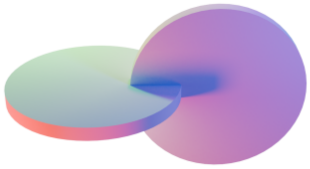
GIREP-EPEC 2025 Conference, Leiden, The Netherlands

Monday 30 June 2025 - Friday 4 July 2025

Leiden University, Gorlaeus building



GIREP-EPEC

Transforming physics learning via Research & Practice

LEIDEN, 2025

Book of Abstracts

Editors: Paul Logman & Claudio Fazio

Contents

Poster session / 294

How social belonging and performance varies across demographic groups in first-year science students

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Social belonging plays a crucial role in shaping the academic experiences and outcomes of first-year science students. This study investigates how social belonging correlates with demographic factors such as gender identity, racialization, and international/domestic status. It combines quantitative and qualitative approaches to uncover the key factors influencing engagement and retention.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 148

Enhancing Engineering Education: A Digital Twin and Interactive Manual Approach for Dynamic Hands-On Learning

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Traditional hands-on lab projects provide valuable learning opportunities but are often constrained by limited lab space, staff availability, and equipment constraints. Additionally, students with social anxiety, neurodiversity, or disabilities may face challenges in traditional lab settings. This work presents a novel approach to addressing these issues through the development of a digital twin—a simulated replica of physical lab hardware—integrated into an interactive course manual (Jupyter book). This open educational resource enables students to refine, test, and optimize their projects in a virtual environment before transitioning to physical labs, enhancing accessibility, scalability, and overall learning outcomes.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 215

Efficacy of Doodles in Learning Quantum Concepts: An Innovative Visual Pedagogical Approach

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As part of the International Year of Quantum Science and Technology 2025, the Indian Association of Physics Teachers is launching a quantum physics outreach program for secondary and first-year undergraduate students. The program aims to make students aware of quantum science and related technologies through targeted topics. A case study on de Broglie's matter wave hypothesis leading to the electron microscope will be presented. The program includes creating doodles, a webinar with teachers, and a concept inventory of multiple-choice questions for students. The effectiveness of visual learning through doodles will be assessed, and results will be shared at the conference.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Quantum mechanics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 79

Exploring Preservice Physics Teachers' Reasoning of Measurement Uncertainty

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This study reports the preliminary results of an ongoing research which aims to explore a sample of Turkish preservice physics teachers' reasoning of uncertainty in scientific measurements. The participants consisted of 23 preservice physics teachers. Data sources included written responses to the Physics Measurement Questionnaire (PMQ), laboratory reports, and in-depth interviews. The initial findings showed that participants held naive ideas about the concept of uncertainty in measurements, largely subscribing to either a point-like or mixed reasoning. It was also found that the participants were mostly not confident in their responses, indicating gaps in their conceptual understanding of measurement and uncertainty.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Poster session / 233

Students' reasoning in choosing measurement instrumentation

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see attached file

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Lab experiments

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 43

Exploring secondary school students' operationalisation of relativistic thought experiments

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Special relativity is a challenging topic for secondary school students due to its abstract and counterintuitive nature. Thought experiments are often used to make relativistic effects tangible. Prior research has shown that students often express thought experiments in intuitive operationalisations, rooted in everyday experiences. We developed and evaluated a three-part lesson series focusing on simulation-based inquiry activities to familiarise students with the formalism of spacetime events. We found that the simulation activities helped students to operationalize displacement, relative velocity, and proper time more formally. Moreover, the insights gained from the simulation activities were successfully transferred to post-lesson questions.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Contemporary and modern physics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 187

Evaluating Scientific Argumentation Skills in Undergraduate Lab Reports at scale using AI

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Evaluating the efficacy of teaching scientific argumentation skills in undergraduate courses is an important task for ensuring that we are providing a high-quality scientific education. To this end, we propose an approach that leverages recent advancements in computational methods to automate the extraction of text from undergraduate student lab reports and identify elements of scientific argumentation. We build on existing argumentation frameworks to develop a new coding scheme that encompasses content labels, inter-sentence relations, and physical and logical correctness. With this method, we aim to investigate the possibility of building a fully automated pipeline for evaluating our teaching.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Evaluation & Assessment

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 49

Concept Mapping in Undergraduate Physics Courses: A Case Study in a Nuclear Physics Course

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Concept maps are visual representations of the relationships between concepts. While a typical undergraduate physics course has a long list of concepts, the concept maps help to organize these ideas into a structure. Physics concept maps can be successfully used in introductory physics courses to visualize the concepts hierarchy and make complex and abstract ideas more comprehensible to learners. This talk will discuss the experience and suggest best practices of using concept maps in an upper undergraduate Nuclear Physics course.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Contemporary and modern physics

Research focus:

Active learning

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Education level

Poster session / 238

AC current through an open circuit: Demonstrating the role of a capacitor as a reservoir of charge

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We measure current in an open AC circuit generated by connecting capacitors which act as charge sinks to the open end of the circuit. In the infinite capacitance limit, the current is the same as for a closed circuit. This demystifies the concept of Earth" or ground in a circuit. A neon lamp is used to measure these small currents non-invassively. The setup can be used to demonstrate the current in open circuits, the concept ofEarth" in circuits, and to measure very small capacitances associated with single conductors. This experiment is appropriate for an undergraduate physics laboratory.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Contemporary and modern physics

Research focus:

Lab experiments

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Track

Workshops / **14**

Building a timer: Modeling Instruction in the Netherlands - INSTR

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Modeling Instruction is a guided inquiry-based learning approach that fosters student engagement and deep understanding of physics through collaborative model development and deployment. This workshop narrates the experiences gained with this method in Dutch classrooms, which sparked enthusiasm among teachers and students alike. Attendees will engage in a hands-on activity encompassing both phases of Modeling Instruction: developing a model for spring mechanics and deploying it to construct a timer. Participants will experience the method's collaborative dynamics, and gain insight into its potential to inspire both teachers and students.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / **122**

Optimizing Large Language Models Assisted Learning in Experimental Physics Lab

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This study explores the integration of large language models (LLMs) in physics laboratory education, focusing on their effectiveness and required adjustments. An LLM assistant was deployed in four implementations involving 190 students in online and in-person instruction. The research identified that LLM performance varies with question type, excelling with factual and analysis questions but requiring detailed context for observation- and measurement-based tasks. Iterative adjustments, including targeted prompting and broader acceptable answer ranges, significantly improved outcomes. Findings highlight the potential of LLMs to support experimental learning and provide actionable insights for educators integrating AI tools into laboratory settings.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Artifical Intelligence

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Parallel oral presentations / 101

Quantifying students' collective creativity in designing soft matter experiments

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Creativity is an important higher order skill but it is hard to measure directly. Various methods to measure students' collective creativity are compared and discussed. These methods were applied to students' design proposals for an own choice experiment in soft matter. After comparison, the most promising quantification of collective creativity was a random probability calculation of the subject distribution. By being able to distinguish smaller changes in collective creativity between years, this new measure will be very helpful in improving future implementations of lab courses to stimulate creativity in students.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Lab course design

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 232

Adaptive Physics for Real Barbies and Kens –Special Educational Needs for Physically Disabled High School Students in Physics Classes

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A few decades ago, Barbie dolls appeared, presenting an idealized body image and indirectly affecting education. The curriculum and methods seemed designed for non-existent students. Nowadays, the toy industry recognizes the need for toys with real personality traits. We should not delay; not all students in physics classes are equally super-capable, and there are increasing special educational needs. Our methods should adapt to these personal learning needs. This inclusive approach is challenging, and the present work offers ideas for solutions.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 170

Faculty Online Learning Communities: Sustaining Inquiry-Based Teaching in Physics Education

Author: Mo Basir[1]

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Faculty Online Learning Communities (FOLCs) provide sustained support for faculty implementing research-based instructional strategies (RBIS), fostering both immediate pedagogical improvements and long-term professional growth. Synthesizing two studies on the Next Generation Physical Science and Everyday Thinking (NGPET) FOLC, this study examines how faculty transition from curriculum adopters to mentors and leaders. Using Wenger et al.'s value creation framework, findings highlight teaching efficacy, leadership development, and institutional influence as key outcomes. FOLCs mitigate institutional barriers and promote faculty persistence in student-centered teaching, underscoring the need for long-term, community-driven faculty development models to drive STEM education reform.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 200

Using the Item Response Theory to Validate the Heat and Temperature Conceptual Evaluation test

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Thermodynamics poses numerous conceptual challenges for pupils. Students frequently possess insufficient knowledge structures for advanced contemplation of thermodynamic processes. Aim of physics education research is often to examine students' comprehension or conceptualisation in physics through standardised assessments. This study examines the 28-item questionnaire titled Heat and Temperature Conceptual Evaluation. Our objective is to validate it through the application of Item Response Theory methodology. The research participants consist of approximately 300 undergraduate students. The IRT model assesses the efficacy of the questionnaire and establishes the difficulty levels of heat and temperature concepts measured by this evaluation tool

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Thermodynamics and Energy

Research focus:

Evaluation & Assessment

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Poster session / 198

Study of rotational motion by a fidget spinner and smartphone

Authors: Aurelio Agliolo Gallitto[1]; Maria Rosalia Carotenuto[1]; Giulia Termini[1]; Claudio Fazio[1]; Onofrio Rosario Battaglia[1]

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Rotational motion is experimentally investigated using a modified fidget spinner and smartphone. The experimental results are described by a didactic model based on the Newton's second law for the rotational motion, considering the resulting resistive torque acting on the system. We analyse the physics concepts that are involved in the experimental activity, such as angular velocity and moment of inertia. We show that it is possible to transform a well-known popular toy into an opportunity to teach/learn physics concepts, by performing easy and valuable physics experiments in classroom at undergraduate and first-year university laboratory.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Lab experiments

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 169

Developing Student Competences for Sustainable Development: Are Teachers Prepared

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Education for Sustainable Development (ESD) equips learners with the knowledge, skills, and values for a sustainable future, yet remains limited in science curricula. This study explores: What are science teachers' views on student competences in ESD? How do they prioritize or dismiss these competences in their teaching? Using Q methodology and KADE software, we identified three factor arrays. Across all arrays, critical thinking and systems thinking were valued, though to varying degrees, while political agency was consistently seen as less important. Understanding these perspectives is crucial for shaping effective policies and frameworks.

Education level:

Pre-service and in-service teacher education

Physics topic:

Interdisciplinary topics

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 218

A network study using historical data to assess the production of women in physics by women's colleges

Author: Joanna Behrman[1]

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Gender equality in physics is a pressing issue as women continue to be underrepresented at almost all levels of education or employment. However, women's colleges have produced a disproportionate number of female science graduates for over a hundred years. In this longitudinal interdisciplinary study, historical institutional records have been used to create a purpose-built database of hundreds of women in physics spanning two centuries. We conducted bipartite (two-mode) network analyses of female physicists with both institutions and people as nodes. Preliminary results indicate key factors in the success of a subset of highly productive institutions for women in physics.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 279

A Structural Model of Grit, Expectancy-Value and 21st Century Skills on the Physics Achievement of STEM College Freshmen Students and Its Implications on Tertiary STEM Education

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Co-author: Sheryl Lyn Monterola [2]

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Recent results of the Basic Education Exit Assessment (DepED, 2019; Manila Times, 2020), a national achievement test that was administered to all Grade 12 students, showed that students had a low mean percentage score (MPS) of 41.6% in Language, 32.1% in Science, and 27.9% in Mathematics. Furthermore, 21st century skills were below proficiency. Specifically, the MPS in problem-solving was 38.1%, 35.9% in information literacy, and 34.9% in critical thinking. The low proficiency in STEM and 21st century skills ran counter to the broader agenda of the country, which was to accelerate human capital development in STEM fields to sustain inclusive economic growth. Similarly, Almerino et al. (2020) evaluated the performance of K-12 students using a standardized test known as the Scholastic Abilities Test for Adults (SATA). Results showed concerns regarding the mismatch between coursework offered in Philippine K to 12 educational institutions with industry demands. Their study showed that many students may still need to prepare for higher education and obtain jobs despite the K to 12 curriculum reforms.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Poster session / 19

Leveraging AI for Rapid Generation of Physics Simulations in Education: Building Your Own Virtual Lab

Author: Yossi Ben Zion[1]

Co-authors: Noah D. FINKELSTEIN [2]; Roi Einhorn Zarzecki [1]; Joshua Glazer [1]

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Generative AI is revolutionizing education by enabling dynamic and personalized learning tools. This talk presents a methodology for creating physics simulations using AI models such as ChatGPT and Claude. By leveraging these tools, educators and learners can generate simulations of physical phenomena without prior coding expertise.
Primary simulations were selected to demonstrate the versatility of the AI-generated tools, representing diverse topics typically taught in introductory physics courses. These examples demonstrate how a generic, adaptable AI prompt can support educators and students. Validation processes ensure accuracy and usability, including technical checks for responsiveness and physical tests for consistency with theoretical models.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Artifical Intelligence

Research method:

Other

Organizing preference criteria:

Track

Parallel oral presentations / **18**

Global Blind Spot in Understanding Trigonometric Derivatives: A Multinational Analysis

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This study identifies a global challenge in mathematics and physics education: a widespread “blind spot” of trigonometric derivatives and their implications for physical systems. Data were collected from 700 university science students across four countries: Israel, USA, China, and India. Findings show that 70%-80% of participants were unaware that these derivatives differ when measured in degrees versus radians, highlighting a systematic gap. In the context of harmonic oscillation, incorrect responses dropped to 35-45%, yet many still struggled to explain why radians are necessary. The consistent results across countries emphasize the need for targeted pedagogical strategies to address this issue.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 22

How do pre-service physics teachers envision physicists?

Author: Angelika Bernsteiner[1]

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To integrate nature of science learning opportunities for pre-service physics teachers into our teacher education program, we first investigate the pre-service teachers' perceptions of physicists. For this, we use an extended version of the Draw a Scientist test, supplemented by open-ended questions on knowledge, skills and personality traits associated with physicists, as well as the relation towards the physics community. The pre-service teachers' drawings show physicists experimenting, calculating and theorizing. However, they mostly assign these physicists content knowledge, rather than epistemic knowledge. This highlights an aspect to be addressed in physics teacher education.

Education level:

Pre-service and in-service teacher education

Physics topic:

Interdisciplinary topics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Poster session / **161**

Modelling Quantum Curriculum Innovation

Author: Jonas Bley[1]

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In our previous work, we modelled quantum curriculum transformation in five dimensions: 1) content conveyed, 2) skills evoked, 3) level of cognitive ability targeted, 4) representations used and 5) teaching approach employed. We extend this work to practical considerations to model quantum curriculum innovation in contemporary courses and the use and development of digital learning modules. We identify innovative methods that are used in quantum education and main hurdles in the way of innovation.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Contemporary and modern physics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Symposium / **173**

Successes and challenges in ISLEzing learning and teaching

Authors: Valentina BOLOGNA[1]; Danielle BUGGÉ[2]; Bor GREGORČIČ[3]; Andreja ŠARLAH[4]

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For over three decades, the Investigative Learning Science Environment (ISLE) approach has been implemented and used in many different countries, systems, and levels of instruction. Worldwide diffusion is confirmed by scientific literature, validating that an epistemologically authentic inquiry process, mirroring what physicists do, is a possible way to develop scientific abilities and become citizens of the new generations facing many challenges. Researchers and teachers involved in the process of ISLEzed teaching-learning practices recognize that there are many issues to address. This symposium focuses on current challenges, strategies to overcome them, and methods to foster instructional innovation from research and teaching perspectives.

Education level:

All ages

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 264

Formal and informal approaches to quantum mechanics using quantum cryptography

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Quantum technologies rely on superposition and entanglement, concepts that challenge classical physics and provide a rich context for teaching. We developed a course for high school teachers that focused on quantum cryptography and used Thorlabs' educational equipment for hands-on learning. The course covered quantum mechanics, light polarization, and the BB84 quantum key distribution protocol through theoretical and experimental sessions. In addition, a card game was introduced as a public outreach tool to interactively perform the BB84 protocol. Feedback from teachers confirmed the feasibility of integrating these concepts into curricula to promote quantum literacy and engagement in secondary education.

Education level:

Pre-service and in-service teacher education

Physics topic:

Quantum mechanics

Research focus:

Competence-based education

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Workshops / **277**

Highlights of the "Quantum"exhibition: How to exploit ad-hoc designed demonstrators and staging activities to introduce quantum physics to a general audience - QUANT

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In recent years, the emergence of quantum technologies and the vast scientific activities in the field of quantum science have also boosted the number of dissemination initiatives regarding Quantum Physics (QP). In the last four years, within the Italian Quantum Weeks project [2], we have been proposing an exhibition where the visitors are introduced to the basic concepts of QP through visual analogies, ad-hoc designed demonstrators and staging activities. In this workshop, we aim to propose these activities to the participants, which will have the possibility to actively test them and discuss their effectiveness.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Quantum mechanics

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Physics topic

Poster session / 254

Hands-on kit for digital electronics

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Abstract. Digital electronics has become an important topic in modern science education. While simulation tools are valuable, hands-on devices play important role in understanding digital principles. Our kit provides a practical way to explore the functionality of physical logic gates, flip-flops, and simple binary decoders. Additionally, it allows students to design and build their own combinations of logic gates using the CD4000 integrated circuit series and pushbutton switches. This approach helps them better understand the operation of digital technology. The teaching kit is designed for high school and undergraduate students across various engineering disciplines.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Lab experiments

Research method:

Other

Organizing preference criteria:

Other

Parallel oral presentations / 301

Advancing Physics Computational Literacy with AI and Open-Source SageMath

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Computational literacy is essential for physics students, yet traditional tools can still be challenging for beginners. We introduce a digital tool, AI-enhanced SageMath HTML notebooks, integrating the Mistral AI assistant for code generation, formatting, and explanation. This seamless integration strongly supports numerical and symbolic calculations, data analysis, and visualization. To assess its impact, we conducted pilot testing in 2024 and launched a case study in 2025 within two university courses. Our findings, with a full data analysis based on current data science methodology, will be presented at the conference, demonstrating how generative AI could enhance physics computational literacy.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 83

Exploring Teaching Strategies and Pedagogical Content Knowledge for Teaching the Band Gap Concept in Secondary Education

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Co-author: Lesley de Putter

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Abstract. This study explores how Dutch secondary school physics teachers introduce the band gap concept in pre-university education. Quantum physics is challenging to teach due to its abstract nature, but the band gap provides a practical link between quantum principles and real-world materials like semiconductors. Seven teachers will be observed teaching the concept and interviewed about their strategies and challenges. This qualitative research examines their pedagogical content knowledge (PCK) and teaching practices, offering insights into effective methods for addressing abstract quantum topics. The findings aim to identify effective instructional strategies and enhance students' understanding of quantum physics in secondary education.

Education level:

Pre-service and in-service teacher education

Physics topic:

Quantum mechanics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Parallel oral presentations / 175

Didactical Effect of Teaching with an Open Access Interactive Textbook on Electricity and Magnetism

Author: Wim Bouwman[1]

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Electricity and Magnetism is a first-year course for about 250 Applied Physics students at TU Delft. To support learning, we developed an open, interactive textbook featuring short videos, descriptive texts, and Python-based illustrations. This article explores the creation process, content, and current use of the textbook in our teaching.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Other

Organizing preference criteria:

Education level

Parallel oral presentations / 147

Open inquiry in undergraduate lab courses

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Labs can be effective in teaching critical thinking and developing student self-efficacy for empirical science. Open inquiry labs allow students agency in all phases of an inquiry, from defining the research question, testing, refining, and implementing the research methods, and drawing conclusions from results. A team of teachers of diverse undergraduate lab courses won a grant to collaborate in improving their open inquiry teaching methods and to publish open-access course materials and design guidelines to help other lab teachers to adopt open inquiry methods. In our conference contributions we present these practices and guidelines.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Lab course design

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Research focus

Poster session / 146

Adaptive learning in mechanics using artificial intelligence

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In education, the effectiveness of teaching plays an important role as well as the assessment of the learning process. Teachers are often hopelessly unaware of their students' prior knowledge and skills, and thus of the ideal developmental tasks to solve individually in a given lesson. In this research topic, we aim to create a computer program that can learn which practice task a learner should do to make the most optimal progress based on his or her knowledge and skills.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Artifical Intelligence

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 123

ToPLab: sustaining innovation in physics labs through Faculty Learning Communities

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In 2024, our department launched the ToPLab initiative to implement department-level, sustainable, and evidence-based innovation in teaching labs. The transition from the broader department initiative to course-specific reforms is facilitated by Faculty Learning Communities along with other change strategies. This complex process entails a collaboration between course instructors and physics education researchers. This contribution describes the project structure and its progress in the 2024/25 academic year. Additionally, it presents a core annual course as a case study. Research-based inputs are considered in both course design and project evaluation. The course will be studied in the second semester through direct observation and focus groups.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Lab course design

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 222

Quantum for the Curious: An academic minor to enhance quantum literacy for non-physics students

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The quantum industry demands a diverse workforce with foundational quantum knowledge, extending beyond traditional physics specialists. To address this, the University of Twente developed Quantum for the Curious, a 15 ECTS minor introducing non-physics students to key quantum phenomena and technologies. Guided by the European Competence Framework for Quantum Technologies, the minor enhances scientific literacy and industry-relevant competencies. In its 2024–2025 debut, 21

students from diverse backgrounds participated. Pre- and post-course evaluations assessed its effectiveness. This study presents key findings and insights for improving quantum education for non-specialists.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Quantum mechanics

Research focus:

Lab course design

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 109

A learning path on electromagnetic waves for high school students

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A learning path on electromagnetic waves was designed for high school students. The theoretical framework we adopted is the Model of Educational Reconstruction, reinterpreted by means of Design-Based Research methods. The path was designed considering three interacting factors: the main conceptual issues characterizing the epistemic structure of the theory, the learning difficulties emerged from the literature, and the structure of physics textbooks. The first version of the path was implemented with a sample of 66 students, and the learning outcomes were assessed through a pre-post test, which provided us feedbacks to redesign a second version of the path.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / 234

Empowering Advanced Physics Teaching through Remote Experimentation: Insights from LA-CoNGA physics

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Physics education at the graduate level in Latin America faces structural and geographical constraints that limit students' access to experimental training. Higher Education Institutions in the region often lack both the human and technical resources required to provide comprehensive hands-on experiences in advanced physics. The LA-CoNGA Physics project financed by Erasmus+ Capacity Building initiative, addresses these challenges by integrating remote access laboratories into a collaborative, research-based learning framework. Present work describes three years of design, implementation, and impact assessment of remote access laboratory experiences within LA-CoNGA Physics, which connects HEIS across Colombia, Ecuador, Peru, and Venezuela with European partners

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Lab experiments

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Poster session / 219

Amplitude Modulation Measurements using Mobile Device Sensors

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This study explores an innovative approach utilizing mobile-based spectrum analyzer applications to visualize and analyze Amplitude Modulation (AM) signals. The methodology involves generating an AM signal using a modulator circuit and capturing the output through the mobile device' s microphone. The acquired signal is then processed using mobile spectrum analyzer applications, which employ fast Fourier transform (FFT) techniques to extract carrier frequency, sidebands, and modulation index. This approach enables cost-effective and portable AM analysis, making the experiment more accessible for students and researchers. The proposed technique not only democratizes access to AM signal analysis but also aligns with the advancement of mobile-assisted experimental techniques in education. The results demonstrate that mobile spectrum analyzers provide sufficient accuracy for fundamental AM parameter measurements, proving to be an efficient alternative to traditional benchtop analyzers. This work underscores the potential of integrating smartphone-based measurement tools in communication engineering laboratories, fostering an innovative and scalable approach to hands-on learning.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Contemporary and modern physics

Research focus:

Active learning

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 194

Enhancing conceptual understanding and reasoning ability in challenging physics classes

Author: ANTONIO ROMANO[None]

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Many students in introductory physics courses struggle to form a conceptual understanding of physics, with additional challenges in short courses with no calculus. Tutorials by the University of Washington PEG are well-established tools to improve understanding and physics reasoning. To face these additional challenges, we introduced tutorials containing context-rich problems to a first-year class in a non-physics STEM degree at the University of Pisa taught with an inquiry-based learning approach. Notably, the course's syllabus contains elements of quantum physics. The results show a general improvement in engagement and comprehension of certain core topics, even if some difficulties remain.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 130

Addressing Inequitable Access to Collegiate Level Physics Education in the U.S.

Author: Geraldine Cochran[None]

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Within the U.S., inequities in primary and secondary education are often perpetuated at the collegiate level, notably in calculus-based introductory physics courses. In this presentation, I will discuss a national initiative aimed at addressing these disparities through a multi-pronged approach involving awareness-raising, curriculum development, and research. The curriculum development component focuses on integrating quantitative literacy and enhancing mathematical skills within introductory physics courses. Concurrently, our research evaluates the effectiveness of various models of introductory sequences on student success using a combination of qualitative and quantitative methods. Ultimately, this initiative has the potential to dismantle systemic inequities in collegiate-level, physics education.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 96

How to teach quantum physics to humanistic students and why

Author: Leonardo Colletti[1]

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The teaching of physics in secondary schools not focused on science is highly ineffective. It encounters significant challenges due to students'low motivation and interest, while being perceived as arid. Therefore, it is imperative to reflect on the aims of school education and subsequently endeavour to present the learning of physics as a cultural enrichment rather than merely a prerequisite for potential future scientific pursuits. Here, I present a decade-long teaching experience conducted in a secondary school with humanities focus, particularly concerning quantum mechanics, alongside a reflection on what might constitute an appropriate cultural education for physics teachers.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Symposium / 121

Interaction of Imaginative Forms of Expression in Physics Education of K-6 Teachers - INSTR

Authors: Federico CORNI[1]; José CANTÓ[2]; Jana DOLEŽALOVÁ[3]; Hans U Fuchs[1]; Jitka HOUFKOVÁ[3]; Almudena MARÍN[4]

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This symposium is proposed by the GIREP Thematic Group "Physics Preparation of Teachers in Grades K-6"and includes four contributions that address the importance of complementing physical experiences with imaginative forms of expressions. Two contributions suggest using stories and fairy tales, while the other two incorporate theatrical embodied representations.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 162

Undergraduate students' conceptual understanding of electromagnetic waves

Authors: Danilo Catena[None]; Lorenzo Santi[1]; Marco Costigliolo[2]; Marisa Michelini[1]; Matteo Bozzi[2]; Maurizio Zani[2]

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A questionnaire about electromagnetic waves was submitted to 35 undergraduate students after the conclusion of the electromagnetism course. The questionnaire consists of 6 multiple choice questions, also asking for justification of the answer. The answers' analysis was carried out through an iterative categorization process, aimed at verifying the consistence between the selected options and the motivations provided by the participants. The preliminary results show which are the most common learning difficulties (e.g. the interpretation of the wave profile representation and the relationships between the velocity and the other quantities characterizing electromagnetic waves) and how they are related to each other.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Parallel oral presentations / 245

Levelling Up Physics - online tutorials for pre-university students of physics to address diversity in physics in higher education

Author: Daniel Cottle[1]

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Online physics tutoring that provides near peer mentoring can support a university physics department to engage with a more diverse range of young people interested in studying physics. Benefits for young people are in their knowledge of university application, confidence in their physics knowledge and demystifying what it is like to study physics at university.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Poster session / 257

Possibilities of gamification in high school physics education

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In high school physics education, maintaining students' attention, motivation, and active participation is challenging. Gamification has a motivating effect and enhances student engagement, but it is crucial to align game elements with the groups' player type composition. This research focuses on gamification and the assessment of player types, using a 10th-grade advanced physics class as an example. After evaluating the group profile, determining the optimal balance of game elements that fits the groups' needs becomes easier. This poster presents experiences with the gamification system and some game elements fitted to the six player types, from the Hexad model, which can be applied to various topics within physics education.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / 224

Exploring the Traits of Competent Physics Teachers: Insights from Secondary School Physics Teachers

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This study explores physics teachers' perceptions of the qualities needed for a competent physics teacher. Data was collected from twenty-two secondary physics teachers through a semi-structured questionnaire. The questionnaire was validated by seven experts using the Lawshe method. Thematic analysis will be employed to identify the key attributes essential for effective teaching. The findings will contribute to professional development and teacher training programs by offering insights into the viewpoints of educators. This study is part of a large project aimed at developing a tool to get a better understanding of physics teachers and their unique attributes.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Other

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / 190

Secondary School Students' Interpretation of Thermal Processes

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The interpretation of thermal processes by every citizen is increasingly important today for energy sustainability. In a previous research work based on experiments of thermal interaction and thermal conduction, emerged the difficulty of interpreting the thermal processes in a coherent framework by students who had already studied thermal phenomena at school. This mainly on thermal conduction in a multilayer wall of a building emerged. The main problems that emerged concern the awareness of the difference between equilibrium states and transient processes, the way in which of a spatial temperature gradient is produced and the different behavior of the various materials. We planned an experimental didactic intervention module with the aim of deepening the difficulties that emerged from the previous research and identifying the ways to overcome the interpretative difficulties.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Thermodynamics and Energy

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Excursions / **307**

Anatomical museum & Hortus Botanicus

Workshops / **144**

Tutorials on Critical Thinking in Climate Change - CLIM

Author: Mieke De Cock[None]

Co-authors: Gesche Pospiech [1]; Lana Ivanjek [2]; Magdalena Micoloi [1]; Rainer Wackermann [3]; Sarah Wildbicher [4]; Thomas Schubatzky [4]

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Climate change is one of humanity's most pressing challenges. Despite abundant scientific evidence, global warming is frequently and deliberately misrepresented in social media. It is therefore of the utmost importance that students develop conceptual understanding and critical thinking skills in the context of climate change. In the context of the ENAGING project, we developed ten tutorials to support students in this context.

Education level:

Pre-service and in-service teacher education

Physics topic:

Climate physics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Keynote speaker / **70**

Navigating the Cosmos: Cognitive Challenges in Astronomy Education

Author: Mieke De Cock[None]

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Astronomy is not only one of the oldest sciences, it also fascinates a broad public. For this reason, it plays a special role within public science communication. However, because of its appeal, astronomy can also play a crucial role in science education, by acting as a "gateway science"which can open doors for many STEM fields.
To establish this, we need dedicated research on the teaching and learning of astronomy related concepts: a growing body of research shows that these concepts are often extremely difficult to grasp and understand deeply. Although over the last decades a wide range of aspects of astronomy education has been studied, including both cognitive and affective dimensions of learning, this talk will specifically focus on the cognitive aspects.
We will explore how students construct mental models of astronomical phenomena examining the challenges they face in grasping abstract concepts such as celestial motion, scale, and three-dimensional spatial relationships. The presentation will discuss findings on conceptual change in astronomy education, focusing on how learners overcome common misconceptions and develop scientifically accurate understanding. We will also discuss the role of visual-spatial abilities in astronomy learning. By synthesizing research from cognitive psychology, astronomy education, and physics learning, we aim to offer both researchers and teachers a deeper insight in student learning and evidence-based approaches to improve astronomy instruction across various educational levels.

Education level:

All ages

Physics topic:

Astronomy and Astrophysics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Parallel oral presentations / 66

Pre-service teachers' flexible use of classical and quantum ontologies during a Kundt's tube analogy assignment

Author: Paul de Haas[1]

Co-authors: Erik Barendsen [1]; Hanna Stammes [1]; Henk de Regt [2]

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SER literature calls for a less formal approach to quantum mechanics education. We designed such a lesson based on Glynn's Teaching-With-Analogies model with Kundt's tube and a quantum well. We researched its implementation asking: What classical and quantum ontologies do Preservice Teachers use? Nine PSTs participated. Qualitative analysis of group dialogues revealed that the PSTs used five different ontologies in a flexible manner. Each group used specific subsets of ontologies across the comparative questions. The lesson and analysis effectively made PSTs preferred ontologies transparent. Implications for teacher training and possibilities for further studies are discussed.

Education level:

Pre-service and in-service teacher education

Physics topic:

Quantum mechanics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 284

Exploring Conceptual Structures of PhD in Education Students Specializing in Physics and Mathematics: A Case Study on the Concept of Vector Analysis

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Vector analysis is an essential concept that connects both theoretical and practical fields. However, its meaning and use can differ depending on the teaching methods and focus of each discipline. This

study aims to explore the perception and understanding of vector analysis among PhD in Education students. The data was collected through online survey from 38 students enrolled in Mathematical Methods in Physics course. Results reveal the notable differences in their understanding of vector analysis. Identifying the gaps in their knowledge can inform professional development programs aimed at enhancing teacher's understanding of cross-disciplinary concepts.

Education level:

Pre-service and in-service teacher education

Physics topic:

Interdisciplinary topics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 75

An Investigation of Radiation Knowledge in First Year Medical Radiations and Pharmacy Students

Authors: Pradip Deb[1]; Vincent Chan[2]

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Ionizing radiations are widely used for diagnostic and therapeutic purposes and hence saving millions of lives every year. Over 25 million people in the world living with cancer. Nearly 11 million people are diagnosed with cancer every year and more than 60% of them get curative and/or palliative treatment using ionizing radiations through radiotherapy or brachytherapy or nuclear medicine. Ionizing radiations have potential health risks. This paper reports a cross-sectional exploratory study involving a self-administered anonymous paper survey investigating some basic knowledge on the properties of ionizing radiations in medical radiations and pharmacy students at RMIT University, Australia.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 185

Examining Ethiopian Physics Teachers' Conceptual Understanding and Pedagogical Content Knowledge in Mechanics

Author: Dereje Aynekulu Dejene[1]

Co-author: Floor Kamphorst [1]

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Poor student physics proficiency is a matter of concern in Ethiopia. This study explores in-service high school physics teachers' conceptual understanding, knowledge of students' understanding and teaching practices in mechanics in the context of Bahir Dar (Ethiopia) as a possible explanation. The FCI was administered in a three-tier approach with 11 teachers and interviews were conducted with 7 of them. Preliminary results indicate some limitations in subject matter knowledge, knowing students' learning difficulties and appropriate teaching strategies.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Parallel oral presentations / 117

CREDO-edu - how to make a citizen science project about Cosmic Rays

Author: Melania Deresz[1]

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Cosmic ray research, a new field in physics and astrophysics, emerged in 1912 [1]. Its deeper understanding became possible through advancements in electronics and detectors. However, it was rarely included in citizen science projects. Our CREDO-edu program aims to change this. We created an app for cosmic ray measurements in schools and homes and developed a year-long school curriculum to engage teachers in introducing students to cosmic rays. The program also includes professional lectures and workshops for educators focused on teaching methods. These components represent a new approach to citizen science.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Contemporary and modern physics

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 138

Characterising Dialogues in Upper-Secondary School Physics Classrooms

Authors: Patrick Diepenbroek[1]; Lesley de Putter[1]; Marloes Hendrickx[1]; Jan van der Veen[1]; Wouter van Joolingen[2]

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This study explores dialogues in secondary schools physics lessons. Physics lessons in the 5th grade (15-17 yr-olds) were observed from nine teachers in six different Dutch secondary schools. Preliminary results show teachers generally assume an authoritative role for a long duration during class, and the contribution of students to dialogues shows varies. At the time of the conference, the authors expect that the results will include relative occurrences of specific talk moves (TQS and T-SEDA) and a description of dialogues over time (Markov Chains). The authors expect to provide useful insights on teacher dialogues to researchers and teachers alike.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Workshops / 139

Scaffolding Dialogues in Upper-Secondary School Physics Classrooms –Using Reasoning Schemes as Co-construction Tools - INSTR

Authors: Patrick Diepenbroek[None]; Lesley de Putter[None]; Marloes Hendrickx[1]; Jan van der Veen[1]; Wouter van Joolingen[2]

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It is important to make dialogues productive during lessons but is a difficult skill. Tools that support explication of thinking can support the explication of thinking and are called co-construction tools. During this workshop, participants will firstly experience how such a reasoning scheme works from a student perspective. Participants will then analyse the strengths and weaknesses of two reasoning schemes and synthesise a new reasoning scheme. This workshop focuses on teachers and scholars who are studying dialogues in secondary-school lessons of physics.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Thermodynamics and Energy

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Education level

Parallel oral presentations / 229

It's all about the BASICs: a framework for a hands-on electronic course

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Our bachelor's Nanobiology electronic instrumentation course has had limited success in fostering student's conceptual development during, in their perception, tedious lab work. To improve students' learning outcomes and their time-management abilities, we developed the Background, Anticipate, Simulate, Implement & Investigate, Compare & Conclude (BASIC) framework to reduce cognitive load: by adapting the Predict-Observe-Explain structure with Just-In-Time-Teaching, a clear scaffolding structure, and improved expectation management. After a one-week pilot study, we ran the BASIC framework for two years. We observe that students come to class better prepared, manage to finish assignments in time, understand better, and are overall more satisfied.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Poster session / 107

Insight into Students' Interest in the Pillars of Quantum Technologies

Author: Ismet N. Dogan[None]

Co-authors: Dagmar Hilfert-Rüppell ; Franziska Greinert ; Malte S. Ubben ; Rainer Müller

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There is a lack of talents in the industry of quantum technologies, which can be counteracted by training of existing workforce. We want to design this training within an interest-oriented approach due to the positive effects of interest on the process and quality of learning. A first step contains the measurement of interest for these topics. The present study aims to assess the interest of N = 383 students in the pillars of quantum technologies (quantum computing, communication, sensing, simulation). Furthermore, correlations between the interests are shown. Initial results suggest a marginal positive interest in the pillars and strong correlations.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Quantum mechanics

Research focus:

Evaluation & Assessment

Research method:

Other

Organizing preference criteria:

Physics topic

Parallel oral presentations / 249

Enhancing Kinematics Understanding Through a Real-Time Graph-Based Motion Video Game

Authors: Mateo Dutra Shaw[1]; Marcos Abreu[2]; Martín Monteiro[None]; Silvia Sguila[2]; Cecilia Stari[None]; Álvaro Suárez[2]; Arturo Marti[None]

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Although kinematics concepts are key in high school and university physics courses, students face significant difficulties in understanding them. Research shows that real-time graph visualization can help improve comprehension of these concepts. In this oral presentation, we will describe a project we are currently developing, which involves the creation of a physical-computational video game environment where students replicate motion using their own bodies based on a given graph. A position sensor generates a real-time graph that is compared to the target graph, and students are scored on their accuracy. Preliminary results show improved comprehension and high student motivation.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Poster session / 247

What makes an airplane take off right or left? Physic explain!

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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, utilizing physics experiments and concepts supported by dedicated games.

Education level:

All ages

Physics topic:

Climate physics

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Other

Parallel oral presentations / 241

Error and Uncertainty: An Incoherent Hybrid in French High School Education

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The Bureau International des Poids et Mesures plays a central role in standardizing metrology. Thirty years ago, it shifted its approach to measurement, moving away from the concept of true value and error toward a framework in which a measurement result is represented as a set of possible values. The transposition of the international standard into secondary education is currently underway. In this study, we analyse the official French physics syllabus and corresponding high school textbooks. While curricula fully align with international standards, textbooks often mix the two approaches inconsistently, resulting in a lack of conceptual coherence.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Lab course design

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Workshops / **63**

Learning to reason with formulas in grade 10-12 physics and mathematics lessons - MATH

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Reasoning with mathematical formulas is important in secondary-school physics education. Often students lack this skill and see formulas as calculation tools and not as relationships between physical quantities. When handling formulas, they experience different cultures in math and physics classes. To reason with formulas, students must learn to blend mathematical and physics knowledge. This study investigates how questioning the formula might support this blending. Based on literature, a collection of questions was formulated and discussed with mathematics and physics teachers, resulting in a set of guiding questions, which might be used to encourage reasoning with formulas in regular lessons.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Education level

Workshops / **296**

Computational Modelling with Graphical Interface and Animations - DIGI

Author: Ton ELLERMEIJER[None]

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In this workshop participants will experience the ease of a special for education developed graphical modelling tool and the added-value of the possibility to design and control an animation by the model. They will, after a short introduction, have hands-on experience with the unique learning environment Coach 7. Unique because Coach 7 integrate also tools for measurement, so model results can be compared with measurement data.
Participants will acquire a temporarily license, so they can practice also on their own in following months.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / **27**

Visual attention and prior knowledge in identifying thermodynamic processes

Author: Paula Fehlinger[1]

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This study examines how domain-specific prior knowledge influences visual attention and the interpretation of graphs. Prior knowledge of functional equations enhances focus on value areas and graphs, enabling more efficient processing. In contrast, the influence of prior knowledge about state changes on efficient processing is weaker, possibly because students struggle to transfer conceptual understanding to graph interpretation. The findings highlight the importance of cognitive factors in directing attention and, as a result, the efficient processing.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Thermodynamics and Energy

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Workshops / **134**

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

Author: Gerald Feldman[None]

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

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 157

Dissecting the interaction between alternative grading, mindset, and self-efficacy in introductory physics courses

Authors: Christopher Fischer[1]; Jennifer Delgado[1]; Jessy Changstrom[1]; Sarah Rush[1]

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The pressures and responsibilities students face inside and outside the classroom can result in a distribution of pathways and rates required by students to achieve proficiency with course content. Our team has sought to better accommodate this diversity of student experience by implementing a standards-based grading system in our introductory physics courses. We report here our preliminary analysis of the connections between this alternative grading mechanism, student mindset, and student self-efficacy within the context of these courses. We show that these connections are further modulated by elements of student identity, such as gender and major.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Evaluation & Assessment

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Workshops / 106

Workshop on Tailor, an application for data analysis and curve fitting in high school and university teaching labs - LAB

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When we teach students to perform physics experiments, we want them to compare their results to a physical model. We found existing data analysis tools to be lacking and built our own. In courses where we now use Tailor, we found that discussions no longer focus on how to perform the analysis, but rather on the outcome. The act of analysing data becomes a minor task and more time is devoted to the physics behind the experiment. In the workshop we will explore how Tailor can improve the teaching of experimental physics, both in high school and college / university.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Lab course design

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 212

Grasping the Invisible: Design and Implementation of Electronic Quantum Dice

Author: Bart Folkers[1]

Co-authors: Aernout van Rossum [1]; Alexander Brinkman [1]; Kirsten Stadermann [1]

[1] *University of Twente*

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We present research on the development and initial implementation of hands-on demonstration material for quantum entanglement using electronically modified dice. These "Quantum Dice"are equipped with displays, orientation sensors, and wireless communication to simulate basic quantum physics concepts. The system supports various educational scenarios, from basic entanglement demonstrations to quantum key distribution experiments. We will share insights into the design and development of Quantum Dice and preliminary results on the implementation. Attendees will have the opportunity to interact with a prototype of the Quantum Dice and discuss the potential of Quantum Dice to facilitate reasoning about abstract quantum phenomena. Understanding the considerations made in our study can contribute to improving demonstration materials for quantum physics education.

Education level:

All ages

Physics topic:

Quantum mechanics

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / 15

Teaching quantum mechanics without waves or matrices

Author: James Freericks[None]

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In 1925, quantum mechanics was discovered by Heisenberg in the form of matrix mechanics, which was quickly superseded by Schrödinger's wave mechanics in 1926. The former worked in an energy eigenspace representation, while the latter predominately in a position-space representation. There is a third way to formulate quantum mechanics in a representation-independent fashion, that I call operator mechanics. In this talk, I will describe how operator mechanics works and show how to teach quantum mechanics this way. The work I discuss is summarized in a forthcoming book called *Quantum Mechanics Done Right* from Springer-Nature.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Quantum mechanics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 119

Carnot's Waterfall and the Notions of Power and Energy

Author: Hans U Fuchs[1]

Co-author: Federico Corni [1]

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We accept the idea of power of a Force of Nature as it arises from Sadi Carnot's Waterfall Analogy. We show in what sense power is experientially and conceptually primary, and how it can be used for motivating the energy principle (rather than taking power as derived from the concept of energy). We use a macroscopic steady-state model of irreversible thermal engines for demonstrating that Carnot's notion of power cannot be derived from the concept of energy.

Education level:

All ages

Physics topic:

Thermodynamics and Energy

Research focus:

Innovative instructional strategies and pathways

Research method:

Other

Organizing preference criteria:

Physics topic

Poster session / **176**

International Commission on Physics Education (C14-IUPAP): Purpose and Activities

Authors: Angela Fösel[None]; Cecilia Stari[None]; Geraldine Cochran[None]; Marisa Michelini[None]; Sachiko Tosa[1]; Tetyana Antimirova[2]

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The International Union of Pure and Applied Physics (IUPAP) aims to assist worldwide strengthening and promotion of physics across all disciplines, particularly in developing countries. It does this through Commissions and Working Groups, each comprising of country representatives on a rotational basis. Commission C14 on Physics Education, also called the International Commission of Physics Education (ICPE) does this through engagement of Commissioners around mandates for each rotation –a term. Activities include publishing and disseminating handbooks, circulating a newsletter, awarding a medal and supporting conferences. This poster presents a description of these activities as well as snapshots from some Commissioners.

Education level:

All ages

Physics topic:

Interdisciplinary topics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Poster session / 179

Physics in the context of seismology: experiments and activities with the Raspberry Shake

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The Raspberry Shake 1D is a low-cost, computerized seismograph that can be used very well to detect ground motions from earthquakes and everyday life. For physics teachers, the system is an excellent tool for teaching physics concepts and scientific methods in a highly motivating way. We will present some ideas for experiments and activities with the Raspberry Shake for students in schools as well as tasks for undergraduate students at universities.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Track

Parallel oral presentations / 141

Designing and Implementing TLSs for Digitally Enhanced Physics Labs: insights from the ADELANTE Project

Authors: Eugenio Tufino[1]; Giacomo Bozzo[2]; Lucia Gabelli[1]

Co-authors: Giovanni Organtini [3]; Graziano Surace [3]; Marta Carli [1]; Peppino Antonio Francesco Sapia [2]

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The ADELANTE project addresses challenges in integrating physics labs into secondary education by incorporating smartphones and Arduino microcontrollers into teaching-learning sequences (TLSs) with educational intentionality. Following the Design-Based Research framework, several TLSs were developed, targeting foundational physics topics: motion, energy, forces and fields, waves and particles. These TLSs include inquiry-based lab activities designed to foster scientific practices and student agency. The process of TLSs development leverages teacher communities at two levels: a group of "teacher leaders"had co-developed the TLSs with the researchers, while larger communities of practices are testing the TLSs nationwide to ensure applicability and effectiveness.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 95

The role of academic engagement on freshmen's performance in an Introductory Physics course

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In this paper, we aim to understand the relationship between academic engagement and students' performance in the first university year, specifically in an introductory physics exam in the first semester of an engineering course. To this aim, we explored if the engagement dimensions have a differential effect on students'performance controlling also for high school background. Overall, 134 first-year university students (female students = 32.8%) participated in the study. A binary logistic regression was used to analyse data. Results show that among the engagement dimensions, peer interaction and university and relational network significantly affected the passing of the physics exam. However, the two dimensions have contrasting effects on students'performance. Our results suggest that the university context in which students find themselves can be more relevant for their performance with respect to the perceived value of chosen degree course.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 192

Influence of a professional learning programme in physics on teachers'beliefs and classroom practices

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Instructional practices in physics classrooms are recognised as having a strong influence on students' lack of interest and continuation in studying physics. Teachers'beliefs are reported to have a significant influence on their classroom practices. This study presents the beliefs of 32 secondary teachers' and their classroom practices, after completing a two-year professional learning programme in physics. Findings reveal that teachers'have stronger beliefs about the importance of child-centred learning and that there is a positive correlation between their child-centred beliefs and their use of inquiry-based learning in physics education.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Track

Poster session / 283

Bounce Light System Device for Teaching Optics to Elementary School Students

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During Basic Education in Mexico, we seek to develop scientific thinking. Students are also expected to understand and explain physical phenomena through interaction with the environment. The objective of this article is to share the didactic experience implementing the use of a device, called Bounce Light System, designed to teach light reflection at school level and develop scientific thinking.
The analysis of the experience was developed in three phases:1) design of the device, 2) implementation of the teaching resource and 3) results of the implementation. The participants were students between eight and ten years old who were studying primary education.

Education level:

Age under 12 (Primary education or earlier)

Physics topic:

Other

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 171

AN ANALYSIS OF QUESTION TYPE IN PHYSICS-RELATED EXHIBITS' LABELS AT SCIENCE CENTRES

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Co-author: Ömer Faruk Özdemir [1]

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This study focuses on investigating question types written on exhibit labels at six different science centres. Exhibit labels are written materials that help visitors communicate effectively with exhibits at a science centre. Different question types can provide insights into exhibit design and scientific activities conducted in science centers. Questions written on labels are analyzed regarding the nature of requested information and the motivational aspects of asking questions. The questions were discussed to interplay between the nature of requested information and the motivational factors. Additionally, the question types written on labels may indicate the possible effectiveness of inquiry in science communication.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 150

Physics Debate: an Educational Path on Energy and Climate

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Co-authors: Andrea Franzetti [1]; Arianna Armanetti [2]; Chiara Aimè [3]; Daniele Aurelio [4]; Davide Santostasi [5]; Denise Trupia [6]; Diego Maragnano [1]; Ettore Budassi [1]; Jacopo Braghieri [1]; Marco Ghilardi [1]; Paolo Montagna [1]; Simone Restelli [1]; Simone Venturini [7]; Simone Verdi [1]

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The "Physics Debate: Energy and Climate" project is an innovative educational path, focused on climate change and energy issues, which exploits the debate technique (following the World School Style debating model). This activity was proposed, and still is, to many high-school students, with the aim of raising awareness on energy-environmental issues and their social implications, while teaching the importance of constructive debate. A pre-post educational test (30 questions) confirms its effectiveness.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Symposium / 155

Fostering Social and Cultural Inclusivity in Physics Education: The PLS Model - IDENT

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The Piano Lauree Scientifiche (PLS) is a national initiative in Italy aimed at advancing physics education across high school and university levels. This symposium highlights research from the PLS framework, emphasizing inquiry-based learning, active engagement, and social inclusivity. It explores the importance of a national project to apply research findings in schools and promote large-scale educational research. The contributions focus on inquiry-based practices, gender and social inclusion strategies, and bridging the gap between high school and university curricula. The PLS fosters educational reform and modernizes physics teaching to enhance student engagement and address societal challenges.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research method

Poster session / 110

Embodied Narratives for Physics Education: Bridging Concepts, Emotions, and Movements

Authors: Marco Giliberti[1]; Luisa Lovisetti[2]

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Physics is often taught as a purely intellectual subject, disconnected from the body and emotional engagement, particularly in undergraduate STEM courses. In Milan, in the "Preparation of Didactical Experiences 1"course for master's students in Mathematics or Physics, we integrate 20 hours of embodied activities within an inquiry-based learning process. These activities, including scientific representation and music, emphasize the interplay of disciplinary understanding, personal meaning, and emotional involvement. Students report deeper comprehension and engagement through collective movements, physical simulations, and interactive exercises. This work presents simple embodied activities used in the course, demonstrating their effectiveness in fostering active, holistic learning.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 116

Exploring the Effectiveness of AR Headsets and AnReAL in Teaching Motion Concepts

Author: Caterina Giovanzana[1]

Co-authors: Giuliano Zendri [2]; Pasquale Onorato [1]; Stefano Oss [1]; Tommaso Rosi [3]

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Over the past decade, Physics Education Researchers have increasingly focused on Augmented Reality (AR) as a key technological tool. This ongoing study investigates the effectiveness of AR headsets,

specifically using the software AnReAL, in teaching motion-related concepts. AnReAL transforms AR headsets into interactive physics labs, enabling real time visualization of mathematical objects of physical interest - such as trajectories and vectors - integrating embodied learning into an immersive and interactive environment. Grounded in Active Learning, AnReAL-based activities involve group and peer discussions, motion and trajectory predictions, and immediate feedback, fostering a deeper understanding of motion concepts.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 295

Pre-service physics teachers learn to write reports in the instructional physics labs

Author: Olga Gkioka[1]

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The paper reports results from a project designed to investigate the difficulties that sixty-four pre-service physics teachers experienced while learning to write lab reports after having performed lab experiments. At the same time, they were giving written comments to peers. Sources of data included lab reports, weekly reflection papers, interviews with the participants and peer-to-peer feedback. Results suggest that pre-service teachers experienced a variety of difficulties related to writing and that feedback enhanced the quality of lab reports throughout one semester.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 20

A critical analysis of the C-TEIR process for assessing practical physics methods

Author: Laura Gray[None]

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This submission outlines the development of a framework which evolved from a need to structure our research findings, and an understanding that publication can be limited if it is not clearly defined. Data analysis from our physics education research project provided the basis for our C-TEIR (Current - Test, Evaluate, Ideal and Reality) process. Both the practical implementation and reporting of research findings is simplified through use of the framework. However, considering the limitations a framework can impose will ensure we evaluate and evolve the C-TEIR alongside our research.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Lab experiments

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Poster session / 207

Out-of-field Teaching in Physics and Science –A Systematic Review

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Out-of-field teaching, where educators teach subjects outside their expertise, is a globally discussed topic in literature. Nevertheless, it remains unclear how research is represented in detail. This contribution describes a systematic review addressing this issue for out-of-field teaching in secondary education in general and particularly in physics and science. Starting with 1058 research articles, 145 were identified for general analysis. The next focus on physics and science revealed 34 publications.

We found the majority of research on out-of-field in the USA and Australia and a research focus on the challenges and consequences of out-of-field teaching.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Education level

Parallel oral presentations / 17

Students' epistemic difficulties in analysing Energy Transfer Problems in Mechanics

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The teaching of the concept of energy, along with the processes of energy transformation and transfer in Newtonian mechanics, is a complex issue that continues to present significant pedagogical challenges. This study examines the epistemic practices of High School students (ages 16-18) in Argentina and Spain when solving problems related to energy transformation, transfer, and the application of the principle of conservation of energy in Newtonian Mechanics. The responses to the problems we administered reveal that many students fail to explicitly define the system and its environment when analyzing energy transfer phenomena, leading to confusion and conceptual errors in their understanding of energy.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Parallel oral presentations / **28**

Sun-Earth-Moon system: Difficulties of secondary school students in understanding eclipses

Authors: ELVIRA GUTIERREZ JIMENEZ[1]; PAULO SARRIUGARTE Not Supplied[None]; Ane Portillo-Blanco[1]; Kristina Zuza[2]

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This study aims to analyse the mental model of secondary school students on the topic of Sun-Earth-Moon system, focusing on Moon phases and eclipses. That for, an open-ended questionnaire was designed and implemented with 265 secondary school students whose answers were analysed with phenomenography. The identified difficulties were similar to the ones obtained in the studies found in the literature review.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / **302**

Artificial Intelligence in Pre-Service STEM Teacher Training

Author: Jozef Hanč[1]

Co-authors: Dominik Borovský [2]; Martina Hancova [3]

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The rapid rise of generative AI offers new possibilities for teaching and learning in STEM education. Based on the DigCompEdu framework, our course integrates AI as a key module, providing pre-service STEM teachers with both practical skills and a conceptual understanding of AI models. Students engage with advanced prompting techniques and use AI to enhance their work as future teachers, e.g., to design innovative lessons. Through a three-year longitudinal study, we observed a significant improvement in lessons' quality. At the conference, we will present our study materials, student outputs, and findings on students' evolving perceptions of AI in education.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Artifical Intelligence

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 297

The impact of spaced learning within physics lessons in secondary schools

Author: Rachel Hartley[None]

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This study investigated the impact of a single video lesson with a spaced learning inputs and timed distraction breaks on students learning of a novel physics topic: atomic structure and nuclear decay. Among 336 students aged 14-16, those receiving SL video lessons alone showed comparable results to traditional teaching in separate science physics. However, using SL in addition to traditional teaching produced 50-90% higher learning gains. For combined science students, SL plus traditional teaching led to 60% greater gains than controls. Results indicate that one hour of SL significantly boosts traditional teaching effectiveness, with implications for teacher workload and wellbeing.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Other

Research method:

Organizing preference criteria:

Workshops / **36**

Optic Cubes –A 3D-Printed Modular Kit for Low-Cost Wave Optic Experiments in Education - QUANT

Author: Nils Haverkamp[1]

Co-authors: Alexander Pusch [1]; Stefan Heusler [1]

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Quantum optics is an emerging field of physics, and an increasing number of applications is expected in the future. Thus, the need for education in this field is essential, while remaining challenging. Especially experimental setups using single-photon experiments are still beyond reach for any school, due to costs and technical difficulties. A promising approach seems to be using cheap, easy-to-use and modular experimental kits for school that allow for wave optical experiments as an analogy for quantum optics. In this Workshop we will present a low-cost experimental setup, that can be build using 3D printing.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Lab experiments

Research method:

Other

Organizing preference criteria:

Research focus

Symposium / **298**

Computational Modelling in the Physics Curriculum - MATH

Author: Ton ELLERMEIJER[None]

Co-authors: André Heck [1]; Giacomo Torzo ; Henning Vinjusveen Myhrehagen ; Peter Demkanin

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In 1984 Jon Ogborn [1] published an article about Dynamical Modelling. He demonstrated clearly the enormous potential added-values for physics education. So one would expect by now, 40 years later, in most countries the application of computational modelling is an integral part in the modern physics curriculum for high schools. Reality is amazingly different. By now, as far as known, only in The Netherlands computational modelling is addressed in the national curriculum of Physics and tested in national examinations.
The symposium aims to share and discuss the experiences with computational modelling for different levels of education and in several countries.

Education level:

All ages

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 120

Avoiding tidal misconceptions - a teacher guide

Author: André Heck[1]

Co-author: Peter Uylings [1]

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Tidal movement is a fascinating phenomenon, but often plagued by misconceptions among students and teachers. This presentation offers physics teachers a clear, accessible model of the frozen (equilibrium) tide, i.e. the tidal movement on an all-ocean world. Using simple expressions for tidal acceleration, water height, and power loss, it provides key insights to address common misconceptions. In addition we propose a practical, ordered instructional strategy for upper secondary students and undergraduate students in geosciences, physics and astronomy. The goal is to equip students with a correct qualitative and semi-quantitative understanding of tides and to inspire them with captivating astronomical examples.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Other

Organizing preference criteria:

Track

Poster session / **259**

Implementation of modular smartphone experiments in physics lessons using the phyphox kit

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The research approach aims to increase acceptance of smartphone experiments in physics lessons by distributing materials and offering teacher support for these experiments using the free phyphox app, which turns smartphones into mobile measuring instruments. The phyphox kit includes worksheets, accompanying materials and accessories for experiments across the core physics curriculum as well as materials for a 90-minute introductory lesson. Teachers from up to 30 schools will be included in a one-year study design, focusing on the use of the provided smartphone experiments and possible changes in teachers'attitudes towards them.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Keynote speaker / **60**

Inclusion and Diversity in Physics

Author: Judith Hillier[None]

There have long been concerns about the lack of diversity in physics, most notably around the under-representation of women, with numerous efforts to make physics a more inclusive discipline. I will present an overview of how far we have come in recent decades, and how the nature of the discourse has changed from trying to 'fix'the people in the minority groups, to asking more searching and challenging questions about the culture of physics and the behaviours that perpetuate it.
Drawing on my own research with CUWiP+ UK & Ireland (Conference for Undergraduate Women and Non-Binary Physicists) over the last 10 years, we will explore what we can learn from the experiences of these young people whilst studying physics, and their hopes and aspirations for careers in physics. By examining their experiences during an annual 3 day conference, we will reflect on what it means to co-construct an inclusive physics community. We will also study the experiences of those who organise these conferences and how these leaders too are changed by this work that is conducted alongside the rest of their roles. Finally, we will consider how the physics education research community might continue this drive to increase inclusion and diversity in physics amidst a swiftly changing and challenging political landscape.

Research focus:

Students'identity, inclusion and wellbeing

Organizing preference criteria:

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Other

Research method:

Mixed method (qualitative & quantitative)

Poster session / 137

Enhancing students'comprehension of equations with physics specific strategies

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Co-authors: Andreas Müller [2]; Josefine Neuhaus [1]; Pascal Klein [1]

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A profound understanding of mathematical equations and their application is a central objective of the physics degree programme, alongside developing experimental skills and conceptual knowledge. Appropriate handling of equations involves their analysis, critical evaluation and verification of plausibility within the physical context. Commonly used methods and approaches in physics include the consideration of dimensions, covariations, as well as special and limiting cases. Although such approaches are considered essential, they are not explicitly taught and practised in university. The present study aims to both assess the implementation of these approaches and support their development through targeted interventions.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Evaluation & Assessment

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Workshops / **140**

Stargazing Live! Discover the transient Universe in the NOVA Mobile Planetarium - ASTRO

Author: Joanna Holt[1]

Co-authors: Bert Bredeweg [2]; Dennis Vaendel [3]; Joris Hanse [4]; Marco Kragten [2]; Marieke Baan [4]; Paul Groot [5]; Steven Bloemen [5]

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Stargazing Live! aims to capture the imagination of students with a combination of live and interactive planetarium lessons, real astronomical data, and lessons built around interactive knowledge representations . The lessons were created using a co-creation model and tackle concepts in the pre-university (astro)physics curriculum which students find difficult to grasp with traditional interventions. An evaluation study in nine Dutch classrooms showed that learners are inspired and engaged by the planetarium but are not always able to link the content to the classroom.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Parallel oral presentations / **274**

E-R-R teaching framework implemented in future physics teacher education

Author: Tereza Hrouzková[1]

Co-author: Roman Kubínek [1]

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In education, there is an increasing discussion about the need to transform teaching approaches. Traditional knowledge-oriented education, where the teacher holds a dominant role, is being replaced

by methods where the student is an active participant in the learning process. In our study, we replaced traditional teaching methods with the E-R-R teaching framework. This model is designed to support the development of critical thinking. In our research we focused on observing whether using these methods in preservice teachers' teaching can change their thinking about methods that promote critical thinking, their motivation to use them, and their level of critical thinking.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / **228**

Probing students' difficulties in electromagnetic induction using an approach based on Conceptual Blending theory.

Author: Saurabhee Huli[1]

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While common student difficulties in electromagnetic induction have been identified in the literature, the exact points of pitfalls in the sequence of the associated cognitive operations remain unexplored. In the process of administering a questionnaire based on simple electromagnetic induction situations to students, we experienced the need for a fine-grained probe into students' mental models that goes beyond a simple test for the presence of conceptual knowledge. This approach uses the theoretical framework of Conceptual Blending and emphasizes the integration of different concepts, laws, conventions, and visualizations involved. Our approach indeed reveals significant new insight into students' thought processes.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 276

Pedagogical partnerships as a distinctive and inspiring strategy for curriculum revision

Authors: Martijn Hunter[1]; Ruth Buning[1]

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This work discusses the pedagogical partnership between faculty and students in our Applied Physics program, aimed at a comprehensive curriculum revision. This unusual approach allows both groups to collaborate as equal partners within the development team. We identify multiple benefits, not only regarding the curriculum itself, but also regarding the professional development of the team members themselves and the educational environment as a whole.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Poster session / 149

Implementation of network theory in the design of a physics curriculum

Authors: Alejandra Ibarra Morales[1]; Leonor Pérez Trejo[1]; Mario Humberto Ramírez Díaz[1]; Oscar Ivan Torres Mena[2]

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This paper proposes the use of network theory tools, such as the adjacency matrix and the Louvain algorithm, to prioritize content and competencies in Physics programs. This process was automated using Python code based on the NetworkX library, which significantly reduced analysis time. The proposal solves historical computational limitations and optimizes the logical construction of knowledge, improving teaching. The analysis guarantees an efficient and consistent hierarchy, providing an innovative approach to the improvement of curricula in Physics.

Education level:

All ages

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Other

Parallel oral presentations / 269

Digital Peer-Evaluation in Project-Based Learning: A BuddyCheck Case Study in BSc Electrical Engineering

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This study examines BuddyCheck's use for peer-evaluation in two project-based BSc electrical engineering courses at TU Delft from 2022 to 2025. We analyse students' academic performance and peer-evaluation results to identify factors critical to their success. Our analysis includes high school and university grades, along with demographic information. BuddyCheck also enables students to self-evaluate, providing insights into their self-efficacy. This research demonstrates how digital tools like BuddyCheck can enhance educational outcomes by improving collaborative learning environments and developing tailored interventions.

Education level:

All ages

Physics topic:

Other

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 253

Educational games in teaching physics

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The paper presents dissertation research focusing on educational games in physics education. The research aimed to map the key factors that influence the successful use of games in the process of teaching physics in upper-secondary schools. In the research process, five new educational games were designed. These games were introduced into the teaching of physics in upper-secondary schools. Data was collected through observation of the gameplay, discussions with students, questionnaires for students and interviews with teachers. The data analysis is still ongoing, and the final results will be presented at the conference.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Poster session / 153

Back to basics: reinventing a simple cart experiment for kinematics

Authors: Katarina Jelicic[1]; Karolina Matejak Cvenic[2]; Maja Planinić[3]; Petra Plavšić[3]; Ana Susac[None]; Lana Ivanjek[None]

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Kinematics is the first unit that students encounter in Croatian high schools, where experiments with ticker tape timer are one of the most common experiments. Analysis of the tape is very long and complex procedure for physics novices, even with great help and guidance from teachers. Our group managed to simplify the experiment, using only the cart, a ruler and two mobile phones. The easier setup enables straightforward analysis of the cart position at a certain time. The poster will present the experimental setup and the measurements for the most common kinematics experiments.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Lab experiments

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 92

STEM Investigations: Integrating Interdisciplinary Learning to Solve Real-World Problems

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Co-authors: Ján Guniš [1]; Ľubomír Šnajder [1]; Anna Mišianiková [1]

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STEM Investigations is a new subject designed for upper secondary school students (aged 17–18) to address real-world problems through interdisciplinary inquiry. Building on knowledge from mathematics, physics, chemistry, biology, geography, and computer science, students engage in activities that integrate scientific methods with digital tools. Example topics include diving safety, UV radiation risks, Earth's climate system, and others emphasizing the connections between science and everyday life. The subject combines guided and open inquiry, encouraging critical thinking, collaboration, and creativity. By promoting problem-solving across disciplines, STEM Investigations prepares students for STEM careers and equips them with essential skills for addressing complex challenges.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Poster session / 225

Student Model of Engagement in DC circuits

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Abstract. This is the culmination of a long and systematics study on contextual variation of student responses in the context of dc circuit. We published the contextual variation from their Forced Choice Responses of eight electrically identical questions with fine grained variations that are trivial to a physicist, the productive and unproductive foothold ideas, then narrated the six micro-episodes from interviews that sketches the complex cognitive terrain of sense-making path that links complex everyday experience, mathematical reasoning and language connotations with the idealised physics model. We reflect on how the overall findings might be used in order to introduce a curriculum on simple DC circuits.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 291

Enhancing University Physics and Chemistry Education through Interdisciplinary Research: The ENACT Project

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The ENACT project represents a pioneering interdisciplinary initiative between the University of Padova and the University of Wroclaw, aiming to integrate materials science, advanced data analysis, and machine learning techniques into physics education. By fostering hands-on learning experiences in energy conversion and storage, the project contributes to the development of critical skills

required in modern scientific research. This paper explores the impact of ENACT on physics education, highlighting its contributions to digital transformation, artificial intelligence, and sustainable energy solutions.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Competence-based education

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 237

Analysis of IBDP Physics Curriculum in terms of its Inclusion of Behavioral Profile Characteristics of a Scientific Literate

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This study aims to analyze the International Baccalaureate Diploma Programme (IBDP) physics curriculum in terms of its inclusion of the behavioral profile characteristics of a scientific literate. For this purpose, the "behavioral profile domain"part of the Citizenship Scientific Literacy (CSL) framework was used for the content analysis of the written curriculum and textbook. Results found that: IBDP physics is a curriculum with strong emphases on "social identity", "evolving ability"and "drive to practice science"subheadings. Moreover, it has greater inclusion rates of the items; "ethics and intellectual honesty", "responsible behavior", "open-mindedness", "autonomy", "attainment value" and "intrinsic value".

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Competence-based education

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 128

Gender Differences in a Context-Based Test in Mechanics

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This study explored how gender affects the performance and confidence of first-year physics students (445 total, 202 female, 243 male) at a Turkish state university taking a context-based test (CBT). Confidence was measured by having students rate their certainty in the correctness of each answer. A mismatch between accuracy and confidence is considered miscalibration, and bias is calculated as the difference between average confidence and average accuracy. Prior research suggests that factors like gender influence confidence and bias. This study specifically examined the impact of gender on CBT accuracy scores and confidence levels using an independent samples t-test. The results showed statistically significant gender differences in both confidence and CBT accuracy scores, with a medium effect size for confidence and a small effect size for CBT accuracy scores. The study concludes by discussing the implications of these findings for teaching and learning.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Parallel oral presentations / 76

Length contraction Thought experiment with Secondary students

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It is desirable that secondary students gain an understanding of special relativistic concepts such as length contraction. In a thought experiment-based task, 4 small groups of 11th grade students (11 students total) derived the concept of length contraction and applied it in new situations. These preliminary results indicate that thought experiment-based tasks can contribute to the development of conceptual understanding of abstract and far from daily life concepts.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Contemporary and modern physics

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Panel discussion / **186**

The ethical role of a Physicist, especially that of a Physics teacher, in contemporary society"

Authors: Aikaterini Benisi[1]; Aristotelis Gkiolmas[2]; Elina Karagiannidou[3]; Gianna Katsiampoura[4]; Zografia Papanagiotou[5]

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Abstract.

This Panel Discussion seeks to investigate the ethical aspects of Physics as a profession, focusing on Physics education and instruction. Relating Physics to the ethical issues in contemporary society has become more and more important, since Physics is involved in or is the basis for many worldwide phenomena and other situations that present problems requiring resolution or treatment according to - among other points of view - their ethical substance and dimension. We believe that there is a definite need for Physics, especially Physics in classrooms and amphitheaters, to address these social, economical and environmental, as well as other, phenomena.

Education level:

All ages

Physics topic:

Interdisciplinary topics

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Other

Organizing preference criteria:

Keynote speaker / **72**

The complexification of physics: Historical episodes and educational implications

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Complex numbers were created (or discovered?) by Italian mathematicians in the 16th century as pragmatic tools to solve cubic equations, and not much attention was given to ontological questions about their "existence". However, this changed significantly in the end of the 18th century, when complex numbers were given a geometrical interpretation. Such concretization motivated physicists to use these numbers to model numerous phenomena, a process that has been called "complexification of physics"by Salomon Bochner. In this talk, different historical episodes will be presented, highlighting, in each case, how and why complex numbers became useful to physicists. Taken together, these examples provide a rather nuanced and pluralistic picture of the interplay between mathematics and physics, and its educational implications.

Education level:

All ages

Physics topic:

Interdisciplinary topics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Workshops / **103**

Inclusive Physics Education: Check your course with us! - IDENT

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Physics remains one of the least diverse STEM fields. To meet the growing demand for STEM professionals, it is crucial to adopt inclusive, diversity-friendly teaching practices. This workshop provides practical strategies for physics educators to foster inclusivity in their classrooms. Together with participants we will explore how gender and cultural bias is present in various physics university courses, gaining awareness of how these biases affect students. Through reflection and discussion, attendees will evaluate the inclusivity of their own courses and consider ways to better support a diverse student body.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / **44**

Exploring Student Estimates of Astronomical Scales: Impact of Question Formulation and Visualisation

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Co-authors: Hans Van Winckel [1]; Jan Sermeus ; Mieke De Cock ; Wim Van Dooren [1]

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This work reports on the administration of an online, interactive survey, assessing the estimates of N=201 high school students on astronomical scales. Five questions were asked, two of which probing estimates on the relative sizes of astronomical bodies, and three on the relative distances between them. We investigated the effects of different question formulations and customised visualisations on these estimates. Results show that students generally underestimated all relative distances. There was a significant difference in the magnitude of the estimates between the two question formulations. The effect of the visualisations was clearly larger for size-related questions than for distances.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Parallel oral presentations / 167

Flexible learning environment for the DigCompEdu competences development of STEM teachers

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The digital competences of teachers, as defined in the DigCompEdu framework, play a key role in the digital transformation of education. The SELFIEforTeachers tool enables the assessment of teachers' preparedness to develop pupils' digital competences. The educational environment in schools should create conditions for active pupil learning, targeted competence development, and creative teacher work. The internet, digital technologies, and artificial intelligence are significantly changing the position and role of teachers in education. Teachers should be specifically prepared and supported to address these new challenges. Based on an analysis of the state of STEM classrooms in Slovakia and in relation to the FCL standard, we present our recommendations for transforming the learning environment. The multifunctional STEM classroom we propose, consisting of learning equipped with digital technologies and teaching tools, serves as a training center for the preparation of pre-service teachers and for the professional development of in-service teachers in line with the DigCompEdu framework. In this paper, we map initial experiences from teacher training and their attitudes towards the use of learning zones in school practice.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Lab course design

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Research focus

Poster session / 34

Compromise between mathematics and physics in teaching: instructors' views on the role of mathematics in advanced physics courses for teachers

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Co-authors: Edit Yerushalmi [2]; Bat-Sheva Eylon [1]

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Learning physics is challenging, in part due to its deep connection to mathematics. What part does mathematics play in in-service teacher education? We have studied an MSc program for science teachers in Israel, where advanced physics courses are taught by physicists. One of the program's design principles is that the graduate be in command of mathematics and understand its relevance for physics. Using semi-structured interviews with the instructors, we sought to understand the value they assign to the above principle. Several views emerged, some distinct from the original principle: one, mathematics as providing coherence, two, mathematics as secondary to qualitative understanding, or three, adapting topics to the teachers' abilities.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Other

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 32

Advanced physics courses for teachers –Physicists' perceptions

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The Rothschild-Weizmann program for excellence in science teaching grants teachers an MSc degree and involves advanced physics courses, going far beyond knowledge taught at Israeli schools. Clearly, such courses deepen content knowledge. However, it is unclear how they change graduates' teaching. We used semi-structured interviews to study how the instructors of the physics courses view their influence on teaching. So far, we have found that they wish to promote a deeper understanding of physics, but also other goals which are less explicit in their courses' syllabi: programming skills, relating physics to "real life", and academic writing. Interestingly, the physicists' adherence to academic freedom hinders their cooperation with their fellow instructors.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Other

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Poster session / 125

Simultaneous measurement of precession and nutation using a wireless sensor in a gyroscope practical experiment

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Students perform a gyroscope practical to study precession, which is measured with a wireless sensor. Precession is also discussed in the accompanying mechanics lectures, but nutation is not. In the practical, however, nutation is often observed in addition to precession and the nutation period is easily derived from the precession measurement. Analysis of the nutation signal is optional for students and this gives them information about a topic not taught in a lecture.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Lab experiments

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 55

Quantum Party at Lowlands: The Impact of a Pop-Up Exhibit about Quantum Technologies

Author: Vincent Koeman[None]

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Quantum technologies are seen as transformative, with potential to revolutionize fields like drug discovery and machine learning. Public engagement is crucial to align these developments with societal needs and foster acceptance. This study evaluated the impact of an exhibit about quantum technologies at the 2024 Lowlands music festival on 812 visitors. Pre- and post-surveys assessed changes in interest, attitude, concern and subjective knowledge. Results showed increases in subjective knowledge but decreases in interest, possibly due to reduced novelty or increased perceived difficulty. These findings highlight the effectiveness of exhibits in outreach and emphasize the importance of maintaining novelty and accessibility.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Quantum mechanics

Research focus:

Evaluation & Assessment

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Poster session / 196

Physics Curriculum for Secondary Schools –Starting Points Grounded Among Leading Physicists and Other Stakeholders

Author: Petr Kolář[1]

Co-authors: Vojtěch Žák [1]; Martin Chvál [1]

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This contribution is focused on the physics curriculum for upper secondary schools. We present the results of longitudinal research whose methodology is inspired by an objectivist grounded theory approach. Our research is based especially on the ideas of the leading Czech physicists obtained from in-depth interviews. The original group of physicists and other stakeholders (other natural scientists, physics teachers, and physics teacher educators) expressed their opinions on the ideas in the subsequent questionnaire. Factor analysis shows general agreement among stakeholders. The research will continue among other stakeholders (engineers, secondary school students, etc.).

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / **214**

The expert-like attitudes of Finnish physics students by major subject and gender

Author: Inkeri Kontro[None]

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Colorado Learning Attitudes about Science Survey (CLASS) is an instrument widely used in evaluating the expert-like attitudes of physics students. Data from the University of Helsinki shows that students who begin physics studies have relatively favourable expert-like attitudes, but there is a gender gap in the factor related to self-efficacy. There are statistically significant differences between students of different study tracks, and students who major in theoretical physics have the most expert-like attitudes. The indications for the culture in physics are discussed.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Track

Parallel oral presentations / **53**

NV-center magnetometer experiment for school and its educational concept

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This conference contribution presents an educational concept designed to facilitate understanding of the physical principles underlying a nitrogen vacancy (NV) center magnetometer setup. This concept is strongly based on an experimental setup to profit from the quantum application perspective. Additional experiments are incorporated to provide further insights into key related concepts, such like energy level schemes, fluorescence, and electron spin. With this approach, we aim to engage students in schools, student academies, and student laboratories.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Poster session / 64

Reflections on Physics Education: Long-Term Memories and Opinions About Physics Learning

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The aim of this contribution is to showcase the results of a nation-wide survey conducted in the Czech Republic on general public regarding the long-lasting opinions on physics and physics education originating mainly in lower secondary school and high school physics classrooms and their comparison with the TIMSS and PISA multinational evaluations. The results of this survey aim to support the modern ideology of focusing more on conceptual understanding and inquiry-based approach to physics education rather than traditional methods focused on formulae, definition, and constant memorization.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Poster session / 108

Interdisciplinary school worksheets (physics-biology)

Author: Dominika Korcanova[None]

Co-authors: Martina Oulehlová ; Tomáš Opatrný

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Interdisciplinary education is one of the many modern didactic methods used in recent years. It is also a very important part of teaching science subjects where it is crucial to understand the connections between topics. This contribution is about creating and using interdisciplinary school worksheets in physics and biology in elementary and secondary education. We describe the theoretical part with modern didactic methods used in designing the worksheets and the practical part describing the creation of the worksheets and the working methods. We also include didactic experiences and observations gained while using the worksheets in practice.

Education level:

All ages

Physics topic:

Interdisciplinary topics

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Poster session / 129

How good AI detectors are the secondary school students in the field of science?

Author: Péter Kosztyó[1]

Co-author: Marton Burkovics

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Artificial intelligence, including large language models (LLMs), is transforming education and daily life. Many online texts are AI-generated without public awareness, and students increasingly use tools like ChatGPT. Our study explored whether 372 high school students could identify if a scientific text was AI- or human-written and examined traits aiding recognition. Results showed students struggled but performed slightly above chance. Factors like gender, prior knowledge, language proficiency, or science skills didn't improve accuracy. The only positive correlation was familiarity with ChatGPT's language. This highlights the need to educate students on recognizing AI-generated content.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Artifical Intelligence

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Workshops / **299**

Physics Cards Different? The Same! Recognising Physics Concepts in a Variety of Representations for a Wide Range of Student Activities - INF

Author: Zdeňka Koupilová[None]

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Gamification has a positive impact on student motivation and learning outcomes. The physics cards called Different? The Same! have been specially designed to encourage student thinking and group discussion. The underlying concept is to recognise, compare, and contrast various representations of certain physics concepts. A set consists of three types of cards that can be combined. This leads to great variability in how the cards can be used in the classroom or in non-formal education contexts. During the workshop, participants will play six or more selected activities, discuss other ways in which the cards can be integrated into students' learning, and we share feedback we have gathered during the two years of using these cards in schools.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Poster session / **239**

Teaching physics through thematic events.

Authors: Daniel Dziob[1]; Hanna Kościelny[2]; Szymon Matlingiewicz[2]

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It is hard to imagine the popularization of physics today without the increasingly frequent theme days. They have become permanent important events that gather large crowds of participants. Their function of promoting knowledge and science cannot be overestimated. An example of this is the theme days at the Kraków Airport Aviation Education Centre. These include the Małopolska Night of Scientists, SPIN-day, Polish Science Days. Topics discussed there include: aerodynamics, mass distribution in an aircraft, X-ray radiation, space. Participants could see the explanation of the mentioned phenomena in practice.

Education level:

All ages

Physics topic:

Other

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Workshops / 142

Understanding stellar properties through conceptual modelling - ASTRO

Author: Marco Kragten[1]

Co-authors: Bert Bredeweg [1]; Joanna Holt [2]

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In this workshop we present three lesson activities to teach core (astro)physics concepts at pre-university level which students find difficult to grasp with traditional interventions: star properties, star states and the fusion-gravity balance. In each activity, students construct and simulate a conceptual cause-effect model. An evaluation study in nine Dutch classrooms showed that the star properties lesson significantly increased students'understanding of the underlying causal relationships. The lessons were created as part of the Stargazing Live! project, which inspires students with an interactive planetarium lesson incorporating real astrophysical data before triggering deep learning with the conceptual modelling activities.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 189

What quantum topics and concepts should be included in an ideal secondary school quantum physics curriculum?

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The integration of quantum physics (QP) into secondary school curricula is a growing area of interest in physics education, yet there is little consensus on which topics to include. To address this gap, we conducted a three-round Delphi study involving a total of 175 experts (physics teachers, physics education researchers, quantum physics experts). The participants provided insights into why QP should be taught, identified key topics, and determined appropriate instructional levels (mathematical, conceptual, or awareness-level) for secondary school students. Using an entropy-based consensus measure, we derived a set of topics with high agreement, contextualized within the Competence Framework for Quantum Technologies (CFQT) and tailored for secondary education. These findings contribute to the development of a realistic and community-informed QP curriculum.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 191

A Remote Laboratory Learning Arrangement for Temperature-Dependent Resistance

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Remote laboratories enhance science and engineering education by providing flexible, online experimentation. As part of the OnLabEdu project, a learning arrangement within the Characteristic Curve Remote Lab was developed to explore temperature-dependent resistance using a design-based research approach. An initial evaluation with 18 pre-service teachers assessed autonomy, interest, flow, and usability. Additionally, interviews with five high school students identified learning obstacles. Results showed positive usability and time management ratings but showed moderate autonomy and perceived choice. Variability in fear of failure and flow suggests areas for improvement, guiding the refinement of the learning arrangement in the next iteration cycle.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Poster session / 193

Development of a Learning Arrangement on the Topic of Wind for Primary Education

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Understanding weather phenomena, such as wind, is essential for fostering scientific literacy from an early age. As part of the binational project "Understanding Weather", this study focused on designing and evaluating a learning arrangement on wind for primary education (3rd grade) using a design-based research approach. The intervention, implemented in four classes (N=89), led to 50% of students correctly identifying wind direction ($p < .001$). The follow-up survey showed no significant decline over time. Nevertheless, we also found hints for improvement of the learning arrangement and all findings inform the next iteration cycle in the development process.

Education level:

Age under 12 (Primary education or earlier)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 26

Empowering Primary School Educators in Inquiry-Based Learning: Evaluating the Impact of a Training Program

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Inquiry-Based Learning (IBL) presents significant challenges for educators due to limited experience and inadequate training. This study evaluates a 20-hour professional development program aimed at equipping Primary School teachers with IBL competencies, utilising the Go-Lab platform's tools and methodology. Through data collected in pre-, mid- and post-training assessments, we claim that the program significantly improved teachers'pedagogical knowledge, scenario design skills, and practical application of IBL. Despite the study's limitations, the results highlight the effectiveness of the program in bridging gaps in IBL training, especially concerning Primary School teachers. Additionally, this study will be the basis for informed modifications in future iterations to enhance active participation and teacher engagement.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 208

Exploring the Potential of Interactive e-Books for Enhancing Learning and Teaching in Physics and Astronomy

Author: Rosaria Lena[None]

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This study focuses on investigating how undergraduate physics and astronomy students engage with interactive e-books, which I designed to support active learning and digital accessibility for two courses I lecture in the School of Physics and Astronomy at my institution. These e-books integrate simulations, videos, code, and interactive assessments, embedded all in one place, offering an accessible and structured alternative to traditional static materials. This research evaluates student usage, preferences, and perceived educational value of these e-books, assessing their effectiveness in digital learning through a survey, identifying strengths, limitations, and areas for improvement.

Education level:

All ages

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 48

Teachers, Students, and the Physmatics Between Them

Author: Hadas Levi[1]

Co-authors: Avraham Merzel [2]; Yaron Lehavi [3]

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[2] *The Hebrew University of Jerusalem*

[3] *The David Yellin Academic College of Education, Weizmann Institute of Science*

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The interplay between mathematics and physics in teaching and learning physics is attributed to a distinct domain, "Physmatics," encompassing unique skills and thinking modes. Students often face difficulties in this domain, yet these difficulties and their link to physmatic skills remain underexplored. This study analyzed recordings of high school physics lessons to identify connections between physmatic skills teachers aim to develop and students' exhibited difficulties. The findings reveal a system of relationships between these skills and difficulties, offering insights to enhance physics teachers' physmatic pedagogical content knowledge (PCK).

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / **73**

How do Different Games make a Difference? Pedagogical Considerations and Teachers' Perspectives when integrating Card Games into Physics Teaching

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Five Phys-Cards games were designed and introduced over a four-year period in a national network of professional learning communities for high school physics teachers. The games consist of summative, hands-on activities that highlight physics concepts and support knowledge organization, using research-based pedagogical principles. Large-scale surveys and an analysis of teachers' classroom experiences showed that they felt the games contributed to student learning. Collaborative reflection helped the teachers find ways to incorporate the games into their lessons. Teachers' preferences for gamification elements across the five games were identified. The results pinpoint the challenges and opportunities of gamification in physics education.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Keynote speaker / **39**

Engaging Students in Authentic Scientific Practices in Physics Lab Courses

Author: Heather Lewandowski[1]

[1] *University of Colorado*

Theoretical models are essential for explaining and predicting physical phenomena, but physics is fundamentally an experimental science. The integration of theoretical or computational models with experimental data is a cornerstone of physics. However, physics education has traditionally prioritized theory through lecture-based courses, often at the expense of experimental education. This imbalance is particularly evident in undergraduate curricula, where theory courses significantly outnumber laboratory courses.
Until recently, this disparity was also reflected in physics education research, which featured only a handful of studies focused on experimental learning. This gap is striking given the unique complexity of the laboratory environment, where students engage in multifaceted interactions—with peers, equipment, instructors, concepts, habits of mind, and technical skills—leading to higher-level learning outcomes. When surveyed, faculty members overwhelmingly identified laboratory courses and undergraduate research as critical spaces for developing the knowledge and skills expected of physics graduates. Addressing these gaps requires greater attention to laboratory education.
I will outline the diverse goals that laboratory education can achieve and discuss how we have partnered with laboratory instructors across the U.S. and Europe to understand student learning and enhance the effectiveness of physics laboratory education.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Lab course design

Research method:

Other

Organizing preference criteria:

Research focus

Poster session / **209**

Developing digital and analogue materials for teaching mechanics in secondary level I - Initial test results

Author: Kerstin Lindmaier[1]

Co-authors: Lana Ivanjek ; Madlen Überreich ; Martin Richard Hopf

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As part of a dissertation project on teaching mechanics at lower secondary level, teaching materials were (re-) developed in digital and analogue form. Additionally, a guideline was created, containing a detailed lesson plan. This should a) support teachers and b) allow for better comparison between them. The new materials/lesson plans where then applied and tested in school. The evaluation process and initial results are presented in this paper.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research method

Poster session / **250**

How contact with CERN researchers shapes students' perceptions of physicists

Author: Adelina Lintuluoto[1]

Co-authors: Sarah Zochling [2]; Guillaume Durey [2]; Cedric Vanhoolandt ; Sascha Schmeling [2]; Julia Woithe [2]

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Engaging with scientists can challenge stereotypes and foster a more inclusive perception of STEM. The CERN-Solvay programme provides a unique opportunity to examine how contact with physicists influences students' perceptions.
This study explores how participation in its one-week summer camps shaped students'preconceived notions of physicists. Pre- and post-camp data were collected using adapted measurement tools assessing perceptions of professional and interpersonal competencies.

Preliminary analyses indicate no significant change in professional competencies but notable positive shifts in interpersonal competencies. Findings suggest direct interaction with physicists humanises scientists and informs future outreach efforts in physics education.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / **136**

Fostering Interdisciplinary Learning: Mathematics and Physics in Secondary Education

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This study explores interdisciplinary approaches to addressing challenges at the intersection of mathematics and physics in secondary education. Involving 297 students, it focuses on collaborative activities integrating vectors, derivatives, and integrals into physics problem-solving. Inspired by research and tailored to local contexts, the interventions aim to strengthen conceptual understanding, foster engagement, and build confidence. Pre-intervention findings from the Physics Inventory of Quantitative Literacy highlight significant gaps in reasoning skills. Post-test results using the Test on Calculus and Vectors in Mathematics and Physics will assess the effectiveness of these strategies in enhancing students'problem-solving abilities and interdisciplinary comprehension.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Symposium / **172**

Symposium: Towards a coherent teaching of energy across ages and disciplines (II) - THERMO

Authors: Paul Logman[1]; Yaron Lehavi[2]

Co-authors: Alessandra DE ANGELIS [3]; Avraham Merzel [4]; Wolter Kaper [5]

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This is the second part of a symposium that addresses the complex challenge of teaching energy as a crosscutting concept coherently across disciplines and grade levels. One key issue is the disparate vocabulary and norms each discipline uses to explain energy and the traditional forms-based teaching approach that often compartmentalizes students' understanding. Our discussions will focus on integrating theory with empirical methods, creating a unified language that spans different ages and disciplines, and connecting abstract concepts to everyday experiences. By emphasizing experimental-oriented approaches, the symposium will explore educational advancements and specially designed curricular materials to enhance energy education.

Education level:

All ages

Physics topic:

Thermodynamics and Energy

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Workshops / **204**

Hands-on and kinaesthetic activities to teach quantum mechanics in an engaging, visual way - QUANT

Author: Andrea Lopez-Incera[None]

Co-authors: Mirte Van der Eyden [1]; Stefan Heusler [2]; Wolfgang Dür [1]

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The rapid advancement of quantum technologies in recent years has emphasized the need to incorporate quantum mechanics into education at various levels. However, introducing complex concepts such as entanglement, macroscopicity or quantum cryptography at the high school level remains a challenge, since they rely on advanced notions in algebra. In this workshop, we present hands-on and kinaesthetic activities to overcome that challenge and make such concepts easy to visualize and understand. The activities require minimal materials and are designed to be accessible to students without prior mathematical knowledge, making them straightforward to implement in classrooms.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 111

History as a Tool for Clarity: Enhancing Quantum Mechanics Understanding through Key Historical Insights

Authors: Luisa Lovisetti[1]; Marco Giliberti[2]

[1] *University of Milan, Department of Physics*

[2] *Università degli Studi di Milano*

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Quantum Mechanics (QM) is often taught without sufficient attention to its historical context. This lack of historical perspective affects learners at all levels, from high-school teachers to young researchers. As Physics Education Research Group in Milan, we conducted a study with high-school teachers and prospective teachers to investigate whether and how a series of selected historical aspects can be useful for fostering a better understanding of the Nature of Science and the conceptual structure of QM. We will present the results of our research, which overall strongly support the inclusion of historical aspects in the teaching of QM.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Quantum mechanics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Symposium / 180

Quantum Mechanics 2025 at the Crossroads of Science and Humanities: Towards the Epiphany of a New Cultural World a Century Later - QUANT

Authors: Luisa Lovisetti[1]; Enrico Giannetto[2]; GRZEGORZ KARWASZ[3]; Mehdi Adrien Ayouz[4]

Co-authors: Michal Pawelkiewicz [4]; Mariya Sosnova [4]; Viatcheslav Kokoouline [5]; Marco Giliberti [6]

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A century after its formulation, we discuss the multifaceted implications for education of the vast cultural connections that quantum mechanics has helped establish between physics and other disciplines. Drawing on the most recent research in quantum mechanics education, we will address the epistemological paradigms that underpin our understanding of nature and the cultural significance of technological aspects for the intellectual development of students at various educational levels; always maintaining a careful focus on the fundamental educational challenge of teaching and learning about the nature of science through physics education.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Quantum mechanics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Workshops / **267**

Changing the role of experiments in learning physics - LAB

Authors: Nastja Mahne[None]; Andreja Šarlah[None]; Sergej Faletic[None]; Aleš Mohorič[None]; Gorazd Planinsic[1]

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

Corresponding Authors: ales.mohoric@fmf.uni-lj.si, nastja.mahne@fmf.uni-lj.si, gorazd.planinsic@fmf.uni-lj.si, sergej.faletic@fmf.uni-lj.si, andreja.sarlah@fmf.uni-lj.si

In our active learning workshop, we will provide an example of a collaborative, student-centred approach for physics course using the Investigative Science Learning Environment (ISLE) approach. The topic studied will be torques and can be therefore adopted to high school levels and introductory physics courses at the university. Participants will engage in various hands-on activities, with special attention paid to lab work to illustrate how such a dynamic classroom can change the strategy for teaching physics. A discussion on the benefits and challenges of this innovative approach will help participants adopt the ISLE learning methodology in their own physics classrooms.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Competence-based education

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / **45**

Online School Scientific Activities with Images of Real Experiments

Authors: Agustin ADÚRIZ-BRAVO[1]; Ewout TER HAAR[2]; NORA LIA MAIDANA[2]; Suelen Fernandes de BARROS[3]; Vito Roberto VANIN[2]

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We have designed several school scientific activities on central topics in the curriculum of classical mechanics about translational and rotational motions, available at http://www.fep.if.usp.br/˜fisfoto. They were developed in a model-theoretical view of science, using videos of experimental arrangements showing the movement of an object next to an instrument to measure its position. Sets of images with time codes enable students to study the dynamic evolution of the system and compare it to a mathematical model. Each activity comprises the image sets, an illustration of the arrangement, and analysis guides. We discuss our motivation, epistemological framework, and some results.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Poster session / 240

Physics at the airport and it smoothly implementation into educational workshops

Author: Szymon Matlingiewicz[1]

Co-authors: Daniel Dziob ; Hanna Kościelny

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Airports are dynamic environments where the laws of physics play a key role in ensuring safety and operational efficiency. It comes into contact with every passenger during their journey, to a greater or lesser extent. Utilizing the infrastructure present at the Aviation Education Centre makes it possible to introduce physics to children, youth and adults. Focusing on infrastructure elements as the first and essential points during every journey.

Education level:

All ages

Physics topic:

Other

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 133

Factors that Support Classroom Implementation of Quantum Concepts in High School

Author: Karen Matsler[1]

Co-author: Ramon Lopez [1]

[1] *UT Arlington*

Corresponding Authors: kmatsler@uta.edu, relopez@uta.edu

The Quantum for All project, funded by the US National Science Foundation, provided opportunities for students to learn about various aspects of quantum science by providing professional development for high school STEM educators to learn and practice quantum information science and engineering (QISE). This paper will share qualitative analysis from the feedback surveys highlighting the components of the professional development that were most useful to teachers and identify any common content threads as well as pedagogical approaches that seem to be most influential in supporting classroom implementation.

Education level:

Pre-service and in-service teacher education

Physics topic:

Quantum mechanics

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Parallel oral presentations / 289

An examination of physics teachers' reflective practices

Authors: Eilish McLoughlin[None]; Stephen Gammell[1]

[1] *Dublin City University*

Corresponding Authors: stephen.gammell@dcu.ie, eilish.mcloughlin@dcu.ie

Teachers often teach the way they were taught themselves as pupils in schools and research highlights that if teachers are to use inquiry methods, they must have met and used these practices as part of their own teacher education programmes. A core aspect of physics teacher learning is supporting them to reflect meaningfully on their classroom practices and experiences. This study examines the influence a two-year professional learning programme that facilitated teachers to carry out a practitioner inquiry on their own practice on their reflective practices and preparedness for teaching physics at lower and upper secondary level in Ireland.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Other

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Track

Workshops / **97**

Transforming physics teacher professional learning via research and practice - TEACH

Authors: Eilish McLoughlin[None]; Dagmara Sokołowska[None]

Corresponding Authors: eilish.mcloughlin@dcu.ie, ufdsokol@cyf-kr.edu.pl

This workshop facilitates global exchange and discussion on current opportunities and challenges influencing physics teaching and teacher education from early childhood to university level. The rapidly changing landscape of the global economy and society in the 21st century demands new approaches to be adopted to recruit, upskill, and educate physics teachers so they can design and facilitate appropriate learning experiences for diverse learners and contexts. Preparing physics teachers with the necessary knowledge, skills and experiences to address changing global issues require cooperation between all shareholders to identify future perspectives and transform physics teacher professional learning via research and practice.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Poster session / **98**

Rich tasks for developing primary students' productive dispositions in physics and mathematics

Authors: Eilish McLoughlin[1]; Paul Grimes[None]; Tandeep Kaur[1]

[1] *Dublin City University*

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Fostering productive dispositions - positive beliefs, perseverance, and emotional engagement - is vital for student achievement in mathematics, physics, and STEM learning. This study explores how rich tasks, grounded in solving real-world problems, nurture student dispositions. A series of rich tasks were designed and implemented with Irish primary students. One of these rich tasks, is presented along with data collected from implementing with 109 primary students. Findings reveal that students who completed rich tasks had increased engagement, confidence, and conceptual understanding. The study highlights the transformative role that rich tasks can play in fostering productive dispositions and strengthening interdisciplinary STEM learning.

Education level:

Age under 12 (Primary education or earlier)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / **272**

A STEAM Education Proposal from the Perspective of the Conceptual Fields Theory

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Co-author: Lisiane Calheiro

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This study explores the integration of the Theory of Conceptual Fields and STEAM education to enhance interdisciplinary learning. Centered on carbohydrates, the project engaged students in an inquiry-based challenge to develop an energy solution for triathlon athletes. Through problem-solving across science, technology, engineering, arts, and mathematics, students strengthened conceptual understanding, critical thinking, and collaboration skills. Findings suggest that applying Vergnaud's theory within a STEAM framework enhances knowledge retention and transfer. This approach fosters cognitive flexibility and real-world problem-solving abilities, highlighting the need for further research on its long-term impact on student learning and adaptability.

Education level:

Pre-service and in-service teacher education

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 82

Why should high-school students learn Quantum Physics? Various stakeholders' perspectives

Authors: Avraham Merzel[1]; Henk Pol[None]

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Corresponding Authors: h.j.pol@utwente.nl, avraham.merzel@mail.huji.ac.il

Teaching quantum physics (QP) in high school (HS) has become common globally, yet the reasons for including it vary among stakeholders. This study explores the justifications provided by physics education researchers, university-level physicists, and HS teachers, analyzing responses from 54 participants using content analysis. Findings reveal key themes for teaching QP: gaining knowledge, inculturation, and inspiration. Quantum technology (QT) emerged as the dominant justification across all professional groups. These insights provide guidance for curriculum design, aligning diverse perspectives on why QP should be part of HS education.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Symposium / 188

Towards a coherent teaching of energy across ages and disciplines (I)

Authors: Avraham Merzel[1]; David Sands[2]

Co-authors: Eilish McLoughlin ; Judith Hillier [3]; Paula Heron ; Yaron Lehavi [4]

[1] *The Hebrew University of Jerusalem*

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This is the first part of a symposium that addresses the complex challenge of teaching energy as a crosscutting concept coherently across disciplines and grade levels. One key issue is the disparate vocabulary and norms each discipline uses to explain energy and the traditional forms-based teaching approach that often compartmentalizes students' understanding. Our discussions will focus on integrating theory with empirical methods, creating a unified language that spans different ages and disciplines, and connecting abstract concepts to everyday experiences. By emphasizing experimental-oriented approaches, the symposium will explore educational advancements and specially designed curricular materials to enhance energy education.

Education level:

All ages

Physics topic:

Thermodynamics and Energy

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Parallel oral presentations / 282

Diagnosis of Elementary Pre-service Teachers' Alternative Conceptions before and after Hands-on Laboratory about Electrostatic

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Métioui_Abstract_Oral presentation: see proposal enclosed below.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 59

In-service science teachers' adaptation of integrated STEM teaching modules on Climate Change

Author: Emily Michailidi[1]

Co-authors: Athanasia Kokolaki [1]; Dimitris Stavrou [1]

[1] *University of Crete*

Corresponding Authors: e.michailidi@uoc.gr, akokolaki@edc.uoc.gr, dstavrou@uoc.gr

This study explores the adaptation and implementation of STEM teaching modules on climate change by 27 in-service science teachers. Supported by experienced mentors in learning communities, participants engaged in designing and implementing tailored STEM teaching modules to foster climate change education. Teachers adapted pre-existing materials by redesigning activities to align with their teaching styles, students' needs, and school contexts. Data analysis revealed extensive adaptations, guided by mentors, ensuring fidelity to the interdisciplinary STEM approach. These findings highlight the transformative potential of collaborative, mentored professional development in promoting sustainable educational innovations.

Education level:

Pre-service and in-service teacher education

Physics topic:

Climate physics

Research focus:

Competence-based education

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Poster session / **159**

FEDORAS'Academy: STEM education for envisioning sustainable futures

Author: Athanasia Kokolaki [1]

Co-authors: Emily Michailidi [1]; Dimitris Stavrou [1]; Olivia Levrini

[1] *University of Crete*

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The present study outlines the rational, objectives and methodology of the European research project "FEDORAS'Academy"which aims at fostering future-oriented STEAM education for sustainability through the establishment of local and European networks among STEM scientists, teacher educators and teachers to promote interdisciplinarity and open schooling. The goal of the networks is to develop innovative teaching materials for advanced STEM topics as well as assessment tools for fostering sustainability competences such as future thinking, action taking etc. Pilot implementations and teacher mobility actions are expected to facilitate the exchange of good practices and promote sustainability values.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Competence-based education

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Panel discussion / **216**

Dialogue symposium about teaching and learning quantum physics

Author: Marisa Michelini[1]

Co-authors: Gesche Pospiech ; Sergej Faletič [2]

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In the event of the International Year of Quantum Science and Technology, the GIREP Thematic Group on teaching and learning quantum physics would like to provide the community with a special experience. We intend to organize a dialogues where three experts will be invited to provide their take on the open questions provided by the community ahead of time. Besides, we intend to create a landscape of quantum teaching and learning practices across countries and educational levels.

Education level:

All ages

Physics topic:

Quantum mechanics

Research focus:

Innovative instructional strategies and pathways

Research method:

Other

Organizing preference criteria:

Other

Poster session / 271

Analyze different student competencies using a computational and experimental task

Author: Marta Mlynczyk[1]

Co-author: Mirela Kaczmarek [2]

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[2] *Institute of Experimental Physics, University of Wrocław, Max Born Square 9, 50-204 Wrocław, Poland*

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Abstract. This article analyzes the key physics competencies and problem-solving approaches of students aged 14–15. The research compares two groups: one consisting of talented students participating in the zDolny Ślązak provincial physics competition, and another comprising typical public school students. The study uses two distinct tasks: one focused on classical computational problem-solving and the other on experimental design. It explores the effectiveness of independent versus group work in planning experiments and solving these tasks, as well as the different problem-solving strategies employed by both motivated and unmotivated students.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Evaluation & Assessment

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 132

Examining Thinking Order Levels in Non-Traditional vs. Standard Physics Problems Through Revised Bloom's Taxonomy

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This study investigates the cognitive demand of standard versus non-traditional Physics problems developed in the ISLE (Investigative Science Learning Environment) approach. Referencing Revised Bloom's Taxonomy, we analyze tasks identified by action verbs in problem statements from Italian high school textbooks, comparing them to a reference sample of non-traditional problems. Our comparison shows that traditional problems mainly involve lower-order thinking, focusing on the activation of procedural and conceptual knowledge, while non-traditional problems involve higher-order cognitive processes, encouraging complex thinking. This research emphasizes the role of integrating non-traditional problems into high school curricula to better prepare students for university and real-world problem-solving.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Competence-based education

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Poster session / 88

Aspects of Physics Education and the role of autochthonous cultures in the São Paulo State curriculum

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This abstract aims to present an excerpt from a study on the aspects of Physics Education that stand out in the high school curriculum of the State of São Paulo, Brazil, considering the main category of autochthonous cultures based on epistemic colonization. To this end, the Physics curriculum of the high school of the State of São Paulo, Brazil, is used as a source of information. The methodology of

analysis was discursive analysis from the French perspective. There is not much presence of Latin American autochthonous cultures in the studied curriculum, which is a characteristic of the process of epistemic colonization.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 248

A powerful interdisciplinary storytelling about energy between history and human societies

Author: Vera Montalbano[1]

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Energy is not merely a means to interpret natural phenomena; it is, above all, a topic on which future citizens will be called to take personal and collective decisions that will shape our collective future. It is essential to combine the right mix of scientific topics with historical aspects that are frequently neglected in the school curriculum to foster students' critical mind and motivate them to deepen their understanding into both. An interdisciplinary narrative on the history of mankind through available energy sources proved to be a powerful tool to engage students and teachers during three non-formal educational events.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Other

Parallel oral presentations / 74

The introduction of circuits in secondary science education: teachers' views on confidence and content

Authors: Iain Moore[None]; Laura Gray[None]

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Results from a survey of Scottish secondary science teachers are presented. This survey investigated methods of introducing electrical circuits. Biology, chemistry and physics teachers teach science as one discipline in most schools. Results indicate elements of the curriculum as defined are taught, but there is variation in delivery. There is no agreement on definitions, with electrons featuring heavily in those of current. This may be problematic as students move towards later phases of their education. Median confidence in teaching the topic is lower for non-physicists and significant concerns are raised amongst specialists about impact on students.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Other

Organizing preference criteria:

Track

Symposium / 195

Symposium ICASE-MIDEC: Remote and virtual experimentation for teaching Physics in Latin America - LAB

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This symposium focuses on collaborations about new trends in remote and virtual experimentation for teaching Physics between teachers of the International Council of Associations for Science Education (ICASE) and the Inter-American Roundtable for Scientific Education (MIDEC), both organizations are interested on improve Physics Education in Latin America. Nowadays, the laboratory of Physics is enriched by the development of technology; mainly computational simulations and remote laboratories make possible the free access of students at any time and help them to create new scenarios and experiments in order to develop their critical thinking.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Lab experiments

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Education level

Keynote speaker / **68**

The Physics of Flocking: Emergence of Collective Motion in Active Matter

Author: Alexandre Morin[None]

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From bacteria colonies, to insect swarms, to bird flocks, collective motion emerges within large groups of living creatures even in the absence of a leader. Physicists aim at uncovering the universal aspects shared by all these systems despite their differences in length scales, environments, or communication means - very much like in phase transitions, such as crystallisation, where some features are independent of the specific atoms or molecules. Characteristic of active matter is the ability of the individuals to self-propel by consuming energy, which keeps these systems out-of-thermodynamic equilibrium and underlies their rich spatio-temporal dynamics.
In this talk, I will present a model experimental system for studying the emergence of collective motion in the laboratory. In place of living creatures, we study plastic microspheres turned into self-propelled individuals via an electro-hydrodynamic instability. This setup allows us to investigate the collective dynamics emerging within large populations of up to millions of individuals, conveniently observed under the microscope. While the system remains isotropic at low density, with individuals moving in every direction, spontaneous symmetry breaking occurs at high density with all individuals moving on average in a common direction: the microspheres flock! I will rationalise this dynamical phase transition by discussing the electric and hydrodynamic interactions between individuals. Finally, I will discuss a few properties of these flocks, from wave propagation to their spontaneous demixing.

Education level:

All ages

Physics topic:

Contemporary and modern physics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Poster session / 292

Elementary Pre-service Teachers' Conceptual Representations of Electrical Circuits Functionality

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This qualitative research aimed to identify one hundred and twenty (N = 120) elementary pre-service teachers' conceptual representations of electrical circuits. We conducted qualitative data analysis, constructing a two-choice questionnaire (True/False) with explanations. The result demonstrated that most pre-service teachers advanced erroneous conceptual representations as 1. Current can flow in an open circuit (unipolar model); and 2. The bulb will light up when the electric current stored in the battery reaches its filament.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Other

Keynote speaker / 71

Quantum Education

Author: Rainer Müller[None]

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The teaching and learning of quantum physics has been an area of intense research in physics education for many years. Based on research on students' conceptions and learning difficulties, teaching concepts have been developed and evaluated. Possible learning objectives and the various ways to achieve them have been discussed at previous GIREP conferences. The first part of the talk will introduce our own approach, the milq concept, which is based on a mini-axiomatic of quantum physics, the 'quantum reasoning tools'.
The second part will examine how the new quantum technologies can enrich the teaching of quantum physics. Quantum computing, quantum sensors and quantum communication have been at the forefront of research in recent years and attract a lot of attention in the public. From an educational point of view, quantum technologies are interesting because the focus on the decidedly non-classical aspects of quantum physics. We will discuss how quantum technologies can be used as possible application contexts in physics teaching at upper secondary level.

Education level:

All ages

Physics topic:

Quantum mechanics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Poster session / 278

LEONARDO DA VINCI DID NOT DISCOVER THE TIME SQUARE LAW BEFORE GALILEO GALILEI

Author: MARCOS CESAR DANHONI NEVES[1]

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The present paper analyzes Leonardo da Vinci's studies on the motion of falling bodies, especially one of them in the Codex Arundel. According to Leonardo, bodies fall according to the relationship: "d proportional to $(t + t^2)/2$". More recent studies mention that Leonardo da Vinci developed a geometry that leads to a gravity acceleration value close to 9.8 m/s^2, according Gharid, et al (2023). However, geometric calculations based on Leonardo's observations demonstrate that his theory results in a less accelerated fall, with a value lower (a half) than the currently accepted one.

Education level:

All ages

Physics topic:

Interdisciplinary topics

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 165

Adopting Nontraditional Labs in a Professional Learning Community - an Ecological Perspective

Author: Adi Noga[1]

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Despite calls to increase student agency in experimental research practices in the instructional lab, traditional labs remain highly prescriptive. This study took an ecological perspective to examine teachers' considerations when engaging in a professional learning community (PLC) designed to support reform in lab instruction. We focus on small group discussions to analyze teachers'discourse in terms of the different environments (e.g., classroom, academic courses, Ministry of Education) they refer to when addressing epistemological and pedagogical challenges. The analysis demonstrates the viability of the ecological framework and highlights the importance of considering various environmental influences in a PLC design.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Lab course design

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Research focus

Poster session / 51

Draw a Scientist: Development of student drawings in middle schools within a four-year STEM engagement project

Author: Markus Obczovsky[1]

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Students'conceptions of scientists influence their attitudes towards science and job aspirations. Within a four-year project of the Kaiserschild-Foundation for STEM engagement in Austrian rural middle schools, we collected drawings of 240 students. To find out how these drawings developed over time, we analysed these drawings and complemented this analysis with twelve semi-structured interviews.

The first analysis shows that the drawings tend to show two kinds of scientists: The stereotypical person in a laboratory and a naturalist, studying plants and animals. Over time less drawings show a naturalist and more drawings show a person in a laboratory.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Poster session / 280

Lesson materials on quantum technology for upper secondary education

Author: Rutger Ockhorst[None]

Co-author: Laurens Feije [1]

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Advancements in quantum sensing and quantum computing are expected to impact many levels of society. This raises the need for a quantum ready workforce. In response, we have written three lesson modules on quantum technology to foster interest and increase awareness among upper secondary school students. This poster presentation explains the procedure followed in writing these materials and highlights a lesson module on the use of NV centers as a context for teaching quantum computation and quantum sensing.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Physics topic

Poster session / 202

An inventory on the principle of relativity and the principle of equivalence in classical mechanics: investigating misconceptions and pitfalls in reasoning

Authors: Alessandro Salmoiraghi[None]; Alessio Marzari[1]; Massimiliano Malgieri[None]; Pasquale Onorato[2]; Stefano Oss[2]

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One of the main aims of Physics education research is to identify and address student difficulties in learning physics. This study investigates student understanding of classical relativity concepts, including the Frame of Reference (FoR), Principle of Relativity (PoR), and Principle of Equivalence (PoE). We designed and administered a 22-item multiple-choice test to 200 students in introductory physics courses to probe misconceptions and deficiencies. Statistical analyses, including classical test analysis, cluster analysis, and item response theory, were employed to evaluate the test's reliability and effectiveness. Findings highlight common difficulties in understanding key concepts, providing insights for improving physics instruction

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Poster session / 203

Bridging Lab work and History of Science: Enhancing Scientific Literacy Through Inquiry and Reflection on the Nature of Science

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This study explores an innovative approach to teaching the Nature of Science (NoS) and the Nature of Scientific Inquiry (NOSI), addressing both well-established and often-overlooked aspects in educational research. Through a lesson plan structured around experimental activities and historical reflections, following an explicit and reflective approach, the aim is to develop students' teachers' understanding of scientific knowledge construction, uncertainty, inference, the provisional nature of theories, and the role of models. Using the historical figure of Galileo, the article examines the

scientific method, the importance of the scientific community, and the self-correcting nature of science. This contextualized, reflective, and historical curriculum approach has enhanced students' teachers' understanding of science and fostered meaningful learning, as evidenced by its application over recent years

Education level:

Pre-service and in-service teacher education

Physics topic:

Interdisciplinary topics

Research focus:

Metacognition

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / 87

Roles of mathematics in physics education: a systematic review

Author: Elina Palmgren[None]

Co-authors: Jesper Bruun [1]; Tommi Kokkonen [2]

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Mathematics plays many roles in physics and physics education. Although these roles have previously been widely discussed in the physics education research community, no systematic picture of the multifaceted considerations has yet been formed. To gain a comprehensive overview of the existing studies on this topic, we have conducted a systematic literature review. In this presentation, we will outline the employed review and analysis methods and discuss our findings along with their implications.

Education level:

All ages

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 281

Inclusive science education: qualitative evaluation of an interdisciplinary teaching concept

Author: Giulia Pantiri[1]

Co-authors: Arnim Lühken [1]; Dieter Katzenbach [1]; Fatime Beka [1]; Lea Burkhardt [1]; Thomas Wilhelm [1]; Volker Wenzel [1]

[1] *Goethe University Frankfurt*

Corresponding Author: pantiri@physik.uni-frankfurt.de

As a design-based research project, the E2piMINT team developed and evaluated an inclusive and interdisciplinary teaching concept for lower secondary schools to promote interest in science and to provide teachers with effective support for lesson planning. For this purpose, two laboratory activities with experiments from physics, biology and chemistry on the topics of "colours"and "glueing and sticking"were designed and implemented in the teaching laboratories of the Goethe University Frankfurt. In this presentation, the developed concept, its inclusive features, and some results of the qualitative analysis are presented.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 135

Enhancing sense-making in teachers through Photogate-based Period determination of a Bar Pendulum

Author: Shirish Pathare[1]

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This study explores how physics teachers from undergraduate colleges in India develop sense-making abilities while using a photogate to measure the period of a bar pendulum's oscillation. Thirty-five participants arranged experimental setup and analyzed data to overcome challenges like measurement discrepancies caused by asymmetry. Teachers initially struggled to interpret observations but later recognized the importance of symmetric configurations and full oscillation setups for accurate measurements. Discussions highlighted the advantages of multiple oscillations and the superior repeatability of photogate results over manual stopwatch readings. The findings underscore the need for careful experimental design to enhance systematic thinking and reduce errors.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Education level

Workshops / 80

Drievliet: Embodied experiences of physics in Amusement Parks and Playgrounds - INF

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Co-author: Jurnan Schilder [2]

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Combining the embodied experiences of forces in amusement rides with simple experiments, mathematical descriptions, video recordings and sensor data can give students a deeper understanding of the meaning and consequences of Newton's laws [1]. Air pressure and rotation data can be collected by a smartphone at the same time as accelerometer data, capturing different aspects of the experience and offering many examples connecting mathematics and physics [2,3]. However, data are sometimes surprising and the interpretation can be challenging. Your own examples are welcome!

Education level:

All ages

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Excursions / **7**

Drievliet: Embodied experiences of physics in Amusement Parks and Playgrounds

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Poster session / **35**

Basic physics in energy transition: a thematic course

Author: Joao Pereira[1]

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Abstract. The purpose of this work is to present various types of energy production from the basic physics point of view. A thematic course was created at our university, aiming environmental sciences and engineering students to develop skills in important areas of physics that are related to energy production and consumption. Selected topics were pinched from different areas of physics and organized to be presented in a way that permits the understanding of simple models and calculations related to different sources of energy. The contents of this course can be simplified to reach high school students.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Thermodynamics and Energy

Research focus:

Competence-based education

Research method:

Other

Organizing preference criteria:

Physics topic

Parallel oral presentations / **244**

Enhancing Understanding of Electromagnetic Fields and Their Application Challenges through Open and Collaborative Active Learning

Authors: Dominique Persano Adorno[1]; Nicola Pizzolato[2]

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[2] *ICS Maredolce*

Active learning methods promote curiosity, enjoyment, and engagement by creating an immersive educational experience. Providing a practical application of physics concepts can boost student interest and academic performance, particularly in today's rapidly evolving landscape. This paper presents a workshop designed for second-year Cybernetics Engineering undergraduates, aimed at developing design skills, enhancing problem-solving abilities, and fostering a deeper understanding of electromagnetic fields and their applications. Starting with the fundamental principles of electromagnetism, students were encouraged to design and conduct collaborative research projects, strengthening their comprehension of core disciplinary concepts while also refining their teamwork and interpersonal skills.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 268

Exploring Potential Use Cases of Immersive Technology in Secondary School Physics

Authors: PHILIPPA PETTS[1]; Peter Swift[1]

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Extended Reality (XR) technologies including virtual reality (VR) and augmented reality (AR) offer new opportunities for physics education and may be integrated into classrooms in the future. This study explores their potential through two XR tools designed for secondary students, expanding on prior AR-based physics simulations for undergraduates. Ten science teachers tested these tools and provided feedback via semi-structured interviews and focus groups. Key themes include engagement, feasibility, and curriculum alignment. While XR was seen as valuable, concerns arose about curriculum constraints, lesson time, and student monitoring. Student data collection is ongoing, with findings to be presented at the conference.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 105

Development of an inquiry-based teaching sequence on energy for secondary school

Author: Maja Planinić[1]

Co-authors: Ana Sušac [2]; Katarina Jeličić [1]; Lana Ivanjek [3]; Petra Plavšić [1]

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A new inquiry-based teaching sequence on energy was developed by the authors with the aim to improve Croatian secondary students'(aged 15-16 years) understanding of the basic concepts related to energy (such as work, kinetic, elastic, gravitational and internal energy) as well as their ability to apply the law of energy conservation. The sequence is designed for ten teaching periods and will be piloted in one Croatian secondary school in Spring 2025. The teaching sequence relies strongly on the system approach and energy bar chart representation. Its key points and the results of the piloting will be presented and discussed.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Thermodynamics and Energy

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 210

Assessing Secondary School Students'Understanding of the First Law of Thermodynamics: Challenges and Insights

Authors: Ana Susac[None]; Karolina Matejak Cvenic[1]; Katarina Jelicic[2]; Lana Ivanjek[3]; Maja Planinić[4]; Petra Plavsic[2]

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To investigate secondary school students' understanding of the First Law of Thermodynamics within the Croatian educational system, we developed a test by adapting the "Survey of Thermodynamic Processes and First and Second Laws (long)". The test was administered to students from three Zagreb secondary schools following their completion of thermodynamics content. Data analysis included the application of the Rasch model, which confirmed the test's functionality and demonstrated that its difficulty appropriately matched the abilities of the participants. Additionally, frequency analysis identified common student conceptual difficulties and areas of difficulty, which will be addressed in the presentation.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Thermodynamics and Energy

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 12

Towards Open Physics Education: Teaching with Jupyter (Note)Books

Author: Freek Pols[None]

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Open Educational Resources have the potential to enhance the quality of teaching materials, but various technical challenges can hinder their implementation. In TU Delft's first-year physics lab course, we use Jupyter Books hosted on GitHub to address these challenges while maintaining student satisfaction with the content. In this presentation, I will explore the benefits of these platforms and demonstrate their advantages. Opportunities for opening and sharing teaching materials will also be discussed.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Other

Organizing preference criteria:

Track

Workshops / **11**

We have 99 demo's, and so much fun - INF

Authors: Freek Pols[None]; Norbert van Veen[None]

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Abstract. Demonstrations are fantastic. They offer wonderful possibilities to showcase the beauty of physics and amaze students. While it may not always be feasible to include one in every class, the objection "which demo then?"no longer applies. In our recent publication of the online, open-access book Show the Physics we present 99 physics demonstrations, including tested approaches to make these educationally effective. In this workshop we present some of these demonstrations, highlight key aspects of the online features and explain how you can utilize these, as well as contribute to the iterative improvement of the content.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / **265**

Teaching quantum science between interpretational debate and pragmatism: learning about Nature of Science

Author: Gesche Pospiech[None]

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This article looks at quantum physics from different perspectives with the aim of rethinking the teaching of quantum physics with the additional goal of learning about the nature of science. The historical, the worldview and the mathematical-physical perspectives are put in relation to each other. In the contribution, we will examine how the historical formation of concepts and the mathematical formulation can help to localise the gap between classical physics and quantum physics and deal with it with the goal of learning about nature of science.

Education level:

All ages

Physics topic:

Quantum mechanics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Physics topic

Parallel oral presentations / **261**

Exploring the relation between physics, energy and sustainability with students, teachers and researchers: the Citizen Science School Rome Technopole case study

Authors: Adriana Postiglione[None]; Giovanni Mazzitelli[None]; Ruggero Ricci[1]; Simona Cerrato[2]; Susanna Bertelli[3]

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Citizen Science stands out as a highly engaging method that can allow students and teachers to delve into physics research. At INFN Frascati National Laboratory we will organize, in collaboration with European Citizen Science Association (ECSA), the European Citizen Science Academy and Citizen Science Italia, a Citizen Science School addressed to high school students, teachers, University students and researchers focused on Rome Technopole's research macro areas. The working group on Physics, energy and sustainability will provide the opportunity to explore how thermodynamics, and physics in general, are fundamental to create an informed and fertile discussion around sustainability and energy transition.

Education level:

All ages

Physics topic:

Thermodynamics and Energy

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 226

Bridging Theory and Experimentation: Identifying the Most Accurate Model for Soap Bubble Deflation

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This study investigates the deflation dynamics of soap bubbles attached to cylindrical straws, combining theoretical modelling with laboratory experiments. A mathematical model is developed to describe the evolution of the bubble's radius, incorporating surface tension and viscosity. The experimental setup validates the model, highlighting the importance of precise measurements, statistical analysis, and the iterative nature of scientific inquiry. The study also emphasizes the didactical value of engaging students with hands-on experimentation, fostering both theoretical understanding and practical skills.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Lab experiments

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 100

When Assumptions Make the Difference: The Curious Case of the Mistreated Bernoulli's Equation

Author: Daniele Battesimo Provenzano[1]

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This work examines widespread misconceptions about Bernoulli's equation, both in high school and university courses, where students and instructors often overlook the assumptions required for its correct application. By analysing the most common mistakes of Italian students taking part in Physics competitions, the work highlights how errors emerge, particularly in relation to assumptions like smoothness, steady flow, and irrotationality. The consequences of violating these assumptions are explored, such as incorrect conclusions or apparent paradoxes. Special attention is given to specific examples, such as the Magnus effect and the Heron's fountain.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Parallel oral presentations / 230

From the atomic nucleus to popcorn: Guided use of AI for the development of critical thinking in IPN high school

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This inquiry refers to how the use of Artificial Intelligence influences the construction of scientific arguments in the process of experimentation in Physics with high school students in Mexico, where a dependence on the excessive use of AI for argumentation was observed, in such a way that limits the development of critical thinking, since AI generates superficial and sometimes inaccurate answers. However, when teaching guidance is provided, students improve significantly, students demonstrate an evaluation of the information provided by AI by ascertaining sources that show a guideline in the construction of arguments.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Lab experiments

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / 118

Preschool teacher training in physics under the new Mexican school approach

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Preschool teachers make a great effort to show science content to the children they oversee, but the conceptual and operational tools they were provided with in their training are insufficient for them to design and evaluate meaningful scientific experiences. Therefore, it is important to provide them with elements that allow them to bring science closer to the children in an effective and playful way. This project presents the results of a physics teaching course under the scheme of the New Mexican School for preschool teachers in hybrid mode: using a digital platform for activities, permanent advisory support, synchronous online work sessions and face-to-face sessions where simple low-cost experiments are shown.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Competence-based education

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 256

Teaching Model-based Reasoning in Physics Undergraduate Classrooms, using Computational Simulations

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Research on Modeling-based Reasoning (MBR) in physics education indicates that students need to move towards understanding the procedural knowledge of building a conceptual model to explain real world phenomena, and validating this conceptual model against measurement models. We have developed a pedagogical model to teach MBR at the undergraduate level, using a simulation that walks students through the process of building the pendulum derivation, and another simulation that helps in understanding the recursive process of validating the model against results from the experimental model. We present results from a pilot study of this design in a classroom, and an extended design based on these results.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Poster session / 58

Analysis of Performance of Slovak Pupils in the Physics Part of IJSO According to Revised Bloom's Taxonomy in 2023 and 2024

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The paper presents the results of an analysis of the performance of pupils who attended international rounds of the International Junior Science Olympiad (IJSO) in 2023 and 2024 (6 pupils each year). The goal of the analysis is to find out how a selected sample of Slovak pupils performs on standardized tests, to be more precise, to find out the extent to which pupils lack the ability to use certain cognitive processes to solve physics problems. Based on the analysis, Slovak pupils demonstrated consistent performance in tasks requiring Applying but faced challenges with tasks involving higher cognitive processes like Analysing.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Education level

Poster session / 168

School physics experiments with Arduino in lower secondary education

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Based on a master thesis, we present a series of six educational lessons designed for basic school students (grades 6–9) that integrate the Arduino microcontroller into physics experiments. The lessons focus on topics such as electricity, magnetism, and semiconductors incorporating elements of computer science and mathematics. The experiments are designed as hands-on, engaging pupils in practical activities reinforcing theoretical concepts. The lessons include detailed methodologies, lists of required materials, historical notes, time schedules, worksheets, and solutions. The experiments were tested in a real classroom setting as part of the "World in Context" subject at a non-state alternative basic school.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Lab experiments

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Poster session / 205

Work-life related exercise with vehicle experiment

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This study explores science education methodologies, combining group-based learning, field experiments, and work-life-related exercises to enhance student engagement. The case study investigated repurposing a decommissioned tracked vehicle. Six master's students conducted a five-day field experiment encompassing planning, execution, iterative observations, and report writing. The project aimed to assess the feasibility and implications of reusing outdated equipment through AI and robotics integration. Preliminary findings suggest this hands-on approach provides valuable experience in developing innovative mobility solutions. In this study evaluation of student feedback has been analysed to see the value of the field experiment for learning.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Other

Research focus:

Lab experiments

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Other

Poster session / **243**

Use of ISLE in STEM lessons to promote scientific thinking

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Teaching materials for middle school based on the ISLE approach were developed following the design based research circle. All together there are 7 teaching units of 100 minutes each for 7th grade (13 -14 year-olds) covering topics that can be explained within the particle model of matter. The materials were tested with 46 students in a rural Austrian middle school. The material development process and the results from the testing will be presented.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Competence-based education

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Parallel oral presentations / 300

Understanding the attention capture of a salient distracting feature in a friction force question

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Physics problems both found in classroom settings and encountered in real world scenarios can often include extraneous or unnecessary information. If the information is salient, it can capture attention potentially driving the problem solver towards an incorrect solution. To understand the role of such features in physics questions, we have tasked undergraduate students with solving one of three versions of a Newton's laws question in the context of friction. We compare student performance on each of these questions, explaining the findings through the lens of dual-process theories of reasoning.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 56

Supporting Teachers in Planning and Implementing Digital Data Acquisition in the Physics Classroom

Author: Lea Runge[1]

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In the physical sciences, today digital data acquisition (DDA) tools play a core role in empirically testing complex theoretical models. However, the integration of DDA into physics teaching remains infrequent, mainly because many teachers lack the professional skills to use these digital tools in classrooms. To address this challenge, we designed a long-term teacher professional development program (TPDP) consisting of five cumulative units, covering the basics of DDA systems and giving teachers the opportunity to practice the use of DDA tools in their own classes. Our submission provides insights into the TPDP's design, including preliminary results of our accompanying research.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 114

Exploring the Photoelectric Effect and the Electromagnetic Spectrum through Art Analysis in Physics Education

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This study explores an interdisciplinary strategy integrating physics and art to enhance students' understanding of the electromagnetic spectrum and the photoelectric effect. Through project-based learning, high school students analyse artworks using non-invasive spectroscopic techniques, experiment with UV light on currency security features, and explore artistic representations of electromagnetic waves. Findings show improved conceptual understanding, increased engagement, and stronger critical thinking skills. This approach demonstrates the relevance of physics beyond the classroom, fostering interdisciplinary learning and scientific inquiry. Future research could expand applications in cultural heritage and science communication.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / 262

Empowering future physics teachers to cultivate critical thinking

Author: Farahnaz Sadidi[None]

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Critical thinking (CT) is essential in physics education, yet teacher training often lacks effective preparation. This exploratory study, based on Halpern's CT framework and behavioral theories, examines the challenges and attitudes of 23 German prospective physics teachers in a seminar on designing CT-integrated physics lessons. Inductive content analysis of discussions and pre-post questionnaire responses reveal that participants valued CT but struggled with topic selection and precise task formulation. The seminar enhanced their understanding of CT teaching's feasibility, especially among skeptics. Findings give insights to the key design principles for effective teacher training programs.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Competence-based education

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Workshops / 181

Let's bring critical thinking into physics lessons together! - TEACH

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This workshop aims to integrate Critical Thinking (CT) into physics education, an aspect often overlooked in daily teaching. Using a scaffolded instructional approach aligned with Halpern's CT framework, the workshop will provide educators and teachers with the essential skills and knowledge to enhance CT in the physics classroom. Grounded in behavioral theories, it emphasizes practical engagement, allowing participants to develop, evaluate, and refine CT-based materials through hands-on activities and peer review.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Competence-based education

Research method:

Other

Organizing preference criteria:

Other

Poster session / 201

Evaluating Misconceptions About the Greenhouse Effect in Textbooks

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This study analyses 26 middle and high school italian textbooks on physics, science, geography, and technology to investigate how the greenhouse effect is presented and identify potential misconceptions. Through a content analysis approach, we aim to evaluate the accuracy and clarity of the information provided to students. This research contributes to the ongoing efforts in the field of climate change education and sustainability, building on our group's long-standing commitment to improving instructional practices. The findings will highlight common misunderstandings and suggest strategies for enhancing the representation of the greenhouse effect in educational materials.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Climate physics

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Poster session / 104

Sabir: a codesign process to foster IBL in the Mediterranean

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The SABIR project is a co-design initiative fostering the network of the International Astronomical Union's astronomy educators in the Mediterranean. It was held both online (February-July 2024) and in person during a one-week residency in Milano, Italy. We discussed together and shared the Inquiry-Based Learning (IBL) approach, then each of the participating educators selected a laboratory activity to be rethought as an IBL one. The project included three cycles of online presentations and discussions, followed by offline implementations. The final versions of the activities were co-designed together during the residency. The future implementation of this approach is now underway.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Active learning

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 197

Towards a theory of thinking and reasoning in physics education: the connection between dual processing theories and mental models

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Dual processing theories (DPT) are increasingly considered in physics education research. However, whilst DPT is an important aspect of thinking and reasoning, there is an impressive body of research suggesting that the primary mechanism of reasoning is via the formation of mental models. Though traditionally viewed as separate topics within cognitive psychology, it might be expected that a connection exists between the two. Recent research on dual processing and mental modelling is cited in support of a strong connection. Drawing on examples from the author's own teaching and research over the years, the relevance to physics education will be shown.

Education level:

All ages

Physics topic:

Other

Research focus:

Metacognition

Research method:

Other

Organizing preference criteria:

Poster session / 263

Development of an online teacher training course for modern quantum physics teaching

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Modern quantum physics is finding its way into education and schools to train specialists for future technologies. Teachers must, therefore, be familiar with modern quantum physics. However, this content was often not a focus of the university training of prospective teachers. Consequently, there is a great need for further and advanced training courses for teachers. In this contribution, we present the concept and implementation of a practice-oriented teacher training course with online self-study units and a focus on content. The focus is on the essential features of quantum physics, single photon physics, Dirac formalism, and the quantum mechanical worldview.

Education level:

Pre-service and in-service teacher education

Physics topic:

Quantum mechanics

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Education level

Parallel oral presentations / 21

Bottom-up implementation of learning goals in physics lab courses by a hands-on didactic training of instructors

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Despite empirical evidence for the effectiveness of competence-based physics lab courses, they frequently still follow historically developed structures pragmatically using the infrastructure given. In this talk, the design of a hands-on didactic workshop for instructors and the experiences made over the years are presented. An integral feature is the development of learning goals for the experiments by the instructors and an alignment of their responsibilities with these goals. Accordingly, the workshop represents a resource-saving solution for promoting the instructors'didactic competences and establishing learning goals in a bottom-up way automatically ensuring their implementation by the instructors.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Lab course design

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Poster session / **184**

The Universe as a Physics Laboratory: Assessment of parents' attitudes and their support of astronomy education at primary school

Author: Karin Schmögnerová[None]

Co-authors: Marian Kires [1]; Rudolf Gális

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Astronomy holds a unique position among the sciences for its capacity to inspire curiosity and interdisciplinary learning. Despite its potential, its presence in curricula remains limited, overshadowed by traditional physics topics. In Slovakia, astronomy is only an optional subject in primary schools, with inconsistent implementation across educational institutions. Our study [1] examines parents' attitudes toward astronomy education, emphasizing its role in enhancing STEM engagement. By identifying key factors influencing parental support –such as their educational background, prior exposure to astronomy, and children's interactive learning experiences –the research provides arguments and support mechanisms for teachers to integrate astronomy into their lessons.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / **25**

Knowledge of Everyday Energy Quantities and Its Relationship to Self-Reported Behaviour

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The transition to a sustainable energy system requires both systemic change and individual behavioral adaptations. While households account for over a quarter of Europe's energy consumption, promoting energy-saving behaviors is challenging due to possibly limited public knowledge of everyday energy quantities. This study introduces a validated test instrument assessing individuals'ability to estimate everyday energy quantities. Data from 447 respondents reveal intermediate knowledge levels, with heating-related tasks posing particular difficulty. Correlational analyses indicate positive relationships between energy knowledge, attitudes, and self-reported energy-saving behaviors.

These findings highlight the potential of enhancing knowledge to foster energy-sufficient behaviours and support energy transitions.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Climate physics

Research focus:

Evaluation & Assessment

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Physics topic

Poster session / 65

Developing Scientific Agency in Bachelor Physics Students

Author: Nazly Sedghinejad[None]

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Science labs offer students unique opportunities to develop scientific agency through experiments that foster relevant skills and attitudes, such as making substantiated decisions. This study explores how science bachelor students develop scientific agency in laboratory settings through decision making. We will focus on the interplay between decision making, higher-order thinking skills and motivation. Using a mixed-methods approach—including surveys, observations, and interviews—we seek to identify factors that influence students' decision-making processes. An educational design study will lead to evidence-based recommendations for the design of science laboratories with the goal of improving laboratory education.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Lab course design

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research method

Parallel oral presentations / 93

Tracking the Swing: Unveiling the Physics of Increasing Amplitude

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The motion of a pendulum, particularly a swing, is a classic example of periodic motion that follows fundamental physical principles. Understanding the factors that affect the amplitude of a swinging object is essential for understanding a wide range of applications. This paper investigates the dynamics of a simple swinging system, analyzing key aspects such as x vs. t, v vs. t, and energy vs. t graphs using Tracker software. It demonstrates the concepts of energy conservation, damping forces, and the influence of external driving forces, such as human input, in amplifying the swing's motion. By examining these factors, the paper provides a comprehensive insight into the mechanics that govern swing amplitude.

Education level:

All ages

Physics topic:

Contemporary and modern physics

Research focus:

Active learning

Research method:

Other

Organizing preference criteria:

Physics topic

Poster session / 273

Inquiry-based learning of nuclear physics using VR learning module

Author: David Smrcka[None]

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Inquiry-based learning in physics education is an excellent method to reinforce what pupils learn at high school. Virtual reality learning modules help in cases where equipment for real-life demonstration experiments is unavailable to a teacher. One such topic is nuclear physics. We designed our VR learning module with inquiry-based learning in mind. Using this VR learning module pupils are guided to complete series of tasks. By doing so, they learn about absorption of nuclear radiation, about nature of the nuclear radiation carriers and about decay chains.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Other

Organizing preference criteria:

Research focus

Workshops / **102**

Introduction to Active Learning in Optics and Photonics (ALOP) - INSTR

Author: David Sokoloff[None]

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

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Education level

Parallel oral presentations / **270**

More Than a Competition: How Physics Contests in Poland Offer Opportunities to Build Varied Skills

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Co-author: Dagmara Sokołowska

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Physics competitions are widely recognized as platforms for assessing students' mastery of scientific concepts and problem-solving skills. Beyond evaluation, these competitions foster intellectual development, creativity, and a deeper understanding of physics. More importantly, they cultivate a lasting commitment to and interest in the subject. This paper provides an overview of physics competitions in Poland, including both well-known international events and unique national contests, analyzing their underlying principles and potential impact on the development of various competencies.

Education level:

All ages

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Opening ceremony / **1**

Welcome by GIREP vice-president Dagmara Sokołowska & EPS-EPEC president Sascha Schmeling

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Parallel oral presentations / **154**

Teacher students' expression of TPACK in GeoGebra-based lesson planning

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This study explored how physics teacher students use educational technology for visualizing physical phenomena during lesson planning. Ten students participated in lectures, an online session, and a workshop focused on GeoGebra, with data collection focused on the workshop. They evaluated and modified simulations, with video-data analysed using the TPACK framework. Most pairs collaborated effectively, demonstrating good TCK and TPK. The findings highlight the developmental process of integrating technology, pedagogy, and content, with room for further development. The TPACK framework provided a valuable structure for evaluating competencies in using GeoGebra in teaching of motion on inclined planes.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Other

Organizing preference criteria:

Education level

Parallel oral presentations / 124

Evaluation of an Activity Connecting Art and Quantum Concepts for Primary Education

Authors: Leonie Sonneveld[None]; Rutger Ockhorst[None]

Co-author: Anna Hotze

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Abstract. The field of quantum technology is rapidly advancing and therefore the public should have a basic grasp of quantum concepts. To this end, we designed an activity around an optical illusion known as Pepper's Ghost to introduce the concept of superposition to primary school students and their teachers.
Research question: What opportunities and difficulties do pre-service primary education teachers see to apply the Pepper's Ghost assignment in their own classroom? What are the perceived learning experiences and outcomes of the pre-service primary education teachers regarding the Pepper's Ghost assignment?
Method: Evaluation research, making use of interviews and learner reports.

Education level:

Pre-service and in-service teacher education

Physics topic:

Quantum mechanics

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Physics topic

Workshops / **255**

Building Thinking Classrooms in Physics - INSTR

Author: Wouter Spaan[None]

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Engaging students in meaningful thinking about physics concepts can be a challenge. In mathematics education a promising approach has gained momentum recently: Building Thinking Classrooms. This approach has been adapted to physics education in a seven-week course for pre-service physics teachers at the Amsterdam University of Applied Sciences. In this workshop participants will experience the approach themselves and receive ideas about implementing it in their own practice.

Education level:

All ages

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / **217**

Assessing Self-Efficacy in University Physics Laboratories: The Impact of Teacher and Peer Collaboration

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This study explores student-teacher collaboration during undergraduate physics laboratory activities and its impact on self-efficacy. Using a longitudinal pre-experimental design, collaborative networks and self-efficacy regarding experimental set-up, data analysis and error handling were assessed in 4 laboratory sections (N=42). Results show an increase in the frequency of teacher assistance as the course progresses. Using multiple linear regression models, it is shown that frequent help from the teacher or peers is relevant to self-efficacy.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Poster session / 178

Exploring Materials Science through Educational Activities in Informal Learning Environments

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This study investigates the development and educational reconstruction of materials science concepts for informal learning environments. Conducted as part of the MaSCot project, the research focuses on creating engaging STEM activities that address socio-scientific issues, such as medical applications of materials science, while fostering collaboration between teachers and scientists. The results highlight the potential for informal learning spaces to bridge gaps in formal education, promoting scientific literacy and active student participation.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Contemporary and modern physics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Closing ceremony / **304**

Introducing GIREP 2026

Corresponding Author: dstavrou@uoc.gr

Organizing preference criteria:

Research method:

Research focus:

Physics topic:

Education level:

Parallel oral presentations / **266**

The impact of different representation types in multi-representational physics instruction

Authors: Ana Susac[None]; Stefan Küchemann[None]; Sarah Malone[None]; Maja Planinic[None]; Jochen Kuhn[None]

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Multiple representations are important in physics education as they help students connect concepts, visualize phenomena, and develop a deeper understanding through various modes of representation. However, students often struggle to interpret these different forms of information, which can hinder learning. We examined how pre-service teachers use multiple representations to understand interference and diffraction using eye tracking. Eye-tracking data were recorded during pre- and post-tests and learning. Results indicated the critical role of mathematical representations and suggested that extracting information was easiest from verbal representations. These findings provide insights into how representations support conceptual understanding.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Evaluation & Assessment

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 174

Active learning and computational simulation of a bouncing ball

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In this work we want to improve the level of learning for the subject of a ball bouncing on flat ground. We have a group of 15 engineering students. By applying an active learning methodology supported with simulations, we get a better interest in the subject, since the behavior of the phenomenon is exposed, and the initial conditions can be controlled. We show the Hake factor obtained with this learning strategy. We hope that these results will be useful in showing the advantages of using active teaching methodologies supported by simulations in the education of some principles of mechanics.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Parallel oral presentations / 290

Exploring Geometric Optics through Project-Based Learning: A Comparative Study

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Project-Based Learning (PBL) has emerged as a powerful instructional approach, especially in STEM education, by promoting deeper conceptual understanding through hands-on activities. This study employs an Educational Design Research (Qualitative Research to investigate the impact of PBL in geometric optics, focusing on the design and application of a laser waterdrop microscope. By incorporating structured project work into the secondary school physics curriculum (ages 15–18), the research evaluates how PBL compares to traditional textbook-based instruction in three areas: conceptual retention, problem-solving skills, and student engagement.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Other

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / **99**

The Meaning of Energy in Physics Teaching in France (grades 7 to 9): an Analysis of Official Documents.

Author: Estelle Tison[1]

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In France, one of the four parts of the Cycle 4 (grades 7 to 9) physics curriculum deals with energy. Teachers are asked to clarify the meaning of the words used to talk about energy, in order to link the concept of energy in physics with that of everyday life. Through a lexicographical analysis, we question the meaning given to these words by the authors of textbooks and official documents. We show that transfers and forms of energy are often undifferentiated. Yet this distinction is a prerequisite for a proper understanding of the social issues surrounding energy.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Thermodynamics and Energy

Research focus:

Other

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / **213**

Comparison of Student Reasoning of Partial Derivatives Before and After the Instruction

Author: Zeynep Topdemir[1]

Co-authors: John Thompson [2]; Michael Loverude [3]

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As a part of a broader project that aims to investigate students'mathematical understanding in physics, this study explores how students understand the partial derivatives of divergence and curl of vector field diagrams. Students are asked to draw vector field diagrams for the given partial derivative before the instruction. After the instruction they have asked to find the sign of the partial derivative of a certain vector field plot. Student difficulties finding partial derivatives of divergence and curl of vector field diagrams before the instruction and after the instruction will be compared.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 50

Effectiveness of Peer Mentoring for Helping College Physics Faculty Members Improve Their Teaching in Japan

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A peer mentoring system for helping college physics faculty members improve their teaching towards active-learning styles was implemented in Japan. Peer mentoring provides faculty members with opportunities to observe different ways of teaching physics and to receive advises from their peers. The results indicate that the peer mentoring system raises their motivation towards improving their teaching. Furthermore, the results indicate that teaching effectiveness towards active learning seems to be dependent on topics. The topic-dependence of teaching is further discussed in the presentation.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Parallel oral presentations / 52

Development and Validation of a Performance-Based AI Literacy Assessment Test for High-School Students Enabling Predictions of their Performance in Tasks Involving AI Tools

Author: Tobias Patrick Treczoks[1]

Co-authors: Jochen Kuhn [2]; Sascha Schmeling [3]; Stefan Küchemann [4]

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AI literacy is pivotal for students navigating AI-driven environments. This research introduces a novel performance-based AI literacy assessment test targeting high-school students (16–19). Built on foundational AI literacy conceptualisations, the tool aims to predict students'proficiency in using AI tools effectively. Validation employs Classical Test Theory and Item Response Theories, eventually linking test outcomes with performance in AI interactions. Initial findings from trials conducted at CERN Science Gateway will be presented. Ultimately, the results will inform AI-themed physics education interventions, enhancing students'critical thinking, input creation, and reflective abilities within AI contexts.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Evaluation & Assessment

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 151

Investigating the impact of digitally-enhanced laboratories on students' scientific abilities and experimental attitudes

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Research in physics education has underscored the importance of making school laboratory activities more engaging and student-centered. The ADELANTE (Adopting Digitally-Enhanced Laboratories in a Network of Teachers) Italian project seeks to promote an innovative approach in secondary school physics labs by integrating digital tools—specifically Arduino microcontrollers and smartphones—within carefully designed Teaching-Learning Sequences (TLSs). This paper outlines the project's rationale, describes the research design adopted to assess the impact of these TLSs on students' scientific abilities and experimental attitudes, and discusses the approach used for implementing them in a network of Italian secondary schools. The ongoing classroom implementation will provide data on the efficacy of these digitally-enhanced labs.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Evaluation & Assessment

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Poster session / 156

Introducing large language models (LLMs) in physics education: A module for future teachers

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We present the design of a six-hour module, "Physics Education Meets AI,"that we taught as part of a master-level course on "Teaching and Learning Physics"at the University of Padua. Twenty students engaged in hands-on activities with Word2Vec, GPT-2, and GPT-4 using Jupyter Notebooks and the LEAP platform, exploring semantic representation and inquiry-based learning with AI as a tutor. Discussions, informed by recent Physics Education Research papers, centered on key epistemological, social, and pedagogical concerns, culminating in an expert panel addressing the potential of AI to transform physics education.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Artifical Intelligence

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / **236**

Key Design Principles for Enhancing the Transfer of Mathematics to Physics in Upper Secondary Education

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Abstract. The transfer of mathematics to physics remains challenging in secondary education. This presentation focuses on four factors hindering transfer: compartmentalized thinking, mismatch in pedagogical approaches, differing teacher beliefs, and a lack of mathematical proficiency. Key design principles for enhancing this transfer include limited intervention in physics textbooks, involving activation of prior mathematical knowledge, applying mathematics in a rule-based manner rather than relying on ad-hoc strategies ('tricks'), and providing strategic hints to guide students effectively towards solutions. These design principles strengthen students' transfer of mathematics to physics and support insight in the underlying mathematics rather than using 'tricks'.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 182

Using Digital Storytelling to Bring Gravitational Waves to School: the GRAVIS Project

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Primary and lower secondary school students are naturally curious, often exhibiting a "little scientist" attitude. However, curiosity alone is not enough for developing structured scientific thinking, essential for their education. We present the GRAVIS project, an educational program which brings together gravitational waves physics and digital storytelling to engage students in inquiry-based learning, hands-on activities, and narrative creation. Developed in collaboration with Einstein Telescope Italy, it fosters critical thinking, creativity, and reflection on scientific discovery. By incorporating AI tools and real-world connections, GRAVIS aims to deepen engagement and prepare students for future STEAM education and careers.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Contemporary and modern physics

Research focus:

Active learning

Research method:

Practitioner's Inquiry / Action Research (Qualitative research)

Organizing preference criteria:

Parallel oral presentations / 47

An Evaluation of Argumentation-Based Studies on Physics Subjects Using the Toulmin Model

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This study is unique in examining how researchers encode components in Toulmin Argument Pattern (TAP)-based applications and their alignment with the TAP framework. Accurate coding practices are important given the increased emphasis on argumentation in PISA, the US National Research Council, and national curricula. As a result of the content analysis, it was seen that the researchers coded misaligned with the TAP. These different coding practices lead to the dissemination of misinformation about argumentation. This research will provide valuable guidance to educators and policymakers in developing curricula and conducting argumentation activities by analyzing these practices.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Other

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research method

Parallel oral presentations / 288

Bridging Sports and Physics: Exploring Experiential Learning, Motivation, and Conceptual Gains among Indian Student Community in Qatar

Author: Mohammed Vallikkaparambil[1]

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This study explores the impact of sports-integrated physics instruction on high school students from diverse cultural backgrounds, such as the Indian community in Qatar. A study with 120 students in grades 11 and 12 across three schools revealed that integrating sports into physics instruction greatly enhanced students' comprehension of physics concepts, boosted their motivation, and fostered a more positive attitude towards learning the subject. The research suggests that incorporating sports into physics education enhances students' understanding and enthusiasm, which is particularly beneficial for high school classes; the findings suggest a move towards interdisciplinary teaching techniques, focusing on active and student-centred learning.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 221

40 years of Physics Correspondence Seminar and its role in education

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Working with talented students so that they develop their full potential is a challenging task for the standard school education. This is a task for non-formal education. Physics Correspondence Seminar (FKS) is a student organization based at Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava. For the past 40 years, it has been working with talented students, organizing competitions, events and other different activities for students interested in physics. It has a unique system in which former participants later become organizers during their university studies. We would like to share our experience we have acquired throughout the years.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Poster session / 223

Náboj Physics –the international physics competition

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Physics competitions are an interesting tool for attracting students to science. Students deepen their understanding of physics and meet other students with similar interests. There are numerous different physics competitions. Many of them aim at the most talented students, who can compete against each other, but only a few are accessible to the majority of students interested in STEM subjects. Náboj Physics is one of them thanks to its unique system. It is an international team competition in the fast solving of physics problems. It became very popular among students, and since 2015, it has been expanding to new countries.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Track

Excursions / **306**

De Leidsche Bierbrouwerij

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Parallel oral presentations / **61**

Understanding the nature of science and the development of a scientist identity through research internships in modern physics

Authors: Marijn van Nijhuis[1]; Lucy Avraamidou[2]; Elwin Savelsbergh[1]

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It is an important challenge for teacher education programs to promote deep understanding of the nature of science (NOS), and the development of a scientist identity among their students. This study examines how internships in modern physics research, as part of the program, can be employed to attain those aims. Interview data and reflective logs reveal that students feel more confident in conducting scientific inquiry. Further analysis aims to uncover how such experiences may contribute to long-term professional development. This presentation will focus on how research internships can be structured and supported to promote NOS understanding and scientist identity development.

Education level:

Pre-service and in-service teacher education

Physics topic:

Astronomy and Astrophysics

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Workshops / **29**

Wall formula murals - sharing science stories on the streets - OTHER

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When walking through the city of Leiden, you cannot escape the more than one hundred beautiful and fascinating wall-poem murals by the artists from the Tegen-Beeld foundation. They tell stories (in the original language) from all over the world, to inspire people. As physicists we joined the project and created murals about our stories, about phenomena in nature discovered in Leiden, written in our language: mathematics. In this workshop participants will explore ways to start such an arts-meets-science wall formula project in their city. New scientists, new formulas, new stories to reveal the hidden international network of curious minds.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Other

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Excursions / **305**

Wall formula walk through Leiden ending at the Old Observatory

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Parallel oral presentations / 143

Student's Understanding of the Celestial Sphere: a Qualitative Interview Study

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Despite educators' efforts using various representations of the celestial sphere to help students reason about the apparent motion of the Sun and stars, this concept remains challenging for students. It is hypothesised that they may not fully grasp the underlying model of the celestial sphere, including its possibilities and limitations. This study aims to explore how secondary school students understand the celestial sphere and how they use it to reason about celestial motion. We therefore conducted a qualitative interview study to gain insight into students'understanding and reasoning processes.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Astronomy and Astrophysics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 54

A School Science Activity based on the Experiment With Images of the Falling Cylinder

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The experiment of a cylinder rolled on a string that falls vertically while unrolling is used to contextualize the teaching of the equation of motion of a body that turns around an axis with fixed orientation. The activity with students is led on the model-theoretical framework of science developed by Giere in the adaptation made by Izquierdo. The students read the position of the cylinder with time in images of a real motion and are oriented to develop a model, whose predictions are checked against the experimental result. This activity is being applied to beginner graduate students of Physics.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Poster session / 163

Gamification of Introductory University Physics Courses

Authors: Péter Jenei[1]; Szabolcs Varga[1]

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Traditional lecture-based teaching methods are becoming less effective in engaging students. This research explores the impact of innovative teaching approaches, incorporating game-like elements, online tools, and research-based learning activities. Conducted among university physics students and teacher trainees, the study used continuous testing with control and experimental groups. Key hypotheses include higher knowledge acquisition, greater professional development, enhanced knowledge retention, and increased student commitment through innovative methods. Assessments were conducted at the beginning, middle, and end of the academic semester, alongside continuous performance monitoring. The findings contribute to optimizing teaching strategies in science, engineering, and teacher education.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Poster session / 220

Stimulation of pupils to experimental activities through learning activities

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This contribution emphasizes encouraging pupils to engage in experimental activities, essential for developing scientific inquiry. The studied stimuli include concept cartoons, role-playing, physics game, an online escape room, and an activity with story. Research involved 341 secondary school pupils (ages 11–15) and their physics teachers. Preliminary findings indicate that pupils felt engaged using these stimuli. Teachers view them as motivating and supportive of experimentation but note that conducting experiments requires teacher assistance.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Poster session / 206

How can embodied learning in the physics classroom energize teachers to promote inclusive practices in secondary education?

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Embodied learning encourages physics teachers to take into account diverse learning needs, social differences and cultural backgrounds of students in order to successfully implement these activities in the classroom. Embodied leaning emphasizes the importance of physical experiences in the learning process, where the body and the learning environment are essential components of the learning process. Embodied learning has added value and promotes students' creativity and motivation. This research focusses on the interactions between teacher and students during an embodied learning activity, where students represent a model of charged particles in electric and magnetic fields in a role play.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Active learning

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 127

Coherent Argumentation in Pre-Service Science Teachers'Computational Essays

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To teach effectively, teachers should be capable of presenting clear and cogent arguments about their subjects. This is especially true in empirical sciences, where many curricula aim to make the students understand how scientific thinking on various fields of study creates new knowledge. Computational essays and open data from today's research world can provide structural support and authentic contextualisation for developing such skills while promoting epistemic agency in the learners. We present findings from the second iteration of a pre-service teachers'field course combining interaction with working experts and data analysis via the medium of computational essays.

Education level:

Pre-service and in-service teacher education

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Poster session / 85

Augmented reality simulation of parallel plate capacitor for mobile devices

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This study introduces CapacitorAR, a mobile augmented reality (AR) simulation designed to enhance students'understanding of parallel plate capacitors. The application combine both marker-based and markerless AR technologies to offer flexible, intuitive interactions that enable users to explore how key physical parameters—such as plate distance, surface area, and dielectric properties—affect capacitance. By combining visual, interactive, and haptic features, CapacitorAR provides a hands-on learning experience that bridges the gap between theoretical concepts and practical applications.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 183

God plays quantum dice –teaching bosons and fermions to high school students

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We present here a teaching unit about bosons and fermions adapted for high school. Despite the importance of the topic as a gateway to many-particle physics, it is absent from most high school curricula and most research on the subject. A teaching unit is presented, and initial findings supporting its adaptation to high school are presented.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Quantum mechanics

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Poster session / 30

Assessing students' carbon competence regarding the effectiveness of climate action measures

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Anthropogenic climate change is shaping the world we live in. Therefore, fostering climate agency is an important goal of science education. To develop climate agency, learners should acquire competences necessary to make informed and effective decisions about climate-related actions. Carbon competence plays a critical role in this process. The contribution presents the development of a test instrument assessing students' carbon competence associated with specific actions. These actions are situated in relation to the dimensions of individual vs. collective agency and everyday vs. strategic and political agency to represent central types of climate action.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Climate physics

Research focus:

Evaluation & Assessment

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Track

Parallel oral presentations / 260

Adaptive, study-accompanying refreshment of school mathematical skills in the STEM degree programs with a focus on Physics and Medical Physics

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Because of a dropout-rate to 60% in physical degree programs in Germany, a students'learning offer has been developed minimizing their individual school mathematical weaknesses which are one component that students quit their studies without graduation. While the first three degree's semesters, the students test their maths competencies and get an individual learn path with exercices and programs supporting their learning attitudes and interdisciplinary competencies parallel to their studies.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Interdisciplinary topics

Research focus:

Competence-based education

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Parallel oral presentations / 94

Validating chained computerised adaptive testing for the Force Concept Inventory

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In our previous study, we developed an algorithm called chained computerized adaptive testing (Chain-CAT), which sequentially links the test results of each administration. To validate the algorithm, we analysed the progression of the conceptual understanding of each student based on Chain-CAT against a clinical interview, then examined the consistency of both results. A pilot study showed that there was uncertainty in scoring among analysts about the methods of quantifying the interview utterance data. To address the issues, the survey procedure was improved for the main study. The results of the main survey (which is now underway) will be reported.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Evaluation & Assessment

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Track

Parallel oral presentations / 78

Using The Trailer Technique to Introduce Marie Curie's Life and Raise Awareness of Being a Woman in Physics

Authors: Beril Yılmaz Senem[1]; Şule Kösem[1]

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The book trailer technique urges students to create a trailer that engages them deeply with a book. This study adapts this technique to physics education, focusing on the life of Marie Curie and raising awareness of the challenges women face in science. Pre-service science teachers read about Curie and prepared a 3-minute trailer. Data was collected through pre- and post-questions, evaluation forms, group discussions, and interviews. Students expressed inspiration from Curie's dedication, sacrifice, and determination. Although they found the trailer preparation challenging, they felt it enhanced their understanding of Curie's scientific contributions, including her discovery of radioactivity.

Education level:

Pre-service and in-service teacher education

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / **164**

Students' reasoning on the characteristics of electromagnetic radiation and its effects

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The reasoning of 64 Greek secondary education students about the nature of electromagnetic radiation and its effects on human health is investigated. The study took place in the context of a teaching-learning sequence on argumentation and climate change. Results indicate that students' reasoning tended to exploit evidence that was accessible as part of the given scenarios but also prior experience and personal opinions.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Competence-based education

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / **152**

Poweri Noi! Watt should we do? A Team Board Game on Energy Transition and Climate Change

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We present an innovative board game for educational purposes in which participants, divided into teams, are called upon to make strategic decisions in the energy sector to improve the economic-social condition of their country. The core message is to show the advantages and disadvantages of the different energy sources, raising participants' awareness of the complexity of the global energy problem and the impact of their decisions on the planet.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Interdisciplinary topics

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Education level

Opening ceremony / **303**

PER: looking back; looking forward

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The first publications in physics education research can be traced to the early 20th Century. However, intense research and development has occurred primarily over the last 50 years. This panel discussion on the evolution of Physics Education Research (PER) over the past 50 years will focus on some key developments since about 1970.

Panel members will share some of their most prominent personal experiences, frustrations, successes and failures while having been active for these 50 years in our field.
By doing this, we will also trace some of the field's development from its nascent stages, focusing on key milestones and influential studies that have shaped our understanding of physics learning. The panel will delve into the shift from traditional instruction to more student-centered, active learning pedagogies, including the role of conceptual change, problem-solving strategies, and the use of technology in the classroom. The panel will also look towards the future and briefly discuss emerging efforts, such as artificial intelligence, and their potential influence on PER.

The panel session aims to provide (younger) PER members some valuable lessons we learned the hard way.

Education level:

All ages

Physics topic:

Full curriculum

Research focus:

Other

Research method:

Other

Organizing preference criteria:

Other

Poster session / **199**

Multidimensional Authenticity in Task Design: Teaching Astronomy and Physics with Historical Stellar Spectra

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This contribution presents an analysis of historical stellar spectrum photographs using digital methods, highlighting their added value for astronomy and science education. Concrete examples of learning activities are provided, and an educational analysis within a multidimensional framework of authenticity is carried out.

Education level:

Pre-service and in-service teacher education

Physics topic:

Astronomy and Astrophysics

Research focus:

Lab course design

Research method:

Other

Organizing preference criteria:

Parallel oral presentations / 115

University students' difficulties related to transformation between graphical and algebraic representations in the case or non-constant acceleration kinematics

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Abstract. The aim of this work is to detect the difficulties of second year (3rd semester) chilean students in kinematics with non-constant acceleration. The focus is on questions in which students receive the information in one representation (graphical or algebraic) and have to transform and answer in the other. The analysis was carried out by phenomenography, which allowed us to categorise the students' answers. The initial results show that although difficulties appear in both transformations, transformation from graphical to algebraic is more challenging for them. These results are intended to guide a future TLS to help students overcome the difficulties detected.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Physics topic

Parallel oral presentations / 33

Identifying opportunities to integrate quantum sensing into bachelor's-level physics courses

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Co-author: Namitha Pradeep [1]

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Quantum principles are driving advancements in quantum computing, communication, and sensing. While quantum computing has gained significant attention in education, quantum sensing remains largely overlooked. To identify opportunities to integrate sensing into existing quantum-related curricula, we performed an analysis of six commonly used textbooks in modern physics, quantum mechanics, and quantum computing. We identified excerpts based on quantum sensing keywords

(e.g., interference, imaging, entanglement) and categorized excerpts based on their context and their conceptual and mathematical depth. This study will inform the development of quantum sensing modules that can be integrated into quantum technology-related courses.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Quantum mechanics

Research focus:

Innovative instructional strategies and pathways

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Track

Parallel oral presentations / **293**

Effect of Experiment-Based and Mathematical Modeling Approaches on Conceptual Understanding of Thermodynamics

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This study investigates the impact of experiment-based learning and mathematical modeling on high school students' thermodynamics understanding. It aims to bridge the gap between theoretical concepts and real-world applications through hands-on experiments and computer-based simulations. A sample of 120 students engaged in activities on heat and temperature concepts. Pre- and post-assessments were conducted to evaluate students' learning outcomes when we compared them to their preliminary information. The results, analyzed through MANOVA to indicate significant improvements in students' conceptual understanding and problem-solving skills. These findings underline combining theoretical and practical approaches and using multidimensional methods in enhancing physics education.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Thermodynamics and Energy

Research focus:

Active learning

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 285

Impact of an Acoustics Course on the Conceptual Understanding of Mechanical Waves Among First-Year Audiology Students

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This study investigates the effectiveness of an acoustics course in improving first-year audiology students' conceptual understanding of mechanical waves. A pre-test/post-test design with 57 participants was employed, utilizing modified Mechanical Waves Conceptual Survey to assess understanding before and after the course. Results showed a significant improvement in students' conceptual understanding. However, students struggled with standing wave concepts. Paired-t test analysis revealed a large, statistically significant difference between pre-test and post-test scores ($t(56) = 7.3$, $p < .001$). Targeted acoustics instruction can enhance students'understanding of wave phenomena, with further focus on standing waves being beneficial.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Full curriculum

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Research focus

Parallel oral presentations / 287

Investigating the Dynamics of Sense of Belonging to Physics and Physics Identity in High School Physics Classes

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[1] *Doğan Cüceloğlu Fen Lisesi*

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This study examines the dynamic nature of students' sense of belonging in physics (SoBP) and physics identity (PI) in relation to different physics topics and emotional states. Using a mixed-methods approach, pre-test and post-test surveys were conducted with 54 11th-grade students in a science high school in Turkey. Data collection is ongoing, covering topics such as motion and projectile motion, with future plans to include momentum, torque, etc. Findings aim to provide insights into the evolving nature of SoBP and PI, offering valuable perspectives for educators to foster inclusive and supportive learning environments.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Parallel oral presentations / 24

Fluid Mechanics and the Ways Pupils Think

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The design of physics education and learning materials in Slovakia is mostly based on constructivist theory, which emphasises pupils'experiences and prior knowledge as important parts of their learning. However, newer approaches are currently used globally. We applied selected principles from cognitive neuroscience to designing learning materials concerning fluid mechanics. Within this article, we present research on how the use of these materials affects pupils'ideas. Results showed that pupils'ideas significantly shifted towards the normative state, and overall, the results of summative assessment in research groups were better or the same as those in the control group.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Poster session / 251

Pupils' mindset on physics and its changes in the first year of teaching - a questionnaire survey

Author: Jan Říha[1]

Co-author: Anna Hrochova

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In the past two years, a questionnaire survey has been conducted in primary schools in the Olomouc Region (Czech Republic). The aim is to find out the position and popularity of the subject Physics in comparison with other subjects in the first year of teaching Physics as a separate subject. The questionnaire was completed by approximately 500 pupils, where they evaluated the popularity and difficulty of the subject Physics, the forms of teaching, teaching materials and other activities used in Physics classes. The results of the evaluation of this questionnaire survey will be presented.

Education level:

Age 12-15 (Secondary education)

Physics topic:

Contemporary and modern physics

Research focus:

Students'identity, inclusion and wellbeing

Research method:

Analytic Physics Education Research (Quantitative research)

Organizing preference criteria:

Parallel oral presentations / 57

College Science Students'Scientific Reasoning in Kinematics: A Resources Framework Analysis

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College physics education aims to develop students'knowledge of fundamental and interconnected physics concepts such as kinematics. Previous research has examined students'understanding of kinematics in various studies addressing naïve beliefs, misconceptions, learning difficulties, and knowledge-in-pieces framework. This study explores students'reasoning in kinematics based on resources framework analysis. Participants were 198 college science students who solved a physics problem, and then, 40 of those students joined an interview. Phenomenographic analysis showed that students used procedural, epistemic, and argumentative resources in their solutions. The study has implications for instructional design in college physics education.

Education level:

Age over 18 (excluding teacher education)

Physics topic:

Other

Research focus:

Student conceptions / Preconceptions / Misconceptions

Research method:

Innovative research strategies (Try-out) (Qualitative research)

Organizing preference criteria:

Education level

Poster session / **231**

Four-Year Research on the Learning Using Mentors (LUM) Method: Implementation and Experience

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The Learning Using Mentors (LUM) method delegates part of a teacher's authority to gifted students who act as mentors. Mentors lead group work, offer tutoring, and play crucial role in creating and grading tests. This contribution summarizes the results of four years of experimental use of this method in upper-secondary physics classes. Semi-structured interviews with both mentors and their peers, along with questionnaire investigations, highlight several benefits of the LUM method, including its motivating power for gifted students, reduced fear of physics and easily accessible help for "non-mentors"or closing language gap between students'everyday language and physics terminology.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Other

Research focus:

Innovative instructional strategies and pathways

Research method:

Mixed method (qualitative & quantitative)

Organizing preference criteria:

Research focus

Parallel oral presentations / 177

ESG Junior Program: Knowledge, Skills, and Purpose

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Results of international assessments (PISA, TALIS) revealed below-average performance in scientific literacy, problem-solving and critical thinking of Croatian students and teachers. That highlights the need for improvement. To address this, we undertook an innovative project, integrating ESG principles to contextualize formal knowledge in real-world settings –ESG Junior Program. The program utilizes physics, as a fundamental science, to address real-world challenges. Connecting schools with local communities, students research local issues and develop solutions, gaining practical skills for future labour market participation. Project is implemented in six pilot schools in Croatia. At the conference, we will present developed scenarios and applied methodology.

Education level:

Outreach, Informal & Non-formal learning of physics

Physics topic:

Interdisciplinary topics

Research focus:

Innovative instructional strategies and pathways

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Education level

Poster session / 91

Smartphone-Based Physics Experiments: Evaluating the Accuracy and Precision of Embedded Sensors

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This study investigates the suitability of smartphone sensors for physics experiments by comparing their performance with laboratory-grade instruments. Measurements from various smartphone models were analysed across experiments involving sensors like accelerometers, magnetometers, and light sensors. Results of light sensor measurements reveal significant variability, particularly at high illuminance levels, with uncertainties necessitating careful interpretation. Despite other

limitations such as lower sampling rates and sensitivity to orientation, smartphone sensors offer a cost-effective, accessible tool for hands-on learning, empowering students in resource-constrained environments to engage in meaningful scientific inquiry.

Education level:

Age 15-18 (Secondary education)

Physics topic:

Full curriculum

Research focus:

Digital technologies (multimedia, simulations, AR, VR, remote, games)

Research method:

Educational design research (Qualitative research)

Organizing preference criteria:

Excursions / **308**

Louwman car museum

Excursions / **8**

Space Expo

Opening ceremony / **3**

Welcome by Scientific Director ICLON Fred Janssen

Opening ceremony / **2**

Welcome by Scientific Director LION Sense Jan van der Molen