

# DESIGNING INTEGRATED ELECTRONIC LEARNING MODULES FOR FUTURE PHYSICS AND ASTRONOMY TEACHERS ON THE BASIS OF METHODEDU.UZ

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## Abstract

This article presents a design methodology for integrated electronic learning modules aimed at developing the methodological competence of future physics and astronomy teachers. The research is based on the dissertation plan in which electronic modules are proposed as the main digital-didactic instrument for combining General Pedagogy, the Methodology of Teaching Physics and Astronomy, assessment, reflection, and adaptive digital support. The aim of the article is to describe the structure, content, and methodological logic of such modules. The study applies a design-based approach: qualification indicators are connected with pedagogical topics, subject-methodological topics, digital resources, professional assignments, rubrics, and portfolio products. The results present a four-layer module structure consisting of a pedagogical layer, a physics-astronomy methodological layer, a digital-didactic layer, and an assessment-reflection layer. Six sample modules are proposed: teaching mechanics through problem-based learning, teaching electric circuits through a virtual laboratory, analyzing optical phenomena through experiments, designing an astronomy STEAM project, assessing physics knowledge through PISA-type tasks, and organizing reflection in a physics lesson. The discussion emphasizes that integrated modules can help future teachers transform theoretical knowledge into lesson plans, cases, virtual laboratory analyses, projects, tests, and reflective products. The article concludes that electronic modules in MethodEdu.uz can function as a practical bridge between pedagogical theory, subject methodology, and digital professional activity.

**Keywords:** Electronic learning module; MethodEdu.uz; physics teacher education; virtual laboratory; portfolio; methodological competence; adaptive learning.

## Introduction

Digital transformation in higher education requires teacher preparation programs to redesign not only learning materials but also the structure of professional activity. Future physics and astronomy teachers need digital learning environments where pedagogical theory, subject methodology, laboratory practice, assessment, and reflection are connected in one coherent system. Electronic learning modules are an effective form for organizing this connection because they can combine text, video, simulation, interactive tasks, tests, rubrics, and portfolio assignments.



In traditional instruction, a module is often understood as a thematic unit. In the preparation of future teachers, however, a module should be understood as a professional action unit. It must lead students from a competence indicator to a methodological product. For example, a module on electric circuits should not only explain Ohm's law. It should help the future teacher design a lesson, select a demonstration or virtual experiment, formulate questions, prepare assessment criteria, and reflect on the quality of the teaching strategy.

The dissertation plan on which this article is based proposes MethodEdu.uz as an adaptive digital learning platform with electronic modules, interactive assignments, virtual laboratories, diagnostic tests, competence maps, portfolios, AI assistance, and monitoring. This article focuses on the module design aspect of that platform. The main question is how an electronic module can integrate General Pedagogy and the Methodology of Teaching Physics and Astronomy in a way that develops methodological competence.

The purpose of the article is to develop a module structure and to present sample modules that can be used in the professional training of future physics and astronomy teachers. The article follows the IMRAD format and treats the module system as a design result.

### **Literature Review**

Electronic learning modules are widely used in higher education because they allow learning content to be structured around outcomes, activities, resources, and assessment. From the perspective of constructive learning theory, a module should not only deliver information but also create conditions for active knowledge construction. For physics teacher education this means that students should analyze phenomena, design experiments, solve methodological problems, and create teaching materials.

The theory of pedagogical content knowledge explains why subject-specific modules are necessary. A general digital course on pedagogy may develop pedagogical vocabulary, but it cannot fully prepare students to teach physics and astronomy unless it includes the logic of experiments, models, measurements, problem solving, and scientific explanation. Therefore, the methodological layer of the module must be connected with concrete physics and astronomy topics.

The TPACK framework shows that the digital part of the module should serve pedagogical and subject-methodological goals. A simulation, AI assistant, test bank, or video experiment is useful only if it helps the student design a better lesson or assess learning more accurately. This is why the digital-didactic layer of the module must be planned together with the pedagogical and methodological layers.

Research on formative assessment and reflective learning also supports the use of portfolios and rubrics. In teacher education, the portfolio makes professional growth visible because it collects lesson plans, cases, laboratory analyses, project products, test items, and reflective notes. Rubrics make assessment transparent and help students improve their work according to clear criteria.

### **Methodology and research design**

**Research design:** The article uses a design-based methodological approach. The object of design is an integrated electronic learning module for future physics and astronomy teachers.



The design is not presented as a completed platform implementation; rather, it is a pedagogically grounded module system derived from the dissertation plan and the competence requirements of teacher preparation.

**Module design algorithm:** Each module was constructed through seven consecutive steps: selection of a competence indicator; selection of a General Pedagogy topic; selection of a physics or astronomy methodology topic; formulation of a professional methodological task; selection of a MethodEdu.uz tool; development of an assessment rubric; and definition of the portfolio product. This sequence ensured that every module had a clear pedagogical purpose and a visible professional outcome.

**Four-layer structure:** The module structure was organized into four layers. The pedagogical layer includes didactic concepts, teaching methods, assessment principles, and reflection. The physics-astronomy methodological layer includes the subject topic, lesson type, experiment, problem, or astronomical observation. The digital-didactic layer includes virtual laboratories, interactive tasks, diagnostic tests, AI guidance, and multimedia resources. The assessment-reflection layer includes rubrics, self-assessment, teacher feedback, competence maps, and portfolio entries.

**Evaluation criteria:** The designed modules were evaluated conceptually according to four criteria: coherence between layers, professional relevance of the task, measurability of the result, and suitability for portfolio-based reflection. These criteria were chosen because methodological competence becomes visible through concrete professional products.

### Research Results

The main result is a system of integrated electronic modules that connect pedagogical theory and subject methodology through digital tasks. Each module has a passport that includes the module title, competence indicator, pedagogical basis, physics or astronomy methodological basis, digital resource, student assignment, assessment rubric, and expected portfolio product.

**Table 1 Sample system of integrated electronic modules for future physics and astronomy teachers**

Electronic module	Pedagogical layer	Methodological layer	MethodEdu.uz product
Mechanics through problem-based learning	Problem situation and active methods	Kinematics and dynamics teaching	Case and lesson plan
Electric circuit through virtual laboratory	Visuality and activity approach	Current, voltage, resistance, Ohm law	Virtual experiment analysis
Optical phenomena through experiment	Didactic tools and observation	Reflection, refraction, diffraction	Video experiment and test
Astronomy STEAM project	Project technology and integration	Solar system and observation	Group project and presentation
Physics knowledge assessment	Diagnostics and rubrics	PISA task and laboratory report	Test bank and competence map
Reflection in a physics lesson	Self-assessment and portfolio	Lesson analysis and methodological errors	Reflective portfolio entry



The module on mechanics demonstrates how problem-based learning can be transformed into a methodological task. Students analyze a typical mechanics topic, identify a conceptual difficulty, formulate a problem situation, design guiding questions, and prepare a lesson plan. The AI assistant can generate alternative questions, but the final methodological decision remains with the student and teacher educator.

The module on electric circuits shows the role of virtual laboratories in developing digital-methodological competence. Students do not only observe current, voltage, and resistance in a simulation; they also decide how the virtual experiment should be introduced in a school lesson, what questions should be asked, how safety and measurement errors should be discussed, and how the laboratory report should be assessed.

The astronomy STEAM module develops integrative and creative methodological thinking. Students connect astronomical content with mathematics, technology, engineering design, and visual presentation. The final product is a project assignment with learning objectives, expected outcomes, roles for group work, assessment criteria, and a short reflective explanation.

### **Discussion**

The proposed module system shows that electronic learning modules can become a bridge between separate academic courses. Instead of teaching General Pedagogy and physics methodology independently, the module format allows both to appear in one professional task. This approach is especially useful for physics and astronomy because the subjects require visualization, experiment, measurement, modeling, and explanation of complex processes. Another important advantage is the possibility of accumulating digital evidence. When a student completes a lesson plan, virtual laboratory analysis, PISA-type task, or portfolio entry in MethodEdu.uz, the platform can store the product and connect it with a competence map. This makes methodological growth visible not only for the teacher educator, but also for the student. As a result, assessment becomes more transparent and developmental.

The design also supports individualization. If a student has difficulty with assessment design, the platform can recommend additional materials on rubrics and diagnostic tasks. If another student has difficulty with laboratory methodology, the platform can recommend virtual experiments and examples of laboratory report analysis. Such adaptivity is valuable only when recommendations are connected with clearly defined competence components.

A limitation of the proposed module system is that it still requires empirical testing. Future work should implement the modules with experimental and control groups, analyze completion rates, compare diagnostic results, and evaluate the quality of portfolio products.

### **Conclusion**

Integrated electronic learning modules are an effective form of digital-didactic support for developing future physics and astronomy teachers' methodological competence. The four-layer structure proposed in this article connects pedagogy, subject methodology, digital tools, and assessment-reflection mechanisms. Such modules can help students convert theoretical knowledge into professional products: lesson plans, cases, virtual laboratory analyses, PISA-type tasks, STEAM projects, and reflective portfolio entries.



The MethodEdu.uz platform can serve as the technological environment for implementing these modules because it supports electronic content, interactive assignments, diagnostic tests, virtual laboratories, portfolios, competence maps, adaptive recommendations, and AI assistance. The main recommendation is to design every module as a competence-oriented professional task rather than as a simple collection of learning materials.

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