A RESEARCH-ORIENTED PHYSICS WORKSHOP AS AN ALTERNATIVE TO METROLOGY AND INTRODUCTORY PHYSICS LABORATORIES

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Teaching the principles of scientific experimentation and metrology is a core component of engineering physics education. For many years, this training at the Faculty of Physics WUT has been delivered through two independent courses: an experimental data analysis course and a typical introductory physics laboratory. The first emphasized calculations based on hypothetical datasets and uncertainty evaluation, while the second focused on performing predefined laboratory exercises (according to strict instructions) and preparing formal reports on them. Conducted separately (and, surprisingly, in different semesters), these courses offered limited scope for creativity and failed to effectively develop essential engineering competencies and to train experimental physicists. Moreover, the introductory physics laboratory, constrained by a fixed set of predefined experiments, provided little opportunity for engaging students in physics didactics or authentic research practice (due to the limited number of experiments and the lack of any possibility for modification).

To address these limitations, a new practical, integrated course was introduced. Its aim is to familiarize students with the complete methodology of experimental research in physics and engineering, including hypothesis formulation and verification, experiment planning, direct and indirect measurements, uncertainty analysis, and effective data presentation. These skills are developed through workshop- and project-based activities grounded in real-life and experimental problems.

The course includes an extensive practical component, in which small student groups conduct a specific number of experiments across various branches of physics (e.g., solid-state physics, optics, nuclear physics). Importantly, students receive only a list of relevant physical principles and instrumentation manuals in advance (i.e., prior to the lab session), encouraging independent problem-solving and experimental design. Each group carries out experiments selected individually at the start of the semester, including at least one randomly assigned experiment and one fully student-designed project involving proposal development, experimental realization, and results presentation (9-12h).

Additional course elements include: (i) peer review and discussion of other teams' reports and (ii) oral presentations of experimental results, and collaborative experiment development and realization (related to randomly assigned problem and to the project proposed by the student teams).

Overall, this integrated, practice-oriented approach has demonstrated a positive impact on students' understanding of experimental research methodology, as well as on their ability to analyze, interpret, and communicate scientific results. Knowledge acquired through creative and hands-on activities is more durable and transferable, supporting further university education and in potential research and academic work in the future.