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Didactic Foundations for Organizing Convergent Physics Lectures in the Information and Educational Environment of Higher Technical Education Institutions

Samar Alikulov
Department of General Engineering Sciences Jizzakh Polytechnic Institute Jizzakh, Uzbekistan ORCID: 0000-0002-3118-5795
Orzigul Eshtuxtarova
Department of Physics, Jizzakh State Pedagogical University, Uzbekistan ORCID: 0000-0002-1892-1989
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Abstract-This article examines the didactic foundations for organizing convergent physics lectures in the information and educational environment of higher technical education institutions. It develops a methodological framework that integrates module-based instruction, the flipped classroom, project-based learning, multimedia resources, formative assessment, and face-to-face interaction. The proposed lecture structure comprises knowledge activation, synthesis, theoretical development, and consolidation modules. Before class, students study digital materials, prepare notes, complete learning tasks, and take online formative tests; classroom time is then used for demonstrations, analytical discussion, applied problem solving, collaborative assignments, and mini-projects. The framework also uses concept maps, graphical representations, simulations, videos, and physical experiments to make complex phenomena more accessible. The analysis shows how this organization can support independent learning, strengthen communication between teachers and students, and develop analytical and practical competencies. Convergent lectures are therefore presented not merely as a means of delivering theoretical content, but as a structured communicative process that connects digital preparation with active classroom learning and continuous assessment.

Keywords-convergent lecture, information and educational environment, physics education, flipped learning, interactive collaboration, innovative pedagogy, independent learning

I. INTRODUCTION

The adoption of Resolution No. 466 of the Cabinet of Ministers of the Republic of Uzbekistan, issued on August 7, 2020, "On Measures to Improve the Quality of Teaching in the Higher Education System," established a comprehensive regulatory framework for the modernization and sustainable development of the national higher education system [1]. The resolution emphasizes the need to align educational practices with international quality standards by enhancing teaching and learning processes, promoting the integration of advanced pedagogical approaches and information and communication technologies, strengthening students' professional competencies through practice-oriented instruction, and implementing innovative methods in the organization of higher education.

Contemporary society is characterized by rapid socioeconomic transformation, continuous changes in everyday life, and the increasing digitalization of all sectors driven by the rapid advancement of information and communication technologies. These developments have created new challenges for higher technical education institutions, requiring them to enhance the quality of engineering education and strengthen students' professional and practical competencies to meet the demands of a technology-driven economy. However, several issues continue to hinder this process. Among the most significant are the slow integration of modern information and communication

technologies into educational practice, the continued reliance on traditional instructional approaches in organizing the teaching and learning process, and the absence of a comprehensive pedagogical framework that effectively supports interaction among all participants in the educational environment.

The integration of modern information technologies with innovative pedagogical approaches provides significant opportunities for improving the educational process in higher education institutions, promoting outcome-based learning, and enhancing instructional effectiveness. In the contemporary educational landscape, one of the key prerequisites for the successful implementation of advanced technologies is the development and effective utilization of an information and educational environment that supports teaching, learning, and academic interaction [2].

In this study, the Information and Educational Environment (IEE) is defined as an integrated educational ecosystem that combines subject-specific content enriched with digital information and electronic learning resources, together with both information technologies and conventional pedagogical approaches. From this perspective, the IEE represents a comprehensive pedagogical system founded on the principles of blended learning. Its primary objective is to facilitate students' independent learning while fostering the development of their general, professional, and practical competencies.

Although the development and methodological improvement of an Information and Educational Environment (IEE) constitute essential components of the educational process, these measures alone are insufficient to ensure high-quality learning outcomes. From our perspective, meaningful educational reform requires the creation of a learning environment that actively influences students' intellectual and professional growth rather than serving merely as a technological platform. Such an environment should stimulate learners' cognitive development, encourage self-directed learning, and promote continuous self-improvement through active engagement with educational resources and instructional activities.

The primary objective of this study is to develop a methodological framework for teaching undergraduate students by effectively organizing convergent physics lectures within the information and educational environment of higher technical education institutions.

II. THEORY

The improvement of the educational process in higher education institutions is closely associated with the transformation of teaching paradigms within the Information and Educational Environment (IEE). This transformation is driven by the convergence of contemporary information technologies with established pedagogical theories and practices, creating an integrated educational framework that supports more effective teaching and learning.

Convergence refers to the continuous interaction and mutually reinforcing integration of scientific disciplines, technologies, social communities, and various forms of human activity. Through this process, these domains become increasingly interconnected and adaptable to one another, leading to a higher level of integration. Consequently, the convergent approach promotes the synthesis of knowledge across different fields, generating innovative concepts, methodologies, and experiences that differ qualitatively from those produced within traditional disciplinary boundaries [3].

The essence of the convergent approach lies in the interaction and integration of diverse scientific disciplines and technological domains, leading to the creation of new forms of knowledge with a higher level of complexity and practical value. Such knowledge should not be viewed as a simple aggregation of information from different sources; rather, it represents a qualitatively new outcome that emerges through the dynamic interaction of multiple fields. In the context of education,

convergence can be effectively achieved only when disciplinary boundaries are transcended, enabling continuous knowledge exchange, mutual enrichment, and innovation that collectively enhance the quality of teaching and learning [4]. Within the scope of this research, the methodological framework for physics instruction was implemented in the Information and Educational Environment (IEE) of a higher technical education institution. The instructional process incorporated integrated blended learning strategies, including the module-rating assessment system, the flipped classroom model, and project-based learning as key pedagogical componentsAs a practical component of the proposed instructional framework, convergent lectures were designed and implemented. These lectures were intended to develop students' understanding of the fundamental laws of nature, strengthen their ability to analyze cause-and-effect relationships underlying physical phenomena, and promoteThe flipped classroom model represents an innovative instructional approach that redefines the organization of traditional teaching by placing greater emphasis on students' independent learning activities [5], [6], [7]. Within this model, the instructor no longer serves primarily as a source of information but instead assumes the roles of facilitator, mentor, and learning coordinator. By utilizing the capabilities of the Information and Educational Environment (IEE), instructional materials, learning tasks, and assessment tools are delivered through digital platforms, enabling students to study course content independently outside the classroom.

Before attending class, students review lecture materials, analyze the presented concepts, identify key the acquisition of theoretical concepts that contribute to the formation of a scientific worldview.

The blended learning model extends beyond the delivery of theoretical content by providing opportunities for students to analyze experimental tasks, synthesize information, and draw evidence-based conclusions. Within this framework, blended learning is understood as an educational model that combines face-to-face instruction with active learning activities supported by a digital learning environment. The model enables up to 70–80% of learning activities to be completed through online and independent study, while classroom sessions are optimized according to students' learning outcomes and progress demonstrated within the electronic learning platform [5].

Integrating the innovative components of blended learning-including the module-rating system, the flipped classroom model, and project-based learning-with the principles of the convergent approach provides a foundation for redesigning lecture-based instruction in accordance with contemporary educational requirements. In this study, module-based instruction was adopted as the primary teaching strategy, and the lecture content was organized into four functional modules (Table

Dividing theoretical content into self-contained instructional units and presenting it through concept maps, graphical illustrations, tables, and symbolic visual representations improved the clarity and accessibility of learning materials. This approach reduced the complexity of theoretical concepts, facilitated visual comprehension, and enhanced students' understanding and retention of key physics principles [6].

FUNCTIONAL STRUCTURE OF A LECTURE BASED ON MODULE-BASED INSTRUCTION

Knowledge Activation	**Knowledge Synthesis Module**	**Theoretical Module**	**Theoretical Development Module**
Focuses on establishing the relevance of the topic by incorporating recent	Integrates students' prior knowledge and synthesizes key	Develops theoretical knowledge through	Provides conclusions aimed at synthesizing,

scientific advances, modern technologies, and current engineering developments.	concepts, physical laws, phenomena, and experimental results.	the presentation of new principles, cause-and-effect relationships, and fundamental characteristics of physical phenomena.	consolidating, and deepening theoretical knowledge.

theoretical ideas, and evaluate their understanding through interactive online assessments. The results of these assessments contribute to their overall course performance. Classroom sessions are then devoted to analytical discussions, problem-solving activities, collaborative learning, and project-based tasks rather than the direct presentation of theoretical material.

By integrating independent study with face-to-face learning activities, the flipped classroom establishes a coherent and student-centered learning process. This approach encourages active participation, promotes self-directed learning, and strengthens students' ability to acquire knowledge autonomously while developing higher-order cognitive and professional competenciesTable II summarizes the relationship between independent preparation and face-to-face classroom activities.

METHODOLOGY FOR ORGANIZING CONVERGENT PHYSICS LECTURES IN THE INFORMATION AND EDUCATIONAL ENVIRONMENT

III. Experimental Results

Students' Independent Learning Activities (within the Information and Educational Environment)	**Face-to-Face Classroom Sessions**
Lecture materials are made available through the course platform. Independent learning tasks are assigned to students. Students study the learning materials and prepare structured notes. An online formative test is completed, and the results are included in the overall course assessment. Interactive learning activities are completed within the Information and Educational Environment (IEE). Students prepare for the subsequent face-to-face classroom session.	Knowledge Activation: Establishing the relevance and importance of the lecture topic. Knowledge Synthesis Module: Activating and integrating students' prior knowledge. Theoretical Module: Presenting and explaining new concepts, scientific principles, and physical phenomena. Theoretical Development Module: Consolidating and systematizing knowledge through practical exercises and learning tasks. Collaborative activities, creative assignments, and mini-project implementation.

The lecture sessions conducted in the classroom were organized in two consecutive stages. During the first stage, the instructor provided a comprehensive explanation of the lecture content by presenting multimedia materials, demonstrating experimental observations, introducing key concepts and scientific principles, and explaining the cause-and-effect relationships underlying physical phenomena [8]. Since students had already reviewed the lecture materials and prepared notes in advance, the second stage could be devoted to a more in-depth examination of complex concepts, analytical discussions, and creative problem-solving activities.

Classroom instruction was primarily practice-oriented and focused on reinforcing fundamental

concepts, solving applied physics problems, and promoting a systematic understanding of the learning material. The lecture design integrated multiple instructional strategies by organizing the content into thematic modules, dividing complex material into manageable learning units, and presenting information through multimodal resources. This approach enabled students to process theoretical concepts through multiple channels, including text, audio, video, graphical illustrations, and experimental demonstrations.In the process of teaching physics, the practical demonstration of physical phenomena plays a significant role in enhancing students' comprehension of complex theoretical concepts. Various instructional tools, including real laboratory experiments, computer-based simulations, educational videos, and visual physical models, are employed to provide students with a clear and comprehensive understanding of the underlying principles governing the phenomena under study.

Following the presentation of the lecture content, students complete a series of pre-designed learning tasks aimed at reinforcing, organizing, and applying the acquired theoretical knowledge in practical contexts. This instructional approach contributes to the development of analytical thinking and problem-solving skills while substantially increasing students' cognitive engagement and active participation during classroom activities.

IV. CONCLUSIONS

The lecture content is presented through a sequence of interconnected micro-topics, enabling students to acquire complex theoretical concepts in a gradual and systematic manner. Throughout the instructional process, video materials, demonstration experiments, and collaborative learning activities are extensively employed to facilitate Consequently, the convergent multimedia lecture provided a more coherent, accessible, and visually enriched learning experience, facilitating deeper conceptual understanding and improving students' engagement with the subject matter. Table III presents representative passport tasks for two physical phenomena.

SAMPLE TASKS FOR PREPARING A PHYSICAL PHENOMENON PASSPORT

Physical phenomenon passport: Fraunhofer diffraction (parallel light rays)	**Physical phenomenon passport: Compton effect**
1. Explain the concept of Fraunhofer diffraction.	1. Explain the physical principles underlying the Compton effect.
2. Draw the ray diagram for diffraction through a single slit.	2. Draw the interaction diagram showing the directions of the incident and scattered photon, as well as the recoiling electron.
3. State the conditions for diffraction maxima and minima.	3. Write the law of conservation of momentum for the Compton scattering process.
4. Explain how the diffraction pattern is formed under the Fraunhofer condition.	4. Write the equation for the Compton wavelength shift.
	5. Explain why the scattered photon has lower energy (and correspondingly lower frequency) after interacting with the electron.

conceptual understanding. Group-based learning supports the organization and integration of knowledge while encouraging students to solve creative and practice-oriented tasks. For example, in statistical physics, students are assigned to compare entropy under conditions of constant temperature and pressure, with the results presented in tabular form. In the study of optical phenomena, students compare diffraction and interference maxima, as well as fringes of equal inclination and equal thickness.

During classroom sessions, students complete research-oriented assignments and mini-projects using lecture notes and relevant online resources. For instance, within the topic of Direct Current, one group is assigned the following problem: An amateur radio operator requires a resistance of 70 kΩ but has only 100 kΩ, 50 kΩ, and 25 kΩ resistors available. Determine whether the required resistance can be obtained and, if so, propose an appropriate resistor configuration. Another group undertakes a more advanced project by identifying the principal components of solar panels used in artificial satellites, explaining their operating principles, and providing a scientific justification for the requirement of large photovoltaic surface areas.

The effectiveness of convergent lectures lies in their integration of complex problem-solving activities into the lecture process through a blended learning approach. This instructional model facilitates the development of practical competencies while promoting effective communication and collaborative interaction. As a result, students participate in learning activities more actively, independently, and creatively.

In conclusion, a convergent lecture extends beyond the transmission of theoretical knowledge by fostering its deeper comprehension, critical analysis, and further expansion. This objective is achieved through the integration of independent learning activities within the digital educational environment and diverse forms of classroom instruction. Students acquire knowledge not only through verbal explanations but also through a variety of instructional methods, educational resources, and information channels. Consequently, a convergent lecture is designed as a structured and purposefully organized communicative process. Successful learning outcomes achieved during instructional activities enhance students' motivation to sustain active engagement and strive for higher academic performance. The assessment of both classroom and independent learning activities is based on a rating system that functions not only as an evaluation instrument but also as a mechanism for the continuous monitoring of student engagement and learning progress.

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