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DEVELOPING PRACTICAL COMPETENCE IN PHYSICS LABORATORY INSTRUCTION THROUGH MULTIFUNCTIONAL PROFESSIONALLY ORIENTED TASKS: A COMPETENCY-BASED DIDACTIC MODEL

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ABSTRACT	KEYWORDS
This article presents a scientifically enriched and methodologically updated model for developing students' practical competence in physics laboratory instruction through a system of multifunctional professionally oriented tasks. The study reinterprets the physics laboratory not as a procedural space where students mechanically reproduce a prescribed experiment, but as a competence-forming learning environment in which theoretical knowledge, measurement culture, data analysis, professional reasoning, evidence-based conclusion-making and reflective self-assessment are integrated into a single didactic cycle. The proposed approach structures laboratory work through preparation, admission to the experiment, experimental performance, data processing, defense of results and reflection. Multifunctional tasks are designed to activate conceptual understanding, practical application, analytical comparison, modelling, evaluation and transfer of knowledge to engineering contexts. The article substantiates the pedagogical value of professionally oriented tasks in connecting physics concepts with real technical situations, improving students' autonomy, and strengthening the methodological culture of laboratory learning. A competency-based didactic model, assessment evidence, and a pedagogical-didactic matrix are proposed for implementation in technical higher education institutions.	Physics laboratory instruction; practical competence; professionally oriented tasks; multifunctional tasks; competency-based education; didactic support; experimental learning; reflective assessment; engineering thinking; evidence-based learning.

Introduction

In technical higher education, physics laboratory instruction occupies a special position because it links theoretical concepts with observation, measurement, modelling, interpretation and engineering decision-making. For future engineers, physics is not only a fundamental discipline but also a methodological basis for understanding technological processes, evaluating the reliability of experimental data and making justified technical conclusions. Therefore, the effectiveness of laboratory instruction cannot be reduced to the correct execution of a prescribed sequence of operations. It should be evaluated by the extent to which students are able to transform theoretical knowledge into practical action and professional reasoning.

Traditional laboratory manuals usually contain the title of the work, its aim, theoretical background, list of equipment, safety instructions and a step-by-step procedure. Although such structure supports discipline and technical accuracy, it often leaves insufficient space for independent problem analysis, hypothesis formulation, selection of methods, interpretation of errors, professional transfer and reflection. As a result, students may complete the laboratory report formally while their practical competence remains underdeveloped.

The development of multifunctional professionally oriented tasks is therefore a relevant pedagogical problem. Such tasks extend the laboratory beyond the reproduction of a known result and turn it into a competence-based didactic technology. They require students to explain the physical meaning of the investigated phenomenon, choose appropriate formulas and measuring procedures, analyse experimental uncertainty, compare theoretical and empirical results, and relate the final conclusion to a real technical or engineering situation. The purpose of this article is to substantiate the methodology for designing multifunctional professionally oriented tasks in physics laboratory classes and to show how improved didactic support can develop students' practical competence in technical universities.

Literature Review and Theoretical Background

Research on laboratory learning emphasizes that experiment-based instruction contributes to the development of scientific reasoning when students are actively involved in planning, measuring, interpreting and defending their results. In physics education, laboratory work is most effective when it combines conceptual understanding with procedural knowledge and reflective interpretation. From this perspective, the laboratory becomes a space where students learn not only how to operate instruments but also how to formulate a problem, justify a method, evaluate evidence and communicate a scientifically grounded conclusion.

Competency-based education shifts attention from the amount of transmitted information to the student's ability to act effectively in a meaningful situation. In the context of physics, practical competence includes the integrated use of conceptual knowledge, experimental skills, mathematical modelling, technological interpretation, communication and reflective self-regulation. This means that laboratory tasks should be designed not only for checking whether a formula is known, but for observing how a student applies that formula in an experimental and professional context.

The idea of progressive cognitive demand is important for the design of multifunctional tasks. A well-developed task system moves students from recognition and explanation toward application, analysis, modelling, evaluation and transfer. This progression prevents laboratory work from becoming a mechanical procedure and helps students develop higher-order thinking. At the same time, modern pedagogical design requires that cognitive progression be combined with constructive alignment: the expected learning outcome, the task, the assessment criteria and the feedback mechanism should correspond to one another.

Theoretical foundations of this approach are also connected with activity-based learning, experiential education, formative assessment and reflective pedagogy. Activity-based learning views knowledge as something formed through purposeful action. Experiential learning emphasizes the importance of direct interaction with objects, instruments and data. Formative assessment provides feedback during the learning process, while reflective pedagogy develops students' ability to evaluate their own strategies and mistakes. Together, these perspectives provide a methodological basis for designing laboratory instruction as a developmental and professionally meaningful process.

Research Methodology

The methodology of the study is based on the principles of professional orientation, problem-based organization, staged learning, logical consistency, activity-based participation, reflective assessment and continuous feedback. These principles ensure that the student acts as an active subject of laboratory learning rather than a passive executor of instructions. The laboratory process is interpreted as a didactic cycle in which preparation, admission to the work, experiment, data processing, defense and reflection are interconnected.

The proposed system of multifunctional tasks is designed to develop several interconnected functions: conceptual explanation, practical application, analytical comparison, diagnostic interpretation, modelling, evaluation and professional transfer. In this system, every task has more than one educational function. For example, a pre-laboratory question can prepare students theoretically, diagnose their initial understanding and direct their attention to the key variables of the experiment. A calculation task can check the application of formulas, but also require comparison with experimental data and interpretation of uncertainty. A reflective task can reveal not only what result was obtained, but also how the student understands the reliability, limitations and practical meaning of that result.

The laboratory class is organized in five stages. First, students prepare by studying theoretical materials, answering self-check questions and analysing the professional context of the work. Second, they receive admission to the experiment after demonstrating readiness, safety awareness and initial understanding of the task. Third, they perform the experiment, collect data and observe the behaviour of the studied system. Fourth, they process the results, prepare tables and graphs, calculate errors and compare the outcome with the theoretical model. Fifth, they defend their results and formulate a reflective conclusion connected with a professional situation. At each stage, the teacher performs the role of facilitator, consultant, diagnostician and evaluator, while the student performs cognitive, practical, analytical and reflective actions.

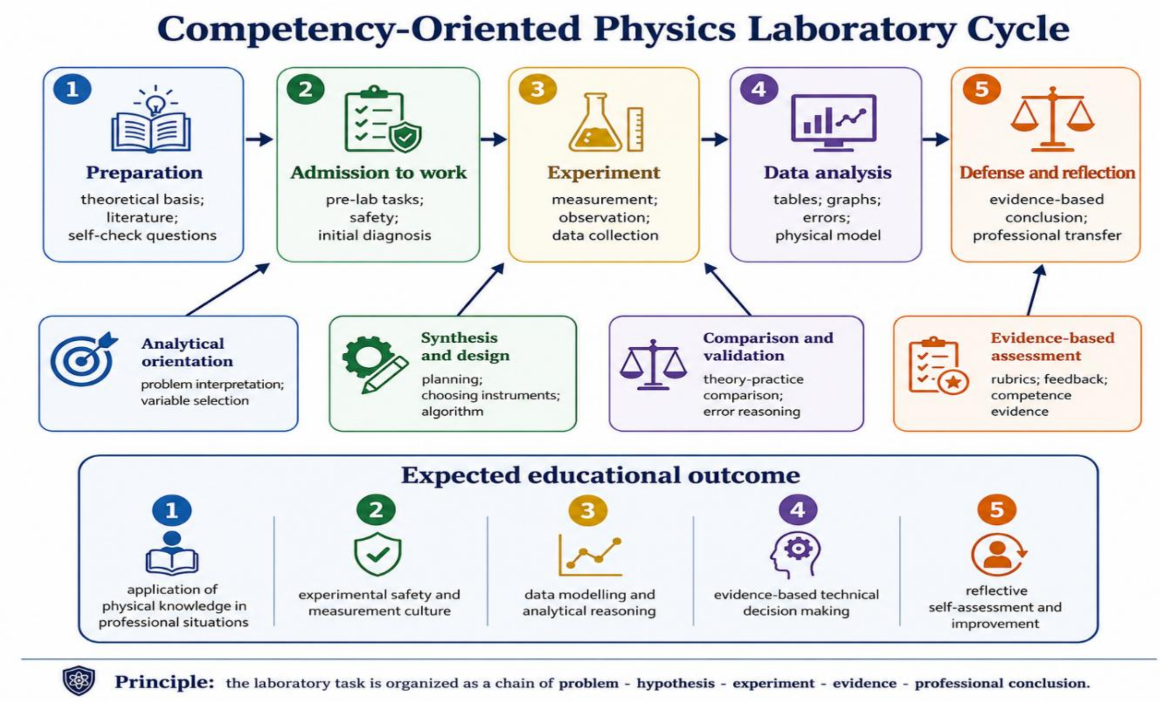

Figure 1. Competency-oriented cycle of professionally focused physics laboratory instruction

Results and Analysis

The analysis shows that the traditional laboratory manual should be transformed into a comprehensive didactic resource that supports independent preparation, self-control, professional problem solving, evidence-based analysis and reflection. In its improved structure, laboratory support includes a logical map of the topic, selected learning elements, semantic links between didactic units, a list of preparatory literature, self-check questions, preliminary tasks, multifunctional professional-practical problems, tables for recording measurements, graphical analysis tools, control questions and reflective assessment tasks.

This structure changes the role of the student. Instead of only following instructions, the student becomes a participant who prepares theoretically, makes procedural decisions, analyses data, interprets errors and defends a professional conclusion. It also changes the role of the teacher. The teacher is no longer only a controller of the final report but a designer of learning situations, a facilitator of inquiry, and a provider of evidence-based feedback.

The laboratory work 'Determination of Young's modulus of a solid body' may serve as a representative example. At the initial level, tasks require students to explain Young's modulus, mechanical stress, relative elongation and Hooke's law. At the application and analysis level, students calculate deformation, potential energy and measurement error for springs connected in series and in parallel. At the modelling and evaluation level, students estimate the maximum load or possible structural limitation for a material used in construction. In this way, the same laboratory topic develops conceptual understanding, calculation skills, experimental interpretation and professional judgement.

Multifunctional tasks perform three major didactic functions. First, they connect theoretical knowledge with real experimental activity. Second, they help students reveal functional and causal relations between physical quantities. Third, they develop the ability to interpret experimental results in professional terms, evaluate error sources and justify an engineering conclusion. The laboratory therefore becomes not only a place for measurement but also a learning environment for developing engineering thinking.

A key result of the proposed approach is the strengthening of feedback between teacher, student and laboratory environment. Feedback is provided during preparation, admission, experimentation, analysis and defense. It should not be limited to the statement that an answer is wrong. Effective feedback clarifies the source of difficulty and indicates the next step for improvement. For example, instead of saying that the calculation is incorrect, the teacher can point out that the student did not convert units into the SI system, did not identify the independent variable or did not compare the graph with the theoretical dependence. This type of feedforward supports further growth and promotes responsible learning.

Comparative Structure of Traditional and Improved Laboratory Support

Table 1. Comparative characteristics of traditional and improved laboratory didactic support

Traditional laboratory manual	**Improved competency-based didactic support**
Title, aim, short theory, equipment, procedure, control questions.	Title, logical structure, didactic units, preparatory literature, self-check questions, professional tasks, experimental data tables, graph analysis and reflection.
Student mainly follows a given algorithm.	Student becomes an active subject of preparation, experimentation, analysis and conclusion-making.
Assessment is mostly based on the final written report.	Assessment includes process, evidence, error analysis, professional interpretation and reflective defense.

Example of Leveled Tasks for the Laboratory Work “Determination of Young’s Modulus”

Table 2. Leveled multifunctional tasks for developing practical competence through a mechanics laboratory

Task level	**Task content**	**Student activity**	**Competence evidence**
Conceptual orientation	Define Young’s modulus, stress, relative elongation and Hooke’s law.	Explains core concepts and units.	Theoretical readiness and correct terminology.
Application and analysis	Calculate deformation, elastic energy and measurement error for springs connected in series or parallel.	Applies formulas, compares results and explains deviations.	Procedural accuracy and analytical comparison.
Modelling and evaluation	Estimate the maximum load or structural limitation for a selected construction material.	Chooses a model, justifies assumptions and formulates a professional conclusion.	Engineering interpretation and evidence-based judgement.

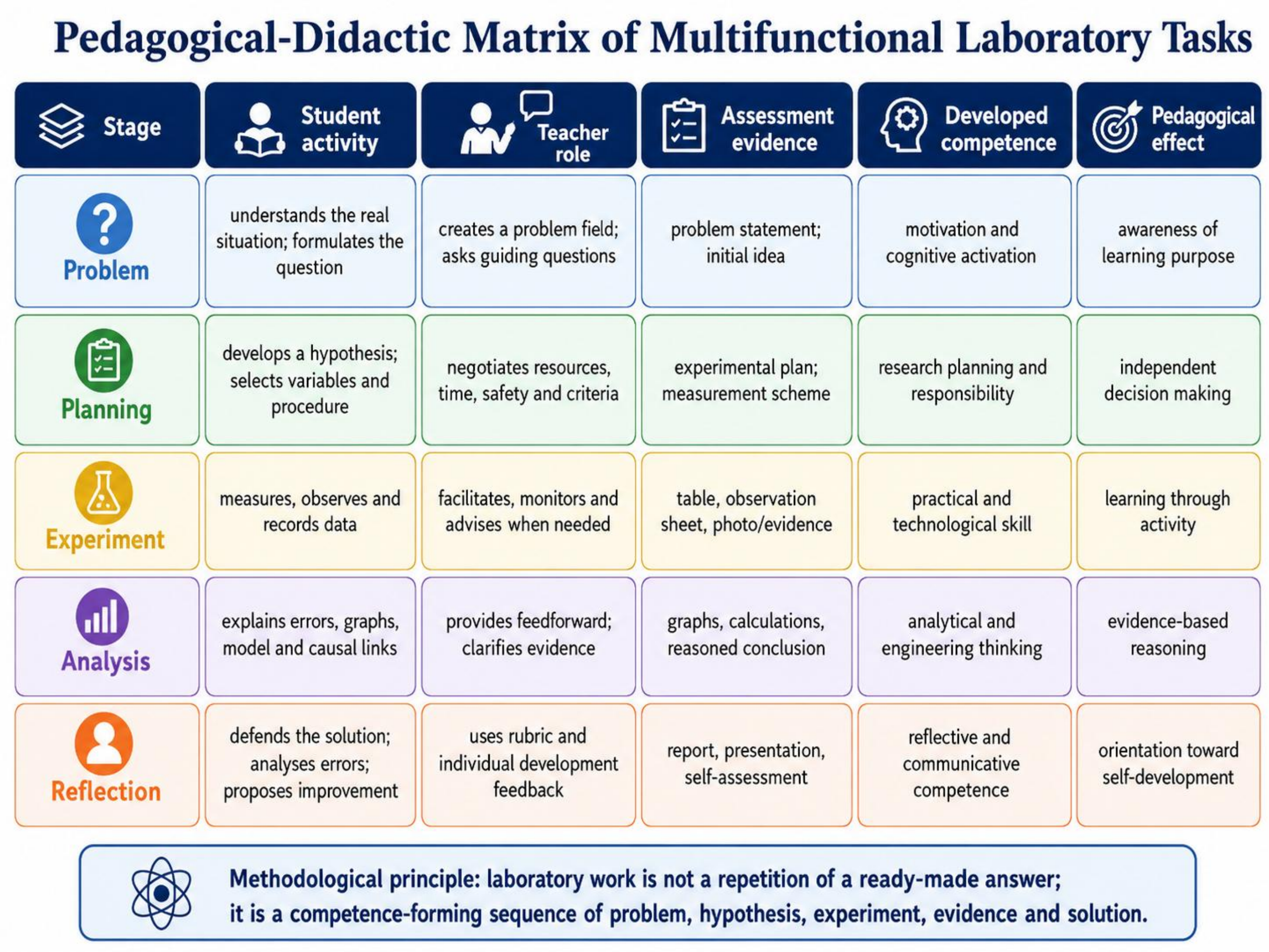

Figure 2. Pedagogical-didactic matrix of multifunctional laboratory tasks

Discussion

The proposed model is pedagogically significant because it integrates the laboratory task with the logic of professional activity. Engineering practice is rarely limited to reproducing a known result. It requires understanding a problem, selecting a model, collecting data, evaluating uncertainty, comparing alternatives and defending a decision. Therefore, laboratory instruction should approximate this logic as closely as possible. Multifunctional professionally oriented tasks help students experience the laboratory as a simplified but meaningful model of future professional activity.

The implementation of this approach requires careful methodological preparation. Teachers need to revise existing laboratory manuals, formulate learning outcomes in observable action verbs, design professional contexts, create multi-level tasks, prepare rubrics and organize formative feedback. Digital tools can support this process through virtual simulations, electronic worksheets, online quizzes, LMS-based submission of reports and digital rubrics. However, digital resources should not replace the methodological logic of the laboratory. Their role is to strengthen visualization, measurement reliability, feedback and monitoring.

The approach is also valuable for developing soft skills. In the process of defending laboratory results, students learn to present evidence, respond to questions, communicate scientific arguments and assess their own limitations. Group-based laboratory work further develops collaboration, distribution of responsibilities and peer learning. These outcomes are particularly important for technical universities, where the graduate's readiness is defined not only by theoretical knowledge but also by the ability to work responsibly in complex professional environments.

Conclusion

Organizing physics laboratory classes through a system of multifunctional professionally oriented tasks develops students' practical competence by connecting theoretical knowledge with experiment, analysis, evaluation and professional application. The proposed approach transforms laboratory instruction from a procedure of technical execution into a competency-based didactic system that develops cognitive, practical, analytical and reflective components of professional readiness.

The improved didactic support should include logical structures, self-check questions, preparatory tasks, professional-practical problems, measurement tables, graph-based analysis, error interpretation and reflective assessment. Such support increases students' independent preparation, ensures conscious performance of laboratory work and forms the culture of defending experimental results with evidence. The task system should be organized as a progressive sequence from conceptual explanation to practical application, analysis, modelling, evaluation and professional transfer. As a result, students' practical competence in physics develops as an integrated formation that includes knowledge, skill, judgement, responsibility and reflective self-regulation. In technical higher education, this methodology can contribute to preparing future engineers who are able to apply physical laws in real professional situations, make justified decisions and continuously improve their own learning strategies.

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