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THE IMPORTANCE OF DESIGNING THE CONTENT OF PHYSICS IN DEVELOPING ENGINEERING SKILLS OF STUDENTS IN CONSTRUCTION ENGINEERING PROGRAMS

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Abstract
This article examines the issues of substantive redesigning physics based on a competency-based approach in the development of engineering abilities in students studying in the field of construction engineering. The necessity of integrating the physics course with engineering activities, the principles of forming the content, the analysis of modules, the strategies used in the educational process, and the criteria for developing students' professional competencies were scientifically investigated.

Keywords: Physics curriculum design, construction engineering education, competency-based approach, engineering skills, virtual laboratories, simulation, problem-based learning, project-based learning, modular education, engineering competencies.

Introduction

ЗНАЧЕНИЕ ПРОЕКТИРОВАНИЯ СОДЕРЖАНИЯ КУРСА ФИЗИКИ В РАЗВИТИИ ИНЖЕНЕРНЫХ СПОСОБНОСТЕЙ СТУДЕНТОВ СТРОИТЕЛЬНЫХ ИНЖЕНЕРНЫХ НАПРАВЛЕНИЙ

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Аннотация:
В данной статье освещены вопросы содержательного перепроектирования физики на основе компетентностного подхода в развитии инженерных способностей студентов, обучающихся по направлению строительной инженерии. На научной основе исследованы необходимость интеграции

курса физики с инженерной деятельностью, принципы формирования содержания, анализ модулей, стратегии, используемые в учебном процессе, а также критерии развития профессиональных компетенций студентов.

Ключевые слова: проектирование содержания физики, строительное инженерное образование, компетентностный подход, инженерные способности, виртуальные лаборатории, моделирование, проблемное обучение, проектное обучение, модульное обучение, инженерные компетенции.

INTRODUCTION

At present, international scientific and pedagogical centers are conducting extensive research aimed at finding practical solutions to a number of problems related to improving the quality of education in technical fields. In particular, in construction engineering programs, the teaching of physics plays a crucial role in shaping students’ professional competencies and developing their engineering skills. Further improvement of this process requires the implementation of innovative methods and modern educational approaches. Therefore, in the contemporary higher education system, enriching the teaching process of academic disciplines especially physics with innovative technologies and developing curricula adapted to engineering programs is considered a pressing issue.

In particular, physics is an integral component of professional training in the field of construction engineering, and students studying in this area must have a deep understanding of the practical significance of physics and be able to apply it to real engineering problems.

Currently, the following innovative teaching methods are widely used in physics education: virtual laboratories, which allow experiments to be conducted not only under real conditions but also through computer-based simulations; problem-based learning, in which students acquire knowledge by solving assigned problems; and project-based learning, where students work collaboratively to develop real engineering projects.

In engineering education, topics such as resonance and forced vibrations are especially closely related to the safety of construction structures. When designing bridges, high-rise buildings, and other engineering facilities, the effects of

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resonance must be calculated in advance. Therefore, these topics should be covered in greater depth in physics textbooks.

METHODS

Pedagogical technologies represent a systematic approach aimed at improving the quality of the process of delivering physical knowledge to students. At present, interactive methods, innovative technologies, and information and communication tools are widely used in the modern higher education system. These pedagogical technologies are particularly effective in increasing learning efficiency and developing students' engineering skills. In turn, they encompass the following modern teaching methods:

1. Modular learning technologies. Modular learning is a system of instruction in which the educational process is divided into separate modules (independent learning units), each of which includes clearly defined objectives, content, tasks, assessment, and evaluation components. This technology fosters the development of active and independent learners. In physics education, its advantages include enabling students to study topics at their own pace; facilitating the understanding of complex topics through modular structuring; ensuring systematic organization of experiments and practical activities; promoting independent thinking; reducing teachers' workload; and increasing overall instructional effectiveness.

2. Problem-based learning methods. Problem-based learning is a pedagogical method based on presenting students with scientific and technical problems and encouraging them to acquire knowledge through independently finding solutions. In this approach, students do not receive ready-made information; instead, they learn through active cognitive engagement aimed at problem solving. Its main objectives include developing the ability to identify problem situations, linking physical laws with practical engineering applications, enhancing analytical thinking and technical reasoning, strengthening modeling and computational skills, and reinforcing design competencies. The advantages of this method include fostering engineering thinking; enabling students to perceive processes not merely as formulas but as real structural systems; encouraging independent inquiry; ensuring more durable learning outcomes through self-discovered

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solutions; and developing practical skills such as calculations, graphical analysis, and model construction skills that promote thinking like professional engineers.

3. Virtual laboratories and simulations. Virtual laboratories and simulations serve to bridge theory and practice. They make it possible to explain physical laws such as those related to mechanics, vibrations, strength of materials, and electrical phenomena by directly linking them to construction processes. Through the modeling of physical phenomena, students gain a clearer understanding of real construction objects and engineering systems.

RESULTS

In addition, through experimental activities it is possible to study physical processes that are essential for construction engineering, such as concrete and steel structures, loads, pressure, and the effects of forces. In this process, students develop skills in working with modern technologies and learn to use digital modeling and simulation software, which prepares them for their future engineering careers. The main advantages are outlined below:

a) Safety – Hazardous or complex experiments (involving large forces, high pressure, or electrical phenomena) can be conducted without any risk to students.

b) Cost efficiency – The need for expensive laboratory equipment, materials, and their maintenance is significantly reduced. Experiments can be repeated multiple times without additional costs.

c) Convenience in time and space – Students can perform laboratory activities at any place and at any time. This approach is also highly effective in distance learning environments.

d) Possibility of repeated experimentation – By analyzing errors, modifying parameters, and comparing results, students gain deeper and more meaningful knowledge.

e) Visual and interactive learning – Complex physical processes are presented clearly and understandably through graphs, animations, and 3D models. This is particularly important for understanding construction mechanics and the strength of materials.

f) Increased student engagement – Skills related to independent work, analysis, and solving problem situations are enhanced. In teaching physics to construction engineering students, virtual laboratories improve the quality of learning, develop practical skills, and contribute to the training of modern engineers. Therefore, virtual laboratories are considered an effective educational tool that complements and in some cases replaces traditional laboratory classes.

4. Simulations. Simulations represent computer-based models of real physical processes and objects and play a very important role in teaching physics to construction engineering students. Through simulations, it is possible to perform real experiments in a virtual environment, observe the mechanisms by which physical laws operate, and analyze results by changing various parameters.
For example, the bending of beams under load, vibration frequencies, and the distribution of pressure and forces can be clearly visualized through simulations.
Their significance includes:
a) Understanding complex processes – such as force equilibrium, deformation, elastic and plastic behavior, vibration and resonance phenomena, and thermal expansion and stresses;
b) Development of practical engineering thinking – finding answers to questions such as "What will happen if a parameter changes?" and fostering design-oriented thinking;
c) Proximity to real construction conditions – modeling loads in bridges, buildings, and structural systems, as well as simulating the effects of earthquakes.

DISCUSSION

Advantages of simulations include the ability to perform hazardous experiments virtually without requiring physical materials or equipment; real-time modification of parameters; clear visualization through graphs and animations; and the possibility of conducting experiments an unlimited number of times. In physics education, simulations are applied to topics such as force, moment, work and energy, statics, dynamics, vibrations and waves, resonance phenomena, stress and deformation diagrams, elastic modulus, heat transfer, thermal expansion, and other related processes.

Commonly used simulation software (examples):
PhET Interactive Simulations
MATLAB / Simulink
ANSYS

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COMSOL Multiphysics
SolidWorks Simulation

5. Experimental activities and project-based learning methods. These methods involve students studying physical laws and phenomena through experiments conducted in real or virtual environments.

Experimental activities are particularly important in construction engineering physics. Their significance lies in reinforcing theoretical knowledge and demonstrating the application of physical laws in real engineering objects. They also develop skills related to measurement, observation, and analysis. The advantages include the development of students' independent working abilities, the formation of technical thinking, and the integration of theory with practice.

Project-Based Learning (PBL) is an educational method in which students apply physical knowledge while solving a specific problem or addressing a real engineering task. Its main characteristics include a focus on problem situations, the development of both teamwork and individual work skills, and an outcome-oriented approach (such as producing a model, report, or presentation).

Examples of projects in construction engineering physics include designing a bridge model (force equilibrium and structural strength), developing an earthquake-resistant building model (vibrations and resonance), creating an energy-efficient building (heat transfer), and designing load-bearing structures (statics and dynamics). The advantages of project-based learning include the development of practical and critical thinking, learning to apply physical laws to real-world problems, increased student creativity and initiative, and the formation of professional competencies.

Taking the above into account, it can be clearly understood that physics plays a particularly important role in developing these competencies among students. Physics is the foundation of all technical disciplines, and most processes in the construction field are physical in nature, including loads, pressures, deformations, heat transfer, material strength, vibrations, resonance, and hydrostatic and hydrodynamic processes. The laws of physics play a decisive role in understanding key processes encountered in construction practice, such as forces, pressure, deformation, heat exchange, flows, and electrical safety.

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Therefore, redesigning the content of physics from a traditional academic format into an engineering-oriented and practice-based structure is one of the most pressing tasks of modern education.

CONCLUSION

Redesigning the content of physics for students of construction engineering programs is one of the strategic priorities of modern education. The engineering-oriented nature of the content, its integration with practical training, enrichment with computer modeling tools, and close connection with real engineering projects significantly enhance students' professional preparedness. As a result of this approach, engineering competencies such as analytical thinking, problem-solving skills, structural assessment, safety assurance, and technical creativity are developed in an integrated and systematic manner.

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