Pre-service teacher education

STR Workshop / 25

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

Authors: Gerald Feldman^{None}; Guillaume Schiltz¹

¹ *ETH Zurich*

Corresponding Authors: feldman@gwu.edu, schiltz@phys.ethz.ch

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 will also address the adaptability of the collaborative approach to online virtual instruction, since this was a necessary circumstance prompted by the recent COVID-19 pandemic.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Strategies and Methods / 41

Friendship drives outside-group collaboration in school physics

Author: Javier Alejandro Pulgar Neira^{None}

Co-authors: Diego Ramirez¹; Cristian Candia²

¹ *Facultad de Ciencias, Universidad del Bío Bío*

² *Universidad del Desarrollo*

Corresponding Author: jpulgar@ubiobio.cl

In the performance of student groups, both within and outside-group interactions are critical for accessing and developing ideas. Outside-group collaboration is rarely studied, let alone the conditions that drive such interactions, for instance having friends outside one's team. This study explores whether random assigned or friendship-based groups associate with higher rates of outside-group interactions in a sample of high school physics students during one semester. Linear models show that outside-group collaboration is associated with outside-group friendship, and students from random assigned groups are more likely to access ideas from unique parts of the classroom network outside their groups.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Strategies and Methods / 14

Development of a climate change concept inventory (CCCI-422)

Authors: Thomas Schubatzky^{None}; Rainer Wackermann¹; Carina Wöhlke¹; Claudia Haagen-Schützenhöfer²; Hannes Lindemann¹; Kai Cardinal¹; Marko Jedamski¹

¹ *Ruhr-University Bochum*

² *University of Graz*

Corresponding Author: thomas.schubatzky@uni-graz.at

Understanding the scientific principles underlying climate change supports students to evaluate information regarding climate change in their everyday life. Concept inventories allow us to capture a current understanding of students but also commonly held alternative conceptions. Therefore, we developed a climate change concept inventory (CCCI-422) regarding five core concepts that are relevant for understanding climate change. After several qualitative development-cycles, we performed a quantitative pilot study in two phases with $N = 173$ and $N = 65$ persons from 8th grade upwards. The results demonstrate that the CCCI-422 is a reliable test-instrument to diagnose understanding of climate change.

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Strategies and Methods / 26**Students' mental models of the Apparent Motion of Sun and stars****Authors:** Hans Bekaert^{None}; Mieke De Cock¹**Co-authors:** Wim Van Dooren¹; Hans Van Winckel¹¹ *KU Leuven***Corresponding Author:** hans.bekaert@kuleuven.be

To better understand student difficulties to explain the apparent motion of the Sun and stars, and to gain insight in whether their explanations are based on specific mental models, we designed a test instrument that systematically probes different aspects of these apparent motions.

We administered the test to 410 Belgian students. Based on students' explanations, we developed a classification scheme and combined it with a latent class analysis to identify several mental models. While we argue for the existence of these mental models based on our data, we also see that many students do not answer the different questions coherently.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):**Strategies and Methods / 35****AMoSS-junior – A new test instrument on the Apparent Motion of Sun and stars for primary school students****Authors:** Mieke De Cock¹; Wim Van Dooren¹¹ *KU Leuven***Corresponding Author:** mieke.decock@kuleuven.be

Many young children, students, and adults have difficulties describing and explaining the apparent motion of the Sun and stars. However, a good understanding is essential to study more advanced astronomical concepts. Bekaert and colleagues developed and validated a dedicated test that allows to systematically map secondary school students' understanding of the Apparent Motion of the Sun and stars (AMoSS test). However, the test instrument is not suitable for substantially younger students.

In this contribution, we report on the development and validation of an instrument based on the AMoSS test, specifically aimed at 10-12-year-old students.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):

Strategies and Methods / 101**Promoting mechanistic reasoning in physics through the construction of stop-motion animations: A cognitive framework****Author:** Rayendra Bachtiar¹**Co-authors:** Ralph Meulenbroek¹; Wouter van Joolingen¹¹ *Utrecht University***Corresponding Author:** r.w.bachtiar@uu.nl

Although existing studies reported the promising results from students-constructed stop-motion animation (SMA) in supporting mechanistic reasoning (MR), these studies lacked theoretical perspectives underlying the results. To fill the need, our study developed a cognitive framework linking the nature of SMA construction (chunking and sequencing) and elements of MR. This framework was utilized to analyze the data from an exploratory case study involving five secondary school students constructing and using a SMA model to explain electrostatics phenomena. The results show that all students addressed the central elements of MR, i.e., entities and activities of entities, when engaging in chunking and sequencing.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Lower-secondary education

Strategies and Methods / 22**Concept Cartoon as a Stimulus for Students' Experimental Activities****Author:** Tatiana Sukeľová^{None}**Co-author:** Klára Velmovská**Corresponding Author:** tatiana.sukelova@fmph.uniba.sk

In this contribution, we focus on concept cartoons as an incentive to stimulate experimental activity. Concept cartoons have many different uses. We were concerned with stimulating experimental activities. We conducted a survey aimed at stimulating discussion in the teaching process using concept cartoons and we found out, they also stimulate students to experimental activities, since students needed to prove their claims by experiment.

How would you like to present your contribution?:

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

Target education level (primary):

Lower-secondary education

Target education level (secondary, optional):

Strategies and Methods / 147**Relationship between mathematical competencies and achievements in physics of 14 year old students**

Authors: Adriana Macuka¹; Ivana Poljančič Beljan²; Rajka Jurdana-Šepić²; Klaudija Lončarić²

¹ *Elementary school "Vladimir Nazor" - Krnica*

² *University of Rijeka, Faculty of Physics*

Corresponding Author: macuka.adriana@gmail.com

Students often have difficulty connecting problems in physics with their respective mathematical representation. Numerous studies have been conducted on this topic, but were almost exclusively focused on high school and college physics students. The sample size in this study is focused on 14-year-old elementary school students. A statistically significant positive correlation was obtained for analyzed relationships between mathematical competencies and achievements in physics (overall physics exam scores vs. overall mathematics exam scores, overall physics exam scores vs. math grades of sample students), suggesting that the latter are strongly entangled from the earliest age at which physics is taught.

How would you like to present your contribution?:

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

Target education level (primary):

Primary school education

Target education level (secondary, optional):**Strategies and Methods / 148****Multimodal expressions of disciplinary relevant aspects in inquiry-based physics learning, a tool to investigate meaning-making.**

Authors: Markku JÄÄSKELÄINEN¹; Roger Andersson²

¹ *Mälardalen University*

² *Malardalen university*

Corresponding Author: roger.andersson@mdu.se

In this study we are investigate how learners of introductory geometrical optics express disciplinary relevant aspects multimodally during inquiry-based learning supported by a computer simulation. Students' discussions and work with the simulation was filmed, transcribed and analysed using conversation analysis. In the parts where students expressed signs of disciplinary relevant aspects, we found proof that the students use nondisciplinary semiotic resources in their reasoning about the tasks. Especially gestures, that by their visual nature are well suited for communication in physics, were used by the students to transduct semiotic information.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Higher-secondary education

Strategies and Methods / 127

The Potential Role of Learning Physics on Paranormal Beliefs

Author: Mo Basir^{None}

Corresponding Author: basir@ucmo.edu

Studies in science education and learning psychology have shown that student misconceptions and paranormal beliefs may have caused by a same mechanism, intuitive thinking. Since the coordination of theory and evidence, and being reflective about the epistemic practice are effective approaches to change student alternative conceptions, they may also influence paranormal beliefs, we wondered. We accompanied NGPET physics curriculum with an online learning community emphasizing the reflective aspect of physics learning. The results of pre- and post-survey and the post-assessment on paranormal beliefs suggest statistically significant changes. We hypothesized these changes may be influenced by being reflective about epistemic practice.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Strategies and Methods / 69

How students understand the one-dimensional wave equation

Author: Muhammad Aswin Rangkuti^{None}

Co-author: Ricardo Karam¹

¹ *Department of Science Education, University of Copenhagen, Denmark*

Corresponding Author: aswin.rangkuti@ind.ku.dk

Even though the (1-D) wave equation may seem simple at a first glance, it actually contains a lot of information and making sense of it is far from trivial. This study investigates students' main conceptual difficulties in understanding the physical meaning of the wave equation, by conducting semi-structured interviews. The study also provides various teaching experiments that assist students more effectively in developing a conceptual understanding of the wave equation. Comparing the results between a pre- and a post-test, we notice the transition of students' response to interpret the wave equation from "reading" and "generalization" into "elaborating" and "distinction".

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Strategies and Methods / 70

The role of domain-specific growth mindset (implicit theories) at the beginning of STEM university studies

Author: Malte Diederich^{None}

Co-author: Verena Spatz¹

¹ *TU Darmstadt*

Corresponding Author: malte.diederich@physik.tu-darmstadt.de

Mindsets can have a great impact on learning and play a particularly important role when facing challenges such as transition from school to university. In two questionnaire surveys at the start and two months into the semester, the mindset of university first-years in several STEM subjects was measured with domain general and newly developed domain specific scales. The relation with the “mindset meaning system” (negative effort beliefs, performance avoidance goals, learning goals, helpless response), academic self-concept and intention to change major or drop out is used to discuss scale validity and the role of mindset during students’ first academic semester.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Strategies and Methods / 85

Teachers’ Interpretation of Data Revealed by GrouPer: A Learning Analytic Tool for Personalized Instruction

Authors: Michal Walter¹; Kana Ofir¹; Eliran Chen¹

Co-authors: Smadar Levy¹; Tanya Nazaretsky¹; Giora Alexandron¹; Edit Yerushalmi¹

¹ *Weizmann Institute of Science*

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GrouPer is a learning analytics tool presenting groups of students who exhibit similar knowledge structures in specific curricular topics alongside related semantic information. It is designed to support teachers in personalizing instruction. We examined how high school Physics teachers (N=20) interpreted the data provided by the GrouPer via interviews and self-reports reflecting on their classroom experience with GrouPer related to magnetic force on a moving charge and static friction. Teachers interpreted the semantic data in terms of a hierarchical scale. They drew conclusions regarding their competency and attended to individual students they perceived as outliers rather than to students’ clusters.

How would you like to present your contribution?:

Live in Ljubljana (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

Strategies and Methods / 138

A Disciplinary Learning Companion: lessons learned

Authors: Elien Sijmkens¹; Mieke De Cock²; Tinne De Laet¹

¹ *Faculty of Engineering Science & LESEC, KU Leuven*

² *Dept Physics & Astronomy & LESEC, KU Leuven*

Corresponding Author: mieke.decock@kuleuven.be

As problem solving is an important aspect of physics education, we want students to become able to regulate their solving process. Therefore, in addition to sufficient conceptual understanding and procedural knowledge, they need metacognitive skills. We present a prototype for an online tool that aims at stimulating students' metacognitive skills for problem solving through problem-specific reflection on the solving process. We discuss a case study of the implementation of the tool within a 1st year mechanics course. In particular, we discuss how teaching assistants can support the development and the integration of the tool in the context of the course.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Strategies and Methods / 47

Analyzing test efficiency of computerized adaptive testing for the Force Concept Inventory

Authors: Jun-ichiro Yasuda¹; Michael HULL²; Naohiro MAE³

¹ *Yamagata university*

² *University of Vienna*

³ *Osaka University*

Corresponding Author: baryogenesis@gmail.com

We improved test efficiency of a computerized adaptive testing (CAT)-based version of the force concept inventory (FCI) by utilizing the pretest proficiency estimate of each respondent. We conducted a Monte Carlo simulation to analyze how implementing this algorithm affects the accuracy and precision of Cohen's d and calculated the minimal test length of the FCI-CAT whose accuracy and precision are equivalent to that of the full-length FCI. Consequently, we found that, for a class size

of 40, we can reduce pre- and post-test lengths of the FCI-CAT totaling 29 items, thereby reducing the testing time to 48%.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Students' Identity and Wellbeing as Learners / 87

Exploring the relationships between undergraduate and high school students' self-efficacy, engagement, and attitudes towards physics: a structural equation model

Authors: Italo Testa¹; Danilo Catena²

¹ *University Federico II Naples*

² *Department of Physics "E. Pancini"*

Corresponding Author: italo.testa@unina.it

The purpose of this study was to analyse the relationships between students' attitudes towards, engagement in, and self-efficacy about physics. The analysis was based on three Likert-scale surveys, which measured the dimensions of the three constructs, administered online to 1971 Italian undergraduate and high school Italian students. After exploring several possible alternatives, we validated a structural model in which attitudes play the role of the independent variable, self-efficacy represents the dependent variable, and engagement acts as total mediator. Our analysis has implication for teaching of physics both at high school and university level.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Higher-secondary education

Students' Identity and Wellbeing as Learners / 49**Assessing the prior knowledge of students in physics minors****Authors:** Kevin Schmitt^{None}; Verena Spatz¹¹ *Technical University Darmstadt***Corresponding Author:** kevin_richard.schmitt@tu-darmstadt.de

The number of students who give up science and engineering in the first semesters is regrettably high. While there is empirical evidence for the relationship between (the lack of) prior knowledge in mathematics and dropout, there are – to our knowledge - no studies concerning the relevance of prior knowledge in physics, even though physics is a compulsory minor in many subjects. Therefore, a knowledge test was constructed and statistically validated with students from different physics minors (n=530). In this paper, we report about the structure of the test and summarize first results showing good reliability in each test section.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):**Students' Identity and Wellbeing as Learners / 154****An epistemic approach to physics identity****Authors:** Francesco De Zuani Cassina^{None}; Olivia Levrini¹¹ *Università di Bologna***Corresponding Author:** francesco.dezuani2@unibo.it

Great attention has been devoted to studying how socio-cultural problems, such as students' participation, gender differences in persistence, epistemic injustice, impact disciplinary identity. However few literature accounting for what kind of impact discipline in itself has on identity development is present; in this work, building on "Reconceptualized FRA to NOS frameworks", we introduce the design of the theoretical construct of epistemic identity, a lens by which to analyze the intertwining of physics epistemological structure and students' identity development through learning. Ultimately is shown an exploratory analysis made on a student interview which exhibits some potentialities of the construct.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

University education

Students' Identity and Wellbeing as Learners / 81**Women studying physics: who are they and what are their experiences?****Author:** Judith Hillier¹¹ *University of Oxford***Corresponding Author:** judith.hillier@education.ox.ac.uk

In many countries, women are still under-represented in physics, despite many initiatives to encourage more women to study and work in physics. This study examines the educational and family backgrounds of 800 women studying physics at universities in the UK and Ireland to explore what influenced their decision to study physics and what have been their experiences so far. The majority do not have physics in their family background; being strongly encouraged to study physics by their physics teacher. However, most have already had a number of negative experiences, including sexist stereotypes, suggesting implications for the cultures within physics departments.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Symposium / 203**Development of quantum concepts via different two-state approaches****Authors:** ALBERTO STEFANEL^{None}; Gesche Pospiech^{None}; Kristóf Tóth^{None}; Lorenzo Santi¹; Marisa Michelini^{None}; Philipp Bitzenbauer^{None}¹ *Sapienza Universita e INFN, Roma I (IT)*

In the last decades two-state approaches were increasingly considered useful for introducing quantum physics to students on all levels. Some promising results were reached. However, a thorough evaluation with reliable and validated instruments is still missing. In addition, it could be possible that some two-state approaches are more suitable to some quantum concepts than to others. In order to be able to evaluate and compare different approaches instruments are developed. In the project "DQC-2stap" first steps towards this goal are taken. We describe the development of a questionnaire on the measuring process and a corresponding activity for in-service teacher education.

Target education level (secondary, optional):**Target education level (primary):****How would you like to present your contribution?:**

Symposium / 204

Community-based development of the Quantum Concept Inventory

Authors: Andreas WOITZIK¹; Aurél GÁBRIS²; Avraham Merzel³; Caterina Foti⁴; Daria ANTILLA⁵; Erica Andreotti^{None}; Franziska GREINERT⁶; Gesche Pospiech^{None}; Henk Pol^{None}; Kim Krijtenburg-Lewerissa⁷; Kirsten Stadermann^{None}; Leon Jurčić⁸; MARILU CHIOFALO⁹; Malte UBBEN¹; Maria Bondani¹⁰; Massimiliano Malgieri¹¹; Mieke De Cock¹²; Pasquale Onorato¹³; Philipp Bitzenbauer^{None}; Rainer MÜLLER⁶; Renaat Frans^{None}; Simon GOORNEY¹⁴; Zdeňka Koupilová^{None}

¹ *Westfälische Wilhelms-Universität*

² *QWorld Association*

³ *The Hebrew University of Jerusalem*

⁴ *Aalto University*

⁵ *University of Turku*

⁶ *Technische Universität Braunschweig*

⁷ *Utrecht University*

⁸ *University of Ljubljana*

⁹ *Department of Physics, University of Pisa*

¹⁰ *CNR - Institute for Photonics and Nanotechnologies*

¹¹ *University of Pavia*

¹² *KU Leuven*

¹³ *University of Trento*

¹⁴ *Aarhus University*

For the improvement of quantum physics education at the secondary level, it is important to develop a flexible assessment tool, which is suitable for evaluating the numerous existing teaching concepts that have emerged from physics education research over the last decades. We therefore give an overview of the plans of the QTedu pilot project 'Community-based development of the Quantum Concept Inventory' to create such an assessment tool. Additionally, we will present the results of a Delphi study aiming to identify the community's perspective on key topics for teaching quantum physics at the secondary school level.

Target education level (secondary, optional):

Target education level (primary):

How would you like to present your contribution?:

Symposium / 205

Cultural Storytellings in Quantum Science and Technology Education

Authors: ALBERTO STEFANEL^{None}; Aditya Anupam¹; Carrie Weidner^{None}; Elif Surer²; Ilke Ercan³; Jacob Sherson⁴; Jorge Yago Malo⁵; Lorenzo Santi⁶; MARILU CHIOFALO⁷; Maria Bondani⁸; Marisa Michelini^{None}; Olga Zabello⁹; Simon GOORNEY¹⁰; Zeki Seskir^{None}

¹ *Georgia Institute of Technology*

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³ *TU Delft*

⁴ *Aarhus University (DK)*

⁵ *University of Pisa (IT)*

⁶ *Sapienza Università e INFN, Roma I (IT)*

⁷ *Department of Physics, University of Pisa*

⁸ *CNR - Institute for Photonics and Nanotechnologies*

⁹ *Offenburg University (DE)*

¹⁰ *Aarhus University*

The field of Quantum Science and Technologies (QST) has the potential to generate significant changes in every citizen's lives, and so a carefully designed approach to its formal and informal education activities is essential. In this contribution, we reflect on the functions of outreach in developing the modern scientific mind, discuss its essential importance in the modern society of rapid technological development, and propose a novel framework, Culturo-scientific storytelling. In a manner consistent with Responsible Research Innovation, we propose tools to implement this narrative within the pilot project Quantum Technologies Education for Everyone (QUTE4E).

Target education level (secondary, optional):

Target education level (primary):

How would you like to present your contribution?:

Symposium / 206

Italian Quantum Weeks outreach activities to enhance quantum awareness

Author: Maria Bondani¹

¹ *CNR - Institute for Photonics and Nanotechnologies*

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The three-year project Italian Quantum Weeks was born from the desire to take the opportunity of the World Quantum Day (April 14) to try to spread the knowledge of quantum mechanics and quantum technologies in schools and, more generally, to the entire citizenry. IQWs involves more than 130 researchers, technicians, disseminators, communicators, teachers, belonging to more than 40 research institutions, universities, scientific societies, in 17 Italian cities.

Target education level (secondary, optional):

Target education level (primary):

How would you like to present your contribution?:

Symposium / 179**Contributions from Pilot Projects in Quantum Technology Education as Support Action to Quantum Flagship****Author:** Sergej Faletic^{None}**Corresponding Author:** sergej.faletic@fmf.uni-lj.si

The GIREP community on teaching and learning quantum physics and the Education section of the Quantum flagship project of the European Union have brought together different stakeholders in the field of teaching quantum physics. From university staff involved in quantum technology and research and with a long history of teaching the topic at university level to researchers and practitioners wanting to bring quantum physics to pre-university level and the general public. Within the initiatives several projects have been initiated. This symposium brings together four of them to discuss challenges, solutions and synergies between them.

How would you like to present your contribution?:

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

Target education level (primary):

Upper-secondary education

Target education level (secondary, optional):

Outreach

Symposium / 31**Connecting research in physics education, curriculum decisions and teaching practices****Authors:** Arturo Marti¹; Jenaro Guisasola²; Ornella Pantano³; Paulo Sarriugarte⁴; Shulamit Kapon⁵¹) *Instituto de Física, Universidad de la República, Montevideo, Uruguay*² *University of the Basque Country*³ *Department of Physics and Astronomy, University of Padova, Italy*⁴ *Donostia Physics Education Research Group (DoPER), Department of Applied Physics, University of the Basque Country (UPV-EHU) Spain*⁵ *Faculty of Education in Science and Technology, Technion***Corresponding Authors:** jenaro.guisasola@ehu.es, ornella.pantano@unipd.it

Abstract. In the PERU symposium we deal about the physics education research and the consequences of its results for physics teaching. The symposium presents four different aspects of physics teaching and learning, but which have in common research-based problem analysis. All four proposals are based on rigorous problem analysis and standard methodology in PER. Thus, their conclusions are not just intuitive proposals based on teaching experience, but on careful planning of data collection, analysis of results, and evidence-based.

How would you like to present your contribution?:

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

Target education level (primary):

University education

Target education level (secondary, optional):

Higher-secondary education

Symposium / 202

University Students' reasoning for Understanding of Moment of Inertia

Authors: Jaume Ametller¹; Jenaro Guisasola²; Kristina Zuza³; Paulo Sarriugarte²

¹ *University of Girona (ES)*

² *UPV/EHU*

³ *UPV/EHU (Applied Physics Department)*

The aim of this contribution is to study the difficulties encountered by first-year university students in understanding the moment of inertia in phenomena of rotation of a rigid body about a fixed axis. Here we complete a previous study by analysing open-ended questionnaires carried out with first year students in a calculus-based introductory physics course. The questions were designed following an epistemological analysis in order to raise the key concepts needed to understand the moment of inertia of a rigid body properly. Obtained knowledge constitutes a relevant contribution when designing a Teaching Learning Sequence (TLS) to be implemented in lectures.

Target education level (secondary, optional):

Target education level (primary):

How would you like to present your contribution?:

Symposium / 201

Test of Calculus and Vector in Mathematics and Physics: A research-based tool for improving the teaching and learning of physics in first-year courses

Authors: Marta Carli¹; Ornella Pantano²

¹ *Department of Physics and Astronomy, University of Padua, Italy*

² *Department of Physics and Astronomy, University of Padua*

The Test of Calculus and Vectors in Mathematics and Physics (TCV-MP) was developed in 2018 as a tool for supporting the teaching and learning of physics in introductory courses at our university. The instrument is a research-based, multiple-choice test aimed at comparing students' ability to answer questions on derivatives, integrals, and vectors in the mathematical and physics contexts. The test is administered to the students as a self-assessment tool, and interactive online learning modules are offered upon completion of the test. In this contribution we discuss the test development and results and provide examples of the online learning modules.

Target education level (secondary, optional):

Target education level (primary):

How would you like to present your contribution?:

Symposium / 200

What are the differences in the attitudes and beliefs about science of students in the physics-mathematics and life sciences areas? and what are their impact on teaching?

Authors: Alvaro SUÁREZ¹; Arturo Marti²; Daniel Baccino¹; Martín Monteiro³

¹ ANEP (UY)

²) Instituto de Física, Universidad de la República, Montevideo, Uruguay

³ Universidad ORT

We compared the attitudes and beliefs about science at the beginning of their university degrees using the CLASS (Colorado Learning Attitudes about Science Survey) tool of two groups of students: physical science and life science. Both groups received similar physics courses during their high-school education. We examined the differences in performance in each of the areas that make up the questionnaire. We found that a larger percentage of life science students (higher than that of physical science students) adopted a “novice” behavior in problem solving. We discuss some of the possible causes of the differences found and their implications for teaching.

Target education level (secondary, optional):

Target education level (primary):

How would you like to present your contribution?:

Symposium / 199

Learning Physics while Engaging in an Engineering Project

Authors: Maayan Schwartz¹; Shulamit KAPON²; Tal Peer³

¹ Technion – Israel Institute of Technology (IS)

² Faculty of Education in Science and Technology, Technion

³ Acheret Center - Multicultural Research Fellowship (IS)

Building on an extended ethnographic case study of two high school students who work on an engineering project as part of their advanced-level studies of physics (Kapon, Schwartz, & Peer, 2021), we discuss the affordances and challenges of engaging students in engineering projects as a venue for learning physics at the advanced high school level.

Target education level (secondary, optional):

Target education level (primary):

How would you like to present your contribution?:

VIRTUAL Workshop / 24**VIRTUAL WORKSHOP: Home-Adapted ILDS—Interactive Lecture Demonstrations Adapted for Active Virtual Learning**

Author: David Sokoloff^{None}

Corresponding Author: sokoloff@uoregon.edu

The pandemic inspired a need for distance learning materials that still exists in many parts of the world. Is it possible to maintain active learning for our students in virtual settings? Home Adapted ILDs bridge this gap. They retain predictions as an essential element in engaging students and make use of the wealth of multi-media materials for observations of the physical world.

We will first review design features of ILDs (1) and then work with examples of Home Adapted ILDs. (2)

(1) David R. Sokoloff, “Active Learning of Introductory Light and Optics,” Phys. Teach. 54: 1, 18 (2016).

(2) <https://pages.uoregon.edu/sokoloff/HomeAdaptedILDs.html>

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