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AUTHENTIC RESEARCH EXPERIENCES IN A PHYSICS LABORATORY COURSE

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In this talk, I will describe how we reconstructed the introductory physics laboratory course at the University of Potsdam, shifting the focus from the transmission of physics concepts to the development of students' experimental skills and expert-like attitudes.

Students are no longer following cook-book-like instructions from the lab manual to reproduce well-known results but are engaging in authentic processes of scientific inquiry.

I will present the iterative redesign process based on the assessment of students' learning, the newly defined learning goals, and some examples of activities carefully designed to reach those goals.

BRIDGING THEORY AND PRACTICE: A FOUR-YEAR RESEARCH CLUB PROGRAM FOR HIGH SCHOOL PHYSICS AND ENGINEERING EDUCATION

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This paper presents an innovative concept for enhancing physics and engineering education by integrating different engineering research fields' labs. The aim is to provide high school students with practical exposure to interdisciplinary research fields, thereby preparing them for future university studies in engineering. The proposed concept involves the development of a four-year research club program where different lab environments and interactive simulations enable students to engage with complex engineering and physics principles in a hands-on manner. By leveraging these innovative tools, students can better understand theoretical concepts and their real-world applications. The complex nature of developing this concept in physics and engineering encompasses technical, educational, and resource-related challenges and considerations that are highlighted. The paper also explores the potential impact on students' learning outcomes and their preparedness for advanced studies in physics and engineering. The findings contribute to the ongoing discourse on modernizing STEM education and fostering the next generation of innovative thinkers and problem solvers.

DESIGN AND ANALYSIS OF A BALMER SERIES EXPERIMENT IN A SELF-MANAGED LABORATORY SETTING

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This paper introduces a lab experiment focusing on the Balmer series, designed as part of a Lab Module for an introductory course on Laser Technology. A key aspect of this experiment is that students are required to independently construct the experimental setup, embodying the principles of the "3P-Konzept" ("Paderborner Physik Praktikum" or "Paderborn Physics Laboratory Course"). Students are able to explore the quantum nature of light by investigating the spectrum of a hydrogen lamp. The discontinuous spectrum demonstrates basic quantum physics concepts such as the processes of absorption and emission, that form the basis of every laser.

The "3P-Konzept" aims to transcend traditional knowledge transfer and facilitate learning in a more active and participatory role to foster solution-oriented thinking in addressing unfamiliar problems. In this setting, instructors transition from a traditional instructive role to a consultative one. Instead of conventional result reports, students are expected to maintain a lab journal, documenting encountered problems and their solutions. This approach is designed to optimally prepare students for their future professional careers as engineers, where independent thinking and problem-solving skills are essential for innovation and success.

DIVERSIFICATION IN PHYSICS TEACHING BY TRANSFORMING PANDEMIC-ERA LEARNING THROUGH OPEN INTERACTIVE TEXTBOOKS

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In response to the evolving educational landscape shaped by the global pandemic, this presentation explores the transformative impact on teaching and learning in the field of applied physics, with a focus on Electricity and Magnetism. Our study introduces an approach to diversify learning methods for students.

We integrated short videos, originally developed in response to the pandemic, into an open and interactive textbook format using Jupyter Books, which can be accessed at https://interactivetextbooks.tudelft.nl/tn1322/. We address the language barrier often faced by non-English-speaking students by providing content in Dutch, a departure from the conventional English-language physics textbooks.

Our presentation will highlight a significant pedagogical shift: the reduction of traditional lectures to allocate time for students to independently watch the instructional videos. This approach grants students the flexibility to consume content at their own pace and allows for more interactive and engaging classroom sessions. With the entire course material available in video format, we have observed an increase in student satisfaction, as they appreciate the autonomy to structure their learning schedules. This model creates an environment conducive to more interactive and personalised learning experiences.

A distinctive feature is the incorporation of Python programming within the book to illustrate phenomena in Electricity and Magnetism. Python serves as a powerful tool to enhance conceptual understanding through simulation.

Our findings contribute to the broader discourse on pandemic-induced pedagogical shifts and provide a tangible model for educators seeking innovative strategies to improve the diversity of learning paths and effectiveness of physics education in a post-pandemic era.

PHYSICS ENGINEERING STUDENTS' PHYSICS EXPECTATIONS

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Previous research on students' physics expectations showed that students' views about physics knowledge and physics learning influence their approaches in physics classes. In this research, we have focused on physics engineering students and examined their physics expectations. Maryland Physics Expectations Survey (MPEX) with 34 Likert-type questions was implemented to 59 undergraduate students registered in a physics engineering program. Statistical tests were used to examine students' physics expectations according to gender and interest to popular physics books. In addition, students' physics expectations were compared with expert views both in overall survey and sub-categories such as independence (physics learning), coherence (structure of physics knowledge), concepts (content of physics knowledge), reality-link (relation of physics with real life), math-link (relation of physics with mathematics) and effort (studying for physics learning). The results about to what extent students had expert like opinions in physics are important for the improvement of epistemological understanding for better physics learning.

EMPOWERING PHYSICS EDUCATORS: EXPERIENCES FROM THE FIRST ROUND OF EUROPEAN FACULTY ONLINE LEARNING COMMUNITY MEETINGS

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Teaching in higher education is often perceived as an innate skill mastered solely through professional knowledge in a given discipline. However, educational research, particularly in Discipline-Based Education Research (DBER), reveals that effective instructional practices constitute a distinct skill set that can be cultivated. Despite this understanding, efforts to disseminate DBER findings into practical application often leave educators with inspired ideas but lacking ongoing support.

This contribution focuses on the attempt to bridge this gap through Faculty Online Learning Communities (FOLCs) [1]. These peer-to-peer networks create a platform for instructors to connect, share experiences, and collaborate on improving their teaching practices. They are typically run by an external facilitator after a faculty development workshop or training, providing ongoing support for instructors in implementing research-based instructional strategies in their classrooms.

In 2023, the inaugural European New Faculty Workshop (NFW) in Switzerland marked the beginning of the FOLC initiative in Europe. Subsequently, the first round of FOLC meetings brought together enthusiastic NFW participants and associated colleagues. This poster describes the character of the Learning Community that was created here and sheds light on the experiences of both facilitator and participants.

[1] Rundquist, Andy, Joel C. Corbo, Stephanie Chasteen, Mathew „Sandy“ Martinuk, Charles R. Henderson, und Melissa H. Dancy (2015). „Faculty Online Learning Communities to Support Physics Teaching“. In 2015 Physics Education Research Conference Proceedings, 279–82. College Park, MD: American Association of Physics Teachers. https://doi.org/10.1119/perc.2015.pr.065.

CREATING A STUDENT-CENTERED COLLABORATIVE GROUP-LEARNING ENVIRONMENT IN A UNIVERSITY PHYSICS CLASSROOM

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The time-honored conventional lecture ("teaching by telling") has been shown to be an ineffective mode of instruction for introductory physics classes. For enhancing critical thinking skills and developing problem-solving abilities, collaborative group-learning environments have proven far more effective. At George Washington University, we initiated a collaborative group-learning pedagogical approach (SCALE-UP) for classes in 2008. Since 2013, our introductory physics sequence is taught exclusively in this mode, eliminating the "standard" lecture.

In SCALE-UP, students sit at tables in groups of three, collaboratively performing various pencil/paper exercises (ponderables) using small whiteboards and engaging in hands-on activities like demos and labs (tangibles). This innovative pedagogy often arouses the curiosity of physics faculty, who wonder how the small-group format is organized and what activities constitute a typical class session. This workshop will answer these questions and will provide examples that can be implemented in your own classrooms.

This workshop is intended to be an active-engagement experience for all participants. We introduce student-centered learning environments and discuss challenges that might arise. Participants will then work together on several exercises illustrating the possible range of group-learning activities suitable for calculus-based introductory courses.

Workshop activities include:
- Conceptual "clicker" questions
- Whiteboard conceptual/numerical exercises
- Group quizzes using "lottery ticket" scratch-off cards
- Hands-on exercises involving tangible manipulation

The focus will be on the in-class delivery of the exercises and the pedagogical value of the collaborative activities. The primary aim is for participants to experience this from the student perspective, which is necessary to fully appreciate the benefits of interactive engagement.

TEACHING PHYSICS TO ENGINEERS IN THE TIMES OF ARTIFICIAL INTELLIGENCE

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Teaching physics to engineers has always been a challenge. Recently, however, we have been observing changes that have entered teaching with great strides. Many teachers faced the dilemma of how to use, for example, ChatGPT in teaching. Pupils and students tend to take shortcuts and use the latest technology to get through their studies more easily. However, those who finish their education begin to worry about jobs. If artificial intelligence makes it easier to do homework, it obviously also makes work easier. Will the job market for engineers shrink then? In this work, I want to present the students' point of view and the strategies they choose related to artificial intelligence (AI). I will also present ideas on how to use physics in teaching to increase the competitiveness of future engineers on the labor market where artificial intelligence is used.

WHAT I WISH I HAD KNOWN… WHEN I STARTED (ACTIVE) TEACHING IN PHYSICS

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The benefits of activating teaching methods are promoted by many colleagues and have been proven by numerous studies. Nevertheless, experienced instructors often do not switch to those methods in their teaching and first-time lecturers start with traditional instead of activating methods. This article is aimed at (future) educators who are thinking about using such methods, as well as experienced ones and educational support staff who wish to provide support for their colleagues. This report is based on (free-response) evaluations, standardized tests, personal experience, and literature. It shows which (partly subjective) aspects made the introduction of and transformation to activating methods difficult at the University of Applied Sciences Merseburg, which supporting factors were important, and which would have been important or helpful. It is shown why a changeover is worthwhile for physics educators despite possible risks.

EXPLORING QUANTUM COMPUTING TECHNOLOGIES IN A CHOOSE-YOUR-OWN-ADVENTURE ACTIVITY

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Quantum computing, with its fundamentally distinct principles from classical computing, often proves mysterious to non-specialists. The abstract nature of quantum concepts leaves many with no concrete idea of how a quantum computer looks or operates. This hands-on activity seeks to demystify the enigma surrounding quantum computers by immersing learners in an engaging choose-your-own-adventure experience.

In an online interface, learners are introduced to quantum computing principles, after which they choose the technology for their quantum computer, such as trapped ions, superconducting circuits, and neutral atoms. Learners are then guided through the setup of quantum computers, gaining insights into the enabling technologies while simultaneously learning about the challenges and complexities inherent in quantum computing. Returning to the activity's start, learners can experiment with different technologies, discovering the advantages and disadvantages of competing technologies.

The choose-your-own-adventure format enables learners to tailor their exploration, fostering a personalized and highly engaging learning journey. By actively participating in the decision-making process, learners will develop a deeper appreciation for the intricacies involved in harnessing quantum phenomena for computational purposes.

EMPOWERING DISADVANTAGED YOUTH THROUGH STEM EDUCATION: INSIGHTS FROM THE MINT LIGA

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The MINT LIGA, a MINT Cluster supported by the BMBF, aims to reach and engage disadvantaged children and adolescents by providing motivating educational opportunities accessible through youth centers.

The presentation will delve into the core aspects of the MINT LIGA, emphasizing its commitment to fostering self-efficacy among participants. By implementing a pedagogical framework centered around self-concept, the initiative seeks to empower young individuals facing socio-economic challenges.

Drawing on experiences from the field of physics didactics and teacher training, we will showcase effective strategies employed to enhance the accessibility and appeal of STEM subjects to a diverse audience. These strategies include hands-on activities and real-world applications designed to capture the interest of underprivileged youth.

The MINT LIGA's approach leverages the infrastructure of youth centers to bridge educational gaps and create a supportive environment for learning. The presentation will highlight successful case studies and share valuable insights gained from implementing the program, demonstrating how collaboration with youth centers can significantly impact the educational ecosystem for marginalized communities.

Ultimately, we want to contribute to the ongoing discourse on inclusive STEM education, shedding light on the importance of tailored interventions and motivating offerings for disadvantaged children and adolescents. By sharing our experiences and lessons learned, we hope to inspire educators and stakeholders to explore similar initiatives, fostering a more equitable and accessible STEM education for all.

MOMENTECH – MODERN EXPLORATIONS OF THE IMPULSE-MOMENTUM THEOREM

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Herein we describe a modern laboratory experiment to investigate conservation of momentum, by way of the impulse-momentum theorem, for engineering & physics students. Microcontrollers with built-in or modular accelerometers are attached to two carts to record accelerations during their collision. Using the acceleration data and the masses of the carts, students then plot net-force vs. time data and a numerical integration routine is employed to find the approximate areas under the F vs. t curves of each cart, which should add to zero due to conservation of momentum. The numerical integration routine can be detailed for advanced students, who can be encouraged to find other or better routines. Furthermore, advanced classes can explore the error of a given routine. The microcontrollers can be further augmented with small screens which can plot a vs. t in real time, allowing students to see the spikes and dips of momentary accelerations. This allows for a visual depiction of the often-confusing idea of accelerating one way, whilst moving the other way. In addition, the accelerometer's sampling rate can be adjusted in the microcontroller code to allow for smoother or rougher graphs. Finally, all of the equipment involved can be acquired (and replaced) at low-cost, and due to the open-source nature of modern microcontrollers, the experiment we describe is fully customizable by simply modifying the code we’ve used, or by writing one’s own bespoke code, to fit any level of student sophistication, the instructor’s preferences, or the class’s curriculum.

ENHANCING EDUCATION THROUGH INNOVATIVE DIGITAL ASSESSMENT TOOL

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The landscape of assessment tools for conducting simple surveys or tests is expanding rapidly. However, the evaluation and categorization of open-ended responses remain challenging. Addressing this problem, the school kit project, in collaboration with the University of Rostock, has been initiated. The project aims to utilize artificial intelligence to automatically assess and subsequently classify students' responses to specifically open questions. The format of those questions could be lecture questions, performance evaluations such as exams, or diagnostic tests on physical concepts.

Responses will be rated, whether they represent correct or incorrect concepts based on a self-categorized system. While the tool is still in development, insights into its initial applications, such as during the Physics Day at the University of Rostock, will be shared.

INVESTIGATE STUDENTS USE OF GENERATIVE ARTIFICIAL INTELLIGENCE TOOLS IN ENGINEERING PROGRAMMING ASSESSMENT

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Integrating the fundamentals of computer science and programming skills into the undergraduate engineering curriculum has been a primary focus for many educational institutions around the world. Learning the basics of programming from the beginning of undergraduate engineering education allows students to incorporate such skills into their work in the future with ease. The Mechanical Engineering Department at University College London (UCL) acknowledges this value and has been running an introductory programming element that teaches the fundamentals of Python programming language for first year undergraduate students since 2021. The addition of this element to the first-year curriculum has shown a notable student engagement with the material and a significant positive impact on their subsequent years' academic performance. The assessment of this element is designed so that it examines and measures students' practical and programming skillsets. In this assessment, students are required to collect a dataset from a 3D printed Stirling Engine and use it to answer coursework questions that analyse its physics, dynamics, and kinematics in a single Jupyter Notebook using Python language. Starting from this year, the UCL policy on academic integrity has required all assessment briefs to provide details on what artificial intelligence tools are allowed within the context of the assignment. Generative artificial intelligence (GenAI) applications in higher education are moving so fast that a wait-and-see approach cannot be taken. These tools, such as ChatGPT by Open AI, have received a lot of global attention from academics on their impact and proper use within the teaching-learning process. Specifically speaking, the use of these tools in programming assessments must be done in appropriate ways that support students' learning. Since the learning outcomes of this element focus on building students' computational, algorithmic and systematic thinking when solving a given engineering problem, it would be impractical to impose a blanket restriction on using GenAI, but rather to embrace it. Therefore, the assessment brief has allowed students to use GenAI as an integral role in view of the fact that the driver of any assessment should be achieving the module's learning outcomes not the mode of the assessment.

WHICH STUDENTS SHALL WE SUPPORT? – STUDENT TYPES IN HIGHER EDUCATION IN PHYSICS

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In recent years, a decreasing success rate in the mandatory modules (e.g. lower participation in exams, higher failure rates) has been observed in the first year of the physics bachelor program at the Ruhr-Universität Bochum. As part of a project on optimization the introductory phase of physics studies, information is to be obtained about the individual goals pursued, the perceived challenges, and how these change during the study introductory phase. Therefore, interviews were conducted with a total of 38 students from two cohorts at four points during their first year of study: during the first week of lectures, shortly before the first partial exam, at the end of the first semester, and after one year of studying physics. A type-forming qualitative content analysis based on results of previous research concerning the introductory phase in higher education (e.g. Bosse 2019, RuhrFutur 2018) was used to carry out the evaluation. Six specific types of students could be identified regarding their individual expectations associated with studying and dealing with any hurdles. The extent to which the types change over the course of the study introductory phase was also examined. In addition, the identified six student types were compared with the students' detailed study progression resulting from a comprehensive cohort analysis. The results indicate that certain types allow an early prediction of the course of the study based on their statements. The presentation will introduce the different types and discuss the results regarding possible implications for the introductory phase of studies in STEM subjects.

LEARNING THE PROCESS OF GAINING SCIENTIFIC KNOWLEDGE

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We present how a teaching unit can be designed to teach the scientific method.

To understand how scientific progress happens, it is necessary to understand the fundamental process by which science generates new knowledge. Teaching the process from observation, hypothesis, prediction, experiment/thought experiment, testing and possibly revising the hypothesis to a theory poses several challenges for the teacher. We will show how we let our students carry out this process themselves in a teaching unit of 1.5 hours.

LEARNING PHYSICS METHODS – IS IT POSSIBLE TO TEACH METHODS INSTEAD OF PHYSIC CONTENTS?

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For many years, a team of physicists at the HTWG Konstanz is shifting the focus of physics education from teaching content to teaching methods. An overview is given on the derived state. Several questions are addressed, such as: What are the advantages? Are there constraints and limits? How can a shift be achieved? What are student reactions and how does other teaching staff deal with the new situation?

PREDICTIVE LEARNING ANALYTICS GENERATING LEARNING FEEDBACK: AI DESIGN, CHALLENGES, FIRST FINDINGS

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Learning analytics involves analyzing data from digital learning environments, allowing predictive modeling to identify potential risks of student dropout from study programs or courses. Our project was inspired by publications indicating that failure rates in STEM exams could be reduced by half through the implementation of a feedback e-mail, which effectively modifies students' learning behavior. For a physics course designed for freshmen in industrial engineering, incorporating active learning components, machine learning models (MLMs) were trained using seven years' worth of historical data to predict potential exam failures in the current course. Potential indicators of exam success were fed into the MLM, including data on prior knowledge, quiz performance, and engagement data from the learning management system. It was decided to prioritize decision trees for analysis, as their predictions are traceable, enabling to provide valuable individual feedback to students. The feedback design, developed in workshops and through questionnaires with students, emphasized the importance of delivering constructive and motivating messages. This ensures students accept and genuinely benefit from the feedback, enhancing their learning process. After nine weeks of term, a learning feedback for the end-of-term exam was given. Due to the initial MLM's unsatisfactory accuracy, the feedback e-mail was split into three parts: i) Data table comparing current performance with peers and offering individual learning recommendations. ii) MLM results with feedback tailored to the student's learning path. iii) Contacts for additional university support if needed. The evaluation of how students perceived the feedback e-mail indicated a generally positive and motivational reception.

USING RESEARCH-BASED INSTRUCTIONAL MATERIALS TO FOSTER CONCEPTUAL UNDERSTANDING – TUTORIALS IN INTRODUCTORY PHYSICS

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Research on the teaching and learning of physics has identified specific conceptual and reasoning difficulties that often prevent students from developing a functional understanding of various topics taught in introductory physics courses. There is evidence that instructional materials that take into account such difficulties and prompt students to critically assess their own understanding can improve student learning. This workshop will introduce participants to Tutorials in Introductory Physics, a set of materials intended to supplement the lecture, textbook, and laboratory of standard introductory physics courses for students in physics, engineering, and other fields. In addition to providing hands-on experience with the instructional materials, we will discuss various aspects of incorporating the tutorials into an introductory course and present data from a large study to assess their effectiveness. The Tutorials in Introductory Physics were originally developed by Lillian McDermott and the Physics Education Group at the University of Washington. They have been translated into other languages, including Spanish, Greek and German. In addition, they served as a model for the development of instructional materials for other STEM subjects, such as electric circuits and engineering mechanics.

INVESTIGATING AND ADRESSING STUDENT DIFFICULTIES WITH BASIC CONCEPTS IN FLUID DYNAMICS

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The dynamics of fluids play an important role in the engineering sciences. From ship construction to aviation and transport processes, the flow of fluids is of great concern. The instruction in the field of fluid dynamics has the difficult task to convey the underlying physical concepts and its applications. Prior research has identified some student difficulties regarding the continuity principle and Bernoulli's equation. In a recent study, we probed student understanding of relevant concepts, including pressure, compressibility, vorticity, potential theory and momentum balance. Through multiple-choice diagnostic tests at the start and end of a semester as well as four shorter quizzes with concept questions throughout the semester, we explored if students had a good grasp on foundational ideas in fluid dynamics. Many and deeply rooted misconceptions about the physics of flow surfaced regarding all of the tested topic. To address these issues, we plan to develop and implement active learning materials known as Tutorials. These evidence-based materials are designed to help students overcome difficulties in a targeted and focused way by confronting students with their own ideas about flow though group discussions, practical examples, guided exercises and thought experiments. The effectiveness of the materials will be monitored through repeated testing.

COMPARISION OF SYNCHRONOUS AND ASYNCHRONOUS TEACHING UNITS IN A HYFLEX PHYSICS COURSE

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The COVID-19 pandemic has accelerated the significance of online teaching, leading to greater demand for flexible learning options. The pre-existing HyFlex modality meets those demands as a hybrid and flexible teaching model. This approach enables students to choose between synchronous, in-person classes and asynchronous learning options for each teaching unit, offering them greater flexibility in their learning experience.

Asynchronous online learning is a highly effective pedagogical approach that offers several benefits. It allows students to engage with course materials at their own pace. Students can revisit content as needed, which is highly beneficial in aiding their understanding of complex concepts. Successful asynchronous courses are highly structured and help students develop self-regulated learning abilities and grant them agency over their educational experience.

However, the teachers have a considerable additional workload when creating a HyFlex course. Some students may find themselves overwhelmed, especially those with poor time-management skills. Additionally, the absence of face-to-face interaction in asynchronous learning environments can impede peer communication and collaboration.

So far, research has explored the effectiveness of asynchronous online lectures in physics. However, a comparison of whether asynchronous online sessions can be equivalent to synchronous in-person sessions still needs to be performed.

A teaching unit designed for comparability in both in-person and asynchronous online formats served as the foundation for an experimental study. Participants engaged in individual modalities, and a literature-inspired test was administered to assess both perceived learning and actual learning. Initial findings and insights derived from the experiment are presented.

IMPLEMENTING THE INVERTED CLASSROOM MODEL (ICM) IN EVERYDAY TEACHING OF FIRST SEMESTER PHYSICS FOR ENGINEERING: CHALLENGES, GAINS AND LEARNINGS

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The "Inverted Classroom Model" (ICM) is now widely recognized as a pedagogical concept. However, translating the theory into continuous practice in higher education teaching still presents numerous challenges.

We draw upon the experience gained from several parallel first-semester classes in "Physics in Engineering" over ten semesters, where the ICM has been implemented in differently graded intensities using varying methods. All monitored courses share a common final exam, part of the classes undergo additional evaluation through pre-post testing using the "Force Concept Inventory".

The challenges in implementing the ICM include a broad, only partly predictable variation in the number of students per semester, along with limitations in available resources such as premises, demonstrational experiments, hands-on experiments, and human teaching capacities. The students attending the classes exhibit a wide heterogeneity in their educational and cultural backgrounds and vary in age and with regard to their financial and social situations. On a practical level, they also differ in terms of the private digital equipment they have access to. The necessity to adhere to formal regulations for study and exams further contributes to the challenges.

We examine both the obstacles, and the solutions implemented in practice. The integration of pandemic-driven (online) formats into the teaching will be highlighted. Adaptations to the ICM that can help to establish the model in practice are discussed. A particular focus is set on the use of materials created with Moodle-STACK, including prompts and differentiated feedback, for use in synchronous and asynchronous learning phases.

TEACHING WITH PHYSICS ONLINE VIDEOS

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The development of an online physics course for engineering students is discussed. The course is based on videos for lectures, experiments and exercises and covers the standard topics in physics education from mechanics, waves, thermodynamics, electro-magnetism to optics and aspects of modern physics. All videos are hosted on YouTube (https://www.youtube.com/c/PhysikExpaerimenteFormelnMatthiasKohl). For a better organization and ordered presentation, all content is presented on the university learning platform (OpenOlat) and a designated website (www.physik-online.com) which provides additional content like texts and pdf-documents.

Each chapter covering a specific topic is introduced by a physical experiment, with emphasis on inside and understanding of nature derived from observation and, in a second step, by interpretation and description within the language of theoretical concepts and mathematics.

Since 2019, this physics course is used for teaching engineering students at University of Applied Sciences Koblenz in ‘flipped classroom’ style, i.e. students are expected to come prepared to the lectures. This required a severe shift in teaching and learning, and both positive and negative aspects are discussed. While the advantage during Covid-lockdown times was obvious, the benefit is less clear when embedded in a standard university environment and schedule.

All course material is open, and its use by other lecturers and students is envisioned and encouraged. Future times will tell whether the impetus towards a more flexible, open and online teaching and learning will hold, and this physics course hopes to contribute to this aim.

QUANTUM COMPUTING: A TROJAN HORSE APPROACH TO TEACHING QUANTUM PHYSICS TO ENGINEERING STUDENTS

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In traditional physics education for engineering students, the curriculum often centers on concepts up to 19th-century electromagnetism, while modern physics, such as quantum mechanics, receives limited attention at best. For information technology students, the rise of quantum computing over the past five decades offers an exciting possibility to explore contemporary physics. The accessibility of powerful quantum computers, such as IBM Quantum accessible via Python over the internet, enables hands-on experiments with quantum systems from abstract high level quantum principles down to tangible physical properties of these systems.

This contribution introduces a semester-long introductory course in quantum computing, implemented at the Department of Information Technology at University of Applied Sciences Mannheim. The course is focused on extensive lab work, fostering practical comprehension and application of theoretical constructs like quantum randomness and superposition in experiments on real quantum systems.

Given in a flipped conference format, this contribution invites participants to actively engage in discussions, sharing their own insights and experiences in teaching quantum mechanics and quantum computing.

VISUALIZATIONS IN QUANTUM PHYSICS/TECHNOLOGIES

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Modern quantum technologies, including quantum computing, are playing an increasingly important role in areas ranging from sensing applications (measuring magnetic fields etc.) and cryptography to computing.

The interdisciplinary character of its applications also leads to an increased demand to teach basic quantum concepts like superpositions and interference to computer scientists, engineers, and other professional groups with different mathematical backgrounds.

Besides its mathematical structure, the unintuitive nature of quantum physics can pose a challenge to understanding the potential and limitations of those quantum technologies. A vital tool to support the learning process, and address both challenges, are visualizations.

There are a range of visualizations (like the Bloch sphere and others in the context of qubits), addressing and requiring different levels of abstraction. However, each visualization comes with certain strengths and drawbacks.

Based on a flipped format, an overview of different existing visualizations is provided beforehand and summarized on a poster (including a visualization that was developed and tested in the Quantum LifeLong Learning Project - a further education program in the quantum technologies for professionals in industry). In the poster session, we enter an open exchange of participants' experiences regarding different visualizations (and their impression of how suitable they are in an engineering context). The discussion is guided by trying out different visualization to explain superpositions and interference.

GRADING, LEARNING AND CREDITS

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Students often claim that passing a test with a minimal grade provides maximal return on investment; although after the test, the knowledge gained is lost even faster.

At the Hague University of Applied Sciences there are engineering courses where the students not only learn the theoretical aspects, but also the skills to operate various devices. Here especially, it is important that, after passing the tests, the students keep their knowledge.

To achieve this goal students have oral assessments in which they need to demonstrate and explain the categories of the course rubric. For this we developed a rubric in which the learning outcomes are the categories and passing the assessment is only possible when every learning outcome is assessed at minimally the basic passing level. If a student fails a certain learning outcome, they have to redo that one. They are allowed to redo one category per course.

With a clear connection between the assignments, learning outcomes and assessments, the students really need to understand what they are doing to be able to answer questions properly and all learning outcomes result in at least basic level of understanding.

In the semester following courses graded in this way we noticed students show more affection towards the learning goals and dare to apply their newly gained knowledge in (slightly) different settings. We are in the process of using more rubrics in the grading of engineering classes, hopefully increasing the affection of students toward these classes and the retention of their knowledge.

CLASSROOM OBSERVATION IN SCALE-UP SETTINGS – FIRST RESULTS

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SCALE-UP (Student-Centered Active Learning Environment for Upside-down Pedagogies) is a pedagogic approach to foster active learning, originally developed for undergraduate physics courses (Beichner et al., 2007). Instead of receiving lectures in SCALE-UP students work actively together in small groups, mostly at round tables and are guided by teaching staff.

This concept is implemented at Rosenheim University of Applied Sciences, Germany, in several classes of physics and mathematics for engineering students. Classroom observations have been carried out in summer term 2023 and winter term 2023/24 in order to investigate student learning in the SCALE-UP setting. The observations are based on ELCOT-3, the Engineering Learning Classroom Observation Tool (Sanders et al., 2018). An observation includes the overt student behavior in combination with the students' output. The data have been analyzed with respect to the ICAP-framework (Chi&Wylie, 2014), where the different observed activities have been assigned to Interactive, Constructive, Active, and Passive mode. In this contribution we present examples on how students interact with the offered material, that means in which ICAP-modes students work with different learning activities in the SCALE-UP setting. Moreover, we show that in all observed courses students have been learning a substantial part of class time in interactive and constructive mode.

MY PERSONAL CLOUD - DRAMA IN THERMODYNAMICS

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In contemporary education, drama pedagogy emerges as a versatile set of teaching methods utilizing dramatic expression throughout maturation. Initially perceived as challenging in physics, chemistry, biology, or mathematics, these methods become dynamic tools when applied to natural sciences. By incorporating dramatic exercises and games, students involuntarily engage as active participants, literally embodying molecules, or mathematical functions. This approach, enhanced for scientific accuracy, not only sparks interest but also effectively elucidates complex natural laws.

The workshop will showcase refined dramatic exercises and games, adapted through trial and error, tailored for seamless knowledge transfer while maintaining scientific precision. Demonstrations on students of various ages will illustrate the ease of achieving conceptual understanding in biology, physics, and abstract mathematics, even among the youngest learners. This interactive and enjoyable method significantly eases instruction and knowledge transfer, providing a unique avenue for physics educators.

Simultaneously, the laws of thermodynamics and molecular kinetic theory offer a microscopic foundation for understanding macroscopic properties through interactions among atoms and molecules. Despite its historical and socio-economic significance, thermodynamics remains challenging due to its abstract nature for students. Inspired by physicist R. Feynman's analogy of jiggling atoms', this presentation proposes a novel teaching approach. Through role-playing and theatre techniques, students step into the roles of atoms, making scientific concepts less abstract and fostering a deeper connection with gas laws and ideal gas model. Drama education and theatre methods, traditionally unconventional in STEM teaching, become powerful tools, enhancing interest, motivation, and conceptual understanding in STEM education.

EFFECTIVENESS OF ACTIVATING TEACHING METHODS IN INTRODUCTORY PHYSICS MODULES – AN EXEMPLARY COMPARISON BETWEEN SWITZERLAND AND GERMANY

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In introductory physics modules on mechanics, peer instruction (PI), just-in-time teaching (JiTT) and physics tutorials were used as activating teaching methods. The effectiveness of the teaching methods was measured using the Force Concept Inventory (FCI), which was carried out as a pre- and post-test at the beginning and end of the courses. The normalized growth according to Hake, the normalized change and the effect size according to Cohen (Cohen's d) were determined as a measure of the learning gains and thus of the effectiveness of the teaching methods. The data collected in the Mechanical, Process and Systems Engineering degree programs at the Zurich University of Applied Sciences (ZHAW) from the years 2012 - 2015 were compared with those collected at the Berlin University of Applied Sciences (BHT) in the Physical Engineering and Medical Physics degree programs from the period 2016 - 2022. The results in the pre- and post-test of the Swiss cohort with averages of 15,5 and 21,4 compared to the German cohort of students with 10,2 and 16,9 differed significantly from each other. The learning gains instead were found mutually compatible in the range between 0,34 to 0,42 with no statistically significant difference. These values are characteristic of activating teaching methods. The amount of time spent using activating teaching methods was roughly by a factor of two higher for the German cohort. Specific differences between the two cohorts like e. g. course attendance, pre-education are discussed as possible influencing factors.

PHYSICS LAB IN THE REFORMED APPLIED PHYSICS PROGRAM AT THE UNIVERSITY OF LJUBLJANA

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The University of Ljubljana, Faculty of Mathematics and Physics is currently reforming its Applied Physics study program through The Recovery and Resilience Facility project. The reform is based on the Investigative Science Learning Environment approach (ISLE) methodology [1,2]. ISLE is a student-centered learning approach, that focuses on the development of students' epistemological knowledge and on the developmental needs and interests of individual students. In this collaborative active learning approach students work together to develop normative concepts through experimentation and reasoning. The program is designed to have its core physics course synchronized, so that the theoretical and experimental aspects of student learning are intertwined similarly to how they interact in physics. This means that students' lab work is seamlessly integrated into the learning process. In ISLE-based labs students work together to design their own experiments to develop, test and apply physics knowledge and solve problems. The reform is a step towards a more innovative and effective research-based approach to teaching and learning. By emphasizing the importance of active student participation and collaboration and the importance of authentic connection between "experiment and theory", the program aims to produce graduates who are better equipped to tackle real-world problems in the field of Applied Physics.

[1] Eugenia Etkina. (2023). When learning physics mirrors doing physics. *Physics Today*, *76*(10), 26-32.

[2] Eugenia Etkina, David T Brookes, and Gorazd Planinsic (2019). *Investigative Science Learning Environment When learning physics mirrors doing physics*. Morgan & Claypool Publishers.

RETHINKING CLASSICAL MECHANICS FOR ENGINEERING UNDERGRADUATES: A HANDS-ON APPROACH TO OSCILLATIONS AND WAVES

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Traditional physics lectures for engineering undergraduates typically adhere to a canonical sequence, starting with Newtonian mechanics and progressing through topics like energy, momentum and rigid body dynamics. While this classical approach is foundational it often lacks direct relevance to engineering students, particularly in specialized fields. Furthermore, integrating lab experiments to aid practical comprehension of abstract concepts is challenging due to time constraints.

In response, we developed an alternative curriculum for undergraduates at the Department of Information Technology at the University of Applied Sciences Mannheim. Despite being bored by topics such as projectile motion, our students need a strong physics background to understand the principles of sensors and signal processing. Thus, our novel approach gathers around (mechanical) oscillations and waves, selectively introducing concepts of classical mechanics that are pertinent to these topics. Crucially, central but complex concepts such as driven oscillations, resonance, or wave impedance are highlighted by hands-on laboratory experiments within the lecture.

The students' first reactions to the new curriculum show this more application-oriented approach with integrated experiments makes physics meaningful to them. Workshop participants will experience these hands-on experiments and engage in discussions about how such an approach can stimulate students' curiosity for physics and also overcome some typical constraints of traditional lecture formats.

LITHOGRAPHY CHALLENGES FOR APPLIED PHYSICS STUDENTS TO DEVELOP MICROSTRUCTURES AND MICRODEVICES

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Lithography is the workhorse for the global semiconductor industry. Multidisciplinary teams of engineers at international companies and institutes aim for pushing patterning strategies to reach the technology nodes for the next device generations. At the Applied Physics department of our institute, we have developed course-based projects in which we train 3rd/4th year's physics students the research, development and engineering skills that are crucial for the fabrication of microdevices by UV-lithography.

In this presentation, I will show an example of a lithography project that is running in our Microfabrication Laboratory. The students' project goal is to design, develop and characterize a fabrication process for aligned metal structures on a silicon wafer. A laser writer is used for the maskless lithography step, and a lift-off process needs to be developed for the patterning of structures smaller than 10 µm. The students obtained their first results by a parameter study, for which they had access to several control parameters (e.g., UV-dose, development time, metal thickness, alignment marks), to optimise the patterning result. They inspected their fabricated microstructures by using a SEM, which enabled the required metrology to assess the KPIs. The students obtained promising results regarding critical dimensions, line edge roughness, and alignment errors. Their work represents an important step towards the controlled fabrication of microstructures.

On the long term, we aim for demonstrating microfabrication processes that pave the way to acquire joint programs with external partners to develop prototypes of novel microdevices and, moreover, to let students grow professionally as skilled lithographers.

INTRODUCTION TO QUANTUM COMPUTING USING A DESKTOP QUANTUM COMPUTER

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The realization of a fully fletched quantum computer has been the subject of intensive research over the last few years. However, the fundamental concepts governing quantum computing contradict our everyday experiences and are thus difficult to imagine. This activity aims to elucidate the main principles of quantum computing, providing the participants with a hands-on experience on an actual quantum device.

By building basic quantum circuits using the user-friendly interface of the quantum computer, the participants can learn about the essential concepts of quantum computing such as superposition and entanglement. They can then directly compare the results of real quantum computations and noiseless simulations getting a feeling for the state of the art of quantum computing.

The interactive experiments with the desktop quantum computer aim to convey the fascination for quantum computing, but also to promote an understanding and intuition for this field.

ENHANCING A CRITIAL ATTITUDE IN EXPERIMENTAL PHYSICS

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A critical attitude is one of the key elements of doing experimental research. However, first year students hardly consider the quality and adequacy of their own approach. But as a critical attitude seems a prerequisite for successfully engaging in lab work, how do we teach critical thinking and enhance a critical attitude towards one's own approach? During this hands-on / minds-on session you will engage in some of the activities that I developed for this specific goal. We will see if you are sufficiently critical towards your own approach...

REDESIGN OF A FIRST YEAR PHYSICS LAB COURSE

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

OPENING UP CLASSROOM DEMONSTRATION EXPERIMENTS

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Classroom demonstration experiments (demos) are often key elements in theoretical lectures as these make the concepts at hand more tangible [1-4]. However, teachers are not always aware of the available demos that fit their needs, or know/understand the most effective way to use them. Moreover, the materials are not always available, affordable or accessible. To still allow all teachers to make effective use of this great teaching method, we will develop an open access repository where the demos are described in such detail (including pictures, recordings, list of materials, theoretical background, didactical approach, coding for data-analysis), that these can 'replace' the live demos. Note! Replacing live demos is not our aim, it merely highlights the quality and level of detail we pursuit. The ultimate goal is collaboratively compile such an open and dynamic archive, enhance the quality of the demos in an iterative process by allowing collaborators to edit the materials, and extend the archive by uploading their materials as well. In this short presentation we will present our ideas, share our (preliminary) results and seek collaboration.

OPTICS IN THE SKY

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Teaching physics or optics by showing beautiful phenomena, that can be easily observed in the sky, is a fascinating task. All the optical phenomena seen in the sky can be explained by the interaction of light with atmospheric particles or molecules. Depending on the particle's size and shape, the light can be scattered, diffracted, refracted, or reflected. Or the light can be bent while passing through air layers of different temperatures. These processes, individually or in combination, are responsible for producing most optical effects seen in the sky. Blue and red colors of the sky, rainbows, or mirages are the most known phenomena. But many others can be also found including halos, son dogs, pillars, lunar coronas, green flash, or iridescent clouds. There are as often as rainbows and keeping our eyes on the sky we can easily recognize them. We can use this natural, big laboratory to encourage students to be attentive observers and to ask questions about how and why they are created. We can also propose student projects to capture them. We should encourage students to develop or maintain their curiosity about the surrounding world and show that natural beauty results from complex scientific principles. Atmospheric optics is a very good tool to do it. When they fail to understand all the details, they can enjoy their eyes with stunning displays gracing the sky.

EXAMPLES ON DIGITAL AND INTERACTIVE TEACHING AND LEARNING

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Our methods of teaching were forced to adapt and improve by the pandemic. The possibilities of using digital media and tools in the classroom were discussed, tested, evaluated and, in some cases, established. However, this didn’t substitute for the well-established need for active student participation in the learning process. Teaching staff have become increasingly willing to try new approaches to interactive engagement in their teaching, which the Physics Education Group encourages with their initiatives. The poster will report on specific developments of teaching formats in lecturing, tutoring and laboratory work, including more active participation of learners and the incorporation of digital formats.

Tutorials and assignments should include conceptual questions, experimental tasks and quantitative questions. An example of this will be given using the topic of polarisation of light, the experimental part of which grew out of the "How do I see 3D?" station. The station uses 3D glasses and additional hands-on models and was developed for our extracurricular school lab PhySch (Physics and School), a teaching and learning laboratory.

THE QUANTUM MECHANICS VENUE – A CROSS REGIONAL LEARNING TEACHING LAB

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The Quantum Mechanics venue is a learning teaching laboratory for high school students at TU Dortmund University. In this context, the lab is continuously used and developed by university students. The lab focuses on the execution of key experiments in quantum mechanics and the visualization of quantum mechanical effects. By exploiting the contradiction between classical expectations and experimental observation, cognitive dissonances are stimulated and later resolved, which leads to an enhanced learning outcome. The execution of existing experiments is in some cases hindered by a complicated alignment, which does not aid the quantum mechanical understanding. The desired learning outcome can, thus, not be achieved in all cases.

In order to address these challenges and to also allow for future remote use of the experiments, three pilot experiments were transformed into cross reality labs. It was found that this increases the visualization of the relevant quantum mechanical effects and allows to decouple the students' learning experience from the location of the lab. This contribution provides an overview over the digitized experiments and the lessons learned and gives an outlook on the future of the learning teaching lab.

FLIPPED CLASSROOM IN TEACHER EDUCATION

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The lecture "Basic Principles in Physics" is a compulsory subject in the education of primary school teachers at TU Dortmund University and actively attended by 100 to 150 students. Previously the lecture was held as a classic physics lecture, utilizing mainly PowerPoint slides and experimental demonstrations.

For the winter term 23/24 the lecture format was shifted towards a more interactive format, aiming specific physics problems to be discussed and solved as part of the lecture. In order to free up the necessary time in the lecture itself, the conveyance of knowledge was shifted to the students' preparation for the individual lecture, by providing texts and videos, which were aided by a short quiz. The lectures itself as well as the preparation for them was assessed over the entire semester.

This contribution will provide an overview over the results obtained from the assessments and the lessons learned. In addition the students' success will be analyzed using specific exercises from the final exam.

COMPUTER-ASSISTED DATA ACQUISITION IN BASIC PHYSICS LABORATORY COURSES

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Computer-assisted data acquisition has become an integral part of industry and research. That is why an important requirement for today's engineering graduates is that they master the communication of computers with measuring devices or sensors and the associated computer-aided data analysis. Until now, microcontrollers were not part of the Basic Physics Lab Course at the TU Ilmenau. Students noted the readings of the measuring devices by hand and later transferred the respective values to the analysis software. This time consuming and error-prone procedure has no additional benefit for the essential learning goals of the physics lab course like the independent realization of an experiment, the scientific analysis of the data and the clear presentation of experiment and results in a report. Therefore, we decided to use the given time more efficiently by adding a secondary learning goal: programming of a microcontroller to read out a sensor and handling of the produced data.

In detail, we opted for a similar approach as reported elsewhere (e.g. [1]). Students perform a physical experiment using one or more sensors and an Arduino microcontroller. Due to limited time during the lab courses, the programs aren't implemented from scratch but students get bricks of the final source code. For some experiments wiring still needs to be made between the microcontroller and the sensors. After completion of data acquisition, students need to deal with formatting of the collected data and to make it readable by the analysis software. This new approach to upgrade long existing physical experiments by microcontrollers is appreciated by the students, which has been evaluated through comprehensive questionnaires. They show a higher motivation throughout the whole experiment and judge the competence of microcontroller and data handling very valuable for further practical projects. After performing the experiment with Arduino students have basic knowledge about microcontroller usage and feel encouraged to try other applications on their own. We couldn`t observe any negative impact of Arduino integration on the main learning goals of the lab course.

[1] Haugen, A.J., Moore, N.T.: *A Model for Including Arduino Microcontroller Programming in the Introductory Physics Lab*. Eprint arXiv: 1407.7613 (2014)

PRINTEDLABS: 3D PRINTED OPTICS EXPERIMENTS

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Experiments are at the heart of physics. A successful experiment requires many decisions, ranging from the choice of equipment and procedures to the evaluation of uncertainties and surprising results. Ideally, students should be able to experience all of this in their laboratory experiments. While it is common to design experiments with many degrees of freedom for students' experience in mechanics and electrodynamics, laboratory experiments in optics tend to guide students more closely. In addition, optics lab equipment is either far away from that of research labs or expensive.

We have set out to build laboratory equipment for optical experiments using 3D printing. This allows us to use in students labs large quantities of components similar to those of real research laboratories. In addition to these basic components for building our own experiments, we have also developed specialised components, such as a spectrometer or a telescope, that can compete with commercial devices that are ten times more expensive. We are targeting undergraduate students and especially those who want to become teachers, as the designs and experiments are openly available [1], including for use in schools.

In this session, we invite you to try out our equipment and experiment with PrintedLabs.

[1] https://printedlabs.uni-bayreuth.de

MATHEMATICAL LITERACY VS. SKILL IN PHYSICS COURSES

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We studied the ‘physics experience’ of students and staff in two different physics departments, one in Europe and one in North America, to understand the criteria and norms that shape how students and staff perceive the culture of university level physics education, and to explore structural issues in physics teaching that may contribute to a demographic imbalance in certain fields. Teaching Physics in a way that is relevant to a technologically changing world has the potential of attracting and keeping a diverse talent pool in those fields. The skillset needed for physicists and engineers to use and to develop technology for fundamental research and for their everyday professional lives changes with time. While it is important to understand mathematical concepts, having to practice and use skills that are rarely used outside of the classroom by most physicists and engineers can be a cognitive overload that hinders one’s understanding of Physics concepts and hence gaining new insights on their potential applications. This presentation will discuss the broad scope of the study, the qualitative approach used for data collection and analysis, and some initial findings.

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ANALYSIS OF STUDENT CONCEPTUAL DEVELOPMENT USING THE FORCE CONCEPT INVENTORY

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The Force Concept Inventory (FCI) is a widely established diagnostic tool for the conceptual understanding of Newtonian mechanics. It consists of 30 multiple-choice questions on kinematics and forces. Many of the distractors reflect widespread preconcepts or misconceptions. By analyzing the frequency of all answers rather than only the correct ones conclusions can be drawn on the conceptual development of students. Using the method of "item response curves" (Morris 2006), the relative frequency of all answers is plotted for each question as a function of the total score achieved in the test. By this, distractors that address common misconceptions can be identified. Furthermore, the conceptual development becomes visible. We have analyzed the results of the FCI over a period of nine years from almost 5000 first-year engineering students at the TH Rosenheim. We compare data taken at the very beginning of physics class with data taken at the end of the term as well as with data from universities in the USA. The consistency of the data is very high. The most frequently selected answers include misconceptions about Newton's third law and the assumption that every movement is based on a force in the direction of the movement. The analysis presented serves as a basis for improving teaching.

NAVIGATING THE AI ERA: ANALYZING THE IMPACT OF ARTIFICIAL INTELLIGENCE ON STUDENT RESPONSES IN PHYSICS EDUCATION

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The integration of Artificial Intelligence (AI) in educational settings has become increasingly prevalent, presenting both opportunities and challenges in education. This presentation aims to explore the various issues teachers encounter when students utilize AI to solve physics problems. It will begin by outlining the current landscape of AI usage in Tampere University of Applied Sciences (TAMK), with a focus on the use in physics. The presentation shows examples of student answer illustrating how AI-assisted answers differ from traditional student responses, highlighting issues such as over-reliance on technology, lack of fundamental understanding, and potential discrepancies in problem-solving approaches. Additionally, aspects to boost critical thinking and conceptual learning in physics are discussed.

THE ROLE OF LEARNING SPACE IN ENHANCING ACTIVE LEARNING: INTRODUCING THE STEM-CENTER AT TAMPERE UNIVERSITY OF APPLIED SCIENCES

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This paper details the transformation of a traditional physics laboratory into a versatile group work and multipurpose space known as the “STEM-Center”, at Tampere University of Applied Sciences. The transformation was inspired by active pedagogical methods such as "Peer Instruction," "PDEODE," and the "SCALE-UP" method and its associated spaces. The focus is on how the learning space and its facilities can enhance the use of active learning techniques, which, in turn, emphasize active participation. After the transformation, the space remains suitable for physics laboratory work. Across all courses, it encourages students to be active participants rather than passive listeners, which in turn improves learning outcomes. The facilities in the STEM-Center encourage students to interact with the material through group work, practical application of concepts, and sharing of ideas. This method not only enhances understanding of physics concepts but also enhances essential soft skills such as communication, teamwork, and leadership, important in professional engineering roles. Feedback from students indicates high satisfaction with the pedagogical methods and the learning environment. Most students express a preference for these engaging and activating methods over traditional lecture-based teaching, highlighting an enhanced learning experience and a stronger sense of ownership over their learning.

A NEW MODEL TO REALIZE PHYSICS TEACHING IN TAMPERE UNIVERSITY OF APPLIED SCIENCES

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In Finnish universities of applied sciences, the main factor of funding is the number of graduated students that graduate on time. Therefore, a smooth progress of studies without major interrupts is essential. Although Physics studies are just a small part of engineering studies, they often are scheduled at the first years. The first two years are seen as the riskiest for students to terminate their studies unexpectedly. Physics and mathematics are also seen as difficult subjects by students.

In the new model, most students study their engineering physics studies in blended implementations in groups of 40 – 80. Some stronger support is available for those students that face severe difficulties. Fully online implementations run alongside. So those students who want to proceed faster or are somehow unable to participate the blended implementations can study asynchronously.

The model's boundary conditions are slightly challenging because all mentioned above should not increase costs but add some flexibility to students. The pass-rate is also expected to rise. This challenge will be tackled with extensive use of ICT tools for learning. Inside the implementations there will be some effective use on Moodle's stack questions. Some parts of the course assessments are planned to handle with an automatized baseline exam.

The model and some of its features are presented and discussed.

FLIPPED ASSESSMENT IN ENGINEERING PHYSICS

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The presentation contributes to the assessment for learning in engineering physics and argues that flipped learning (FL) is not enough, we need to flip assessment as well. Despite recognition of assessment as both a critical influencer of learning and a potential 'silent killer of learning' (Eric Mazur, 2013), the advancement of assessment for learning in physics education is still in its infancy.

The presentation introduces Flipped Assessment (FA) as an assessment for learning method in engineering physics. FA is deeply embedded in socio-cultural learning theories and is specifically designed to improve self-regulation skills, which is the most common barrier to implementing FL. For students, FA appears as two-phase exams of varying levels allowing a 'second chance'. The first phase determines the student's so-called 'failure level'. The second collaborative phase is not only about improving performance, but also promotes co-regulation, empowers students during assessment and encourages them to become mutual learning resources. FA creates a supportive learning environment in physics, encourages active student participation and reframes mistakes as critical learning opportunities. It also develops students' abilities to monitor and manage their learning, deepening their understanding of their responsibilities and choices in their educational pathways.

The presenter's own FL practice is heavily based on self-paced learning, and the time spent on each physics course ranges from two months to one academic year. Exam readiness is also up to the students; each course has two mandatory FA procedures, with exam days available monthly.

PHYSICS TEXT BOOKS FOR TRUE DIGITAL NATIVES: DO THEY EXIST?

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At the Faculty of Engineering Technology (KU Leuven) the text books of D.C. Giancoli are used as course material for the Physics Courses for first-year engineering students. Some years ago, they were carefully selected because of the clear approaches and the possibility to order a Dutch edition. Currently, we wonder whether these textbooks still sufficiently address the current generation of students. In order to know the key elements of attractive course material according to our students, we organised a survey among our 300 first-year students. The results of this survey will be communicated and discussed.

AN APPLIED EXAMINATION FORMAT FOR MEASUREMENT TECHNOLOGIES

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A written exam in measurement technologies usually includes problems for operational amplifier circuits, error propagation, signal analysis and analog to digital conversion. During corona, teaching changed from presence lectures to remote lectures and examination formats changed, too. Instead of a written exam, student project exams were proposed. The projects included a computer aided temperature measurement with operational amplifier circuits, a calibration procedure, error propagation and a written report. The student project exams were successful and the students' feedback was so positive that the student project exams are going to be continued.

THE LECTURE OF THE FUTURE: IS FLEXIBILITY IN TERMS OF TIME AND SPACE AT THE EXPENSE OF LEARNING SUCCESS?

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A major learning of the pandemic is the persistent request of students for more flexibility in space and time. From a university perspective, offering more flexibility could be a potential advantage over other universities that provide only synchronous classroom teaching. In the fall semester 2022, a “hybrid” team-based physics course was developed and rolled out at the Albstadt-Sigmaringen University to provide more flexibility in space and time. This course comprises of weekly alternating asynchronous self-paced learning sections and synchronous sections. During the asynchronous sections, students familiarize themselves with the basic content of the course by reading textbook chapters and watching introductory videos. Complementary, the synchronous sections mainly address specific difficulties of the various individual student teams in conceptual understanding and strategies for solving “real word” physical problems, supported and guided by the teacher. The student teams attend half of the synchronous sections by choosing a 20 minutes time slot out of two 90 minutes time windows at different days in person or remotely. Thus, providing large flexibility in space and time. The learning success was measured by pre- and post-tests on concept inventories with promising results. In practice, however, the teacher’s impression indicated, that remote participation might has negative impact on the learning success, although several studies during the pandemic seem to prove the opposite. Therefore, special attention was paid on the question, whether the frequency of remote and in person participation, which is up to the student’s choice in this course, does correlate with learning success.