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THEORETICAL AND PRACTICAL PRINCIPLES AND FACTORS OF ORGANIZING CONTEXTUAL LEARNING FOR ENGINEERING STUDENTS AT TECHNICAL UNIVERSITIES IN UKRAINE

The article examines the theoretical and practical principles and factors of organizing contextual learning for engineering students at technical universities in Ukraine, particularly using the example of the Igor Sikorsky Kyiv Polytechnic Institute (KPI). The author analyzes current trends in technical education, substantiates the necessity of implementing innovative educational technologies that facilitate the development of professional competencies, the adaptation of students to real industrial conditions, and the development of creative thinking. Contextual learning is based on the principles of professional orientation, integration of knowledge, active engagement, reflection, and the competency-based approach. The article describes in detail the mechanisms for implementing each principle: conducting laboratory work on modern industrial equipment, developing projects for the automation of technological processes, solving cases from real production, internships at enterprises, and the use of software for industrial systems. The practical component of contextual learning is implemented through project-based learning, dual education, case methods, the use of information technologies, industrial practice, and internships.

The article identifies the key factors for the effective organization of contextual learning. The conclusion is made that the implementation of contextual learning in technical universities in Ukraine, particularly at KPI, ensures the preparation of competitive specialists capable of working effectively in the modern conditions of the instrument-making and robotics industries, and also promotes the integration of education, science, and production, the development of innovative educational programs, and the formation of key professional competencies in engineering students.

Key words: *contextual learning, competency-based approach, professional orientation, instrumentation students, dual education, interdisciplinary approach, competence, instrument-making industry.*

(статтю подано мовою оригіналу)

The current stage of technical education development in Ukraine is characterized by the need to train highly qualified engineers capable of creative thinking, independent decision-making, and adaptation to rapid changes in the production environment. In the context of Ukraine’s integration into the global educational space, the implementation of contextual learning, which facilitates the formation of professional competencies close to real working conditions and also involves the integration of theoretical knowledge with practical activity in the professional context, becomes especially relevant.

The aim of the article is a thorough analysis of the theoretical and practical foundations for organizing contextual learning for engineering students at a technical university in Ukraine, particularly using the example of the Igor Sikorsky Kyiv Polytechnic Institute. The author seeks to substantiate the relevance and necessity of implementing innovative educational technologies that facilitate the formation of professional competencies, the development of creative thinking, the adaptation of students to real industrial conditions, and the integration of theoretical knowledge with practical activities in a professional context. Thus, the purpose of the article is to demonstrate that the introduction of contextual learning in technical universities in Ukraine, especially at KPI, is a necessary condition for preparing competitive specialists capable of working effectively in the modern conditions of the robotics and instrument-making industries.

Theoretical foundations of contextual learning.

Contextual learning originated from the theory of activity, cognitive psychology, and the concept of the competency-based approach. Its main idea is to create a learning environment that is as close as possible to the professional context, ensuring the conscious assimilation of knowledge, skills, and abilities. Contextual learning is based on the concept that the acquisition of knowledge and skills occurs in the process of solving real professional tasks.

The main theoretical principles of this technology are:

1. The Principle of Professional Orientation – the educational process is focused on the future professional activities of students. Learning is viewed as a process of active engagement, during which the student acquires experience in solving professional tasks.

Here are specific examples of implementing the principle of professional orientation for instrument engineering students at the Igor Sikorsky Kyiv Polytechnic Institute (KPI):

– Conducting laboratory work using modern industrial equipment. Instrument engineering students perform laboratory tasks using real industrial devices (sensors, controllers, measurement systems), which allows them to familiarize themselves with contemporary technologies and industry standards.

– Designing automatic control and management systems. Within the framework of course and diploma projects, students develop schemes and software for process control systems (for example, automating temperature regulation in production), thereby acquiring skills necessary for employment in enterprises.

– Solving cases from real production environments. Classes involve cases that simulate real industrial situations: troubleshooting in instrumentation systems, optimizing the operation of measurement complexes, analyzing data from industrial sensors.

– Internships and practical training at enterprises. Students undergo industrial practice at factories, laboratories, or service centers, where they directly participate in technical maintenance and device configuration, performing tasks under the supervision of experienced specialists.

– Inviting industry experts to conduct master classes and lectures. The university organizes meetings with representatives of enterprises who discuss current trends in instrumentation, demonstrate the latest equipment, and share practical cases.

– Using software applied in industry. The curriculum includes mastering specialized programs (LabVIEW, Siemens SIMATIC, ABB Automation Builder) that are widely used for designing and analyzing instrumentation systems at modern enterprises.

Thanks to these approaches, instrument engineering students gain experience in solving professional tasks that are as close as possible to the real conditions of their future work.

2. The Principle of Knowledge Integration – the combination of various scientific disciplines to solve complex engineering problems [1]. An interdisciplinary approach enables students to see a comprehensive picture of professional activity.

Students complete course and diploma projects that integrate knowledge from electronics, programming, physics, and automation. For example, the development of an enterprise energy consumption monitoring system requires the use of electrical engineering knowledge, skills in working with microcontrollers, and data analysis.

Laboratory work is organized in such a way that students apply knowledge from several disciplines simultaneously. For instance, when creating a measurement complex, students use principles of physics (parameter measurement), electronics (circuit design), programming (data processing), and mathematics (result analysis).

At KPI, programs are implemented that allow students to acquire knowledge from several fields at once, such as "Automation and Computer-Integrated Technologies," which combines engineering training with IT competencies. Joint seminars are held to address complex issues, for example, the automation of environmental monitoring, which requires knowledge of ecology, instrumentation, information technology, and chemistry.

KPI students participate in competitions that involve solving tasks at the intersection of different sciences, such as hackathons for developing engineering solutions for a "smart" city, where knowledge of electronics, programming, urban studies, and energy is required.

Thanks to these approaches, KPI ensures the integration of knowledge from various disciplines, contributing to the formation of holistic engineering thinking and the ability to solve complex professional tasks.

3. The Principle of Active Engagement – students are involved in practical work, research, design, and modeling of production processes.

Here are practical examples of the implementation of the principle of active engagement for future engineers at KPI:

– Laboratory work on modern equipment. Students perform laboratory tasks using real devices, microcontrollers, sensors, and automation systems, which allows them to acquire practical skills in working with technical tools.

– Design and development of devices. Within course and diploma projects, students independently develop and assemble prototypes of devices, measurement systems, and automated complexes, closely approximating real production tasks.

– Modeling of production processes. Using specialized software platforms (such as LabVIEW, MATLAB, Simulink), students model technological processes, optimize system parameters, and analyze the operation of automated lines.

– Scientific research work. Students participate in department research, carry out experimental tasks, analyze results, and present their findings at student scientific conferences.

– Internships at enterprises. As part of industrial and pre-diploma practice, students work at real enterprises, perform tasks related to maintenance, repair, and modernization of technical systems, and participate in the implementation of new technologies.

– Development and testing of software. Students develop software products for process automation, monitoring systems, and quality control, and test them on real objects.

4. The Principle of Reflection – analysis of one's own activities and results in order to improve the quality of learning; the importance of self-analysis, evaluation of one's own actions and outcomes, which contributes to the development of critical thinking.

Examples of the implementation of the principle of reflection for instrumentation students at KPI:

After completing and defending laboratory work, the student analyzes the obtained results, compares them with theoretical data, identifies the causes of deviations, describes their own mistakes, and suggests ways to correct them in the report.

During presentations of course or diploma projects, students not only demonstrate their results but also analyze the process of performing the work: what was successful, what difficulties arose, how they were overcome, and what skills were acquired.

Students keep reflective journals, in which they regularly record their thoughts about the learning process, difficulties, achievements, analyze their own progress, and set goals for the future.

After completing practical tasks, students discuss in groups their approaches to solving problems, share experiences, evaluate the effectiveness of different methods, and provide feedback to one another.

Students involved in research work analyze their results, determine which knowledge and skills were useful, which need improvement, and formulate conclusions for further development. After completing their internship, the student fills out a self-assessment questionnaire, describing the tasks performed, difficulties encountered, what was mastered, and which professional competencies were improved.

Through these activities, instrumentation students at KPI develop reflection skills, which enhance the quality of learning, foster professional thinking, and enable independent improvement.

5. The Principle of Competency-Based Approach – emphasis on the formation of key and professional competencies necessary for successful professional activity.

Let us analyze how the principle of competency-based approach is implemented at the Faculty of Robotics and Instrumentation (FRP) at KPI.

Educational disciplines are designed in accordance with the modern requirements of the robotics industry: students acquire key competencies such as teamwork, critical thinking, communication, as well as professional ones – robot programming, electronic systems design, and automation of production processes. A significant portion of the educational process is devoted to laboratory work, practical tasks, and projects, which allow students to develop the professional skills required for work in robotics and instrumentation.

Students participate in the development of robotic systems for partner enterprises, performing tasks that correspond to real production conditions and gaining experience in solving practical problems. Internships at enterprises and in scientific laboratories enable students to apply acquired knowledge and skills, and to develop professional competencies necessary for their future careers.

Faculty students participate in robotics competitions, where they develop professional competencies, learn to work in teams, present their own projects, and solve complex technical problems. The use of simulators, CAD systems, platforms for programming and testing robots contributes to the formation of competencies that meet modern industry standards. In addition to technical knowledge, students develop skills in creativity, leadership, and project management, which are key for successful professional activity in robotics and instrumentation.

Thanks to these approaches, the Faculty of Robotics and Instrumentation at KPI ensures the formation of both basic and specialized competencies necessary for a successful career in the relevant field.

Practical Foundations for Organizing Contextual Learning.

The implementation of contextual learning in technical universities of Ukraine is carried out through various forms and methods:

1. Project-Based Learning – students complete real engineering projects in collaboration with enterprises, which allows them to develop skills in teamwork, planning, resource management, and decision-making.

2. Dual Education – a combination of university studies with practical training at enterprises. This form facilitates the consolidation of theoretical knowledge in real production conditions.

3. Case Method – analysis and resolution of specific professional situations arising in the workplace. This promotes the development of analytical thinking, the ability to work with information, and to make well-founded decisions.

4. Use of Information Technologies– modeling of production processes, utilization of CAD/CAM systems, simulators, and virtual laboratories.

Regarding the use of information technologies (IT) for students of the Faculty of Robotics and Instrumentation Engineering of Igor Sikorsky KPI:

– Modeling Production Processes. FRP students use software platforms such as MATLAB, Simulink, and LabVIEW to model technological processes, analyze the operation of automated systems, and optimize the parameters of production lines. Within laboratory and course projects, they create digital models of control systems, conduct simulations of robotic complexes, and study the behavior of devices in various production scenarios.

– Use of CAD/CAM Systems. Automated design systems such as SolidWorks, AutoCAD, Siemens NX, and Fusion 360 are widely used in the educational process. Students design parts and assemblies of robotic systems, create three-dimensional models of mechanical components, develop drawings and documentation for device manufacturing. Using CAM systems, they prepare programs for numerically controlled machines, which enables the realization of prototypes of developed designs.

– Virtual Laboratories and Simulators. FRP students have access to virtual laboratories where they perform experimental tasks online. For example, using robotics system simulators (RoboDK, ABB RobotStudio, Siemens SIMIT), they program and test industrial robots, model automated production lines, and study control algorithms. This allows them to gain practical experience with equipment, even when real devices are temporarily unavailable.

– Integration of IoT and Smart Systems. Within educational projects, students develop monitoring and control systems for production processes using IoT platforms (Arduino, Raspberry Pi, Node-RED). They create prototypes of “smart” devices that transmit data to cloud services, analyze information, and remotely control equipment.

– Use of Specialized Software. Students master programs for automation and diagnostics of devices, such as Siemens SIMATIC, ABB Automation Builder, National Instruments LabVIEW. They develop software for technological process control, create operator interfaces, and test systems on models and real objects.

Thanks to the active use of modern information technologies at FRP KPI, students acquire practical skills in modeling, design, programming, and management of complex robotic and instrumentation systems, which meets the current requirements of engineering education.

Factors in Organizing Contextual Learning.

The effectiveness of organizing contextual learning depends on a number of factors:

1. Material and Technical Resources of the University. The availability of modern laboratories, computer classrooms, access to production facilities, and up-to-date software.

2. Qualification of Instructors. Pedagogical expertise, experience in the industrial sector, and the ability to adapt educational materials to current requirements. The pedagogical and professional competence of instructors, as well as their ability to integrate theory and practice [2].

3. Partnership with Enterprises. Establishing close ties with industrial enterprises for organizing internships, practical training, joint projects, and research is a key factor for the successful implementation of contextual learning. Such cooperation allows students to familiarize themselves with current production issues, gain practical experience, and facilitates graduate employment. Enterprises, in turn, have the opportunity to engage young specialists and influence the content of training for future employees.

4. Individualization of the Educational Process. An important component of organizing contextual learning is consideration of students' individual characteristics, their professional interests, level of preparation and motivation, awareness of the significance of professional training, and desire for self-development [3]. The use of individualized learning trajectories, mentoring, and differentiated tasks increases the effectiveness of education and ensures maximum alignment of training with labor market requirements.

5. Use of Modern Pedagogical Technologies. Implementation of new forms and methods of teaching, adaptation to changes in the technical field. Innovative pedagogical technologies such as problem-based learning, cooperative learning, gamification, the use of digital platforms and online courses contribute to increasing student motivation, developing their autonomy and creative potential. The implementation of blended learning, which combines traditional and online methods, is particularly effective [4].

6. Assessment of Contextual Learning Outcomes. The assessment of students' achievements in contextual learning should be comprehensive and take into account not only the level of theoretical knowledge acquisition, but also the formation of professional competencies, the ability to solve real production tasks, teamwork skills, creativity, and critical thinking. Methods such as portfolios, project defense, participation in competitions, and presentations of research results are used for this purpose.

Problems and Prospects for the Implementation of Contextual Learning.

Among the main problems of implementing contextual learning in technical universities of Ukraine are: insufficient material and technical resources; limited partnerships with enterprises; inadequate preparation of instructors for work in new conditions; difficulty in integrating theoretical and practical components of learning.

The prospects for the development of contextual learning are associated with the modernization of educational programs, expansion of cooperation with business, implementation of the latest technologies, improvement of instructors' qualifications, and the development of effective mechanisms for assessing learning outcomes.

Conclusions: Contextual learning is an important factor in preparing competitive engineering personnel for the modern economy of Ukraine. Its effective organization requires a comprehensive approach, integration of theoretical and practical aspects, development of partnerships with industry, and continuous improvement of the educational process.

Contextual learning is a powerful tool for preparing engineering personnel capable of independent activity in the modern production environment. Its implementation requires systematic efforts to modernize educational programs, develop partnerships with enterprises, enhance the pedagogical skills of instructors, and ensure the availability of modern material and technical resources.

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О. Суліма. Теоретико-практичні засади і чинники організації контекстного навчання студентів інженерних спеціальностей у технічному університеті України

У статті розглядаються теоретико-практичні засади та чинники організації контекстного навчання студентів інженерних спеціальностей у технічному університеті України, зокрема на прикладі Київського політехнічного інституту ім. Ігоря Сікорського (КПІ). Авторка аналізує сучасні тенденції технічної освіти, обґрунтовують необхідність впровадження інноваційних освітніх технологій, що сприяють формуванню фахових компетентностей, адаптації студентів до реальних виробничих умов та розвитку креативного мислення. Контекстне навчання базується на принципах професійної спрямованості, інтеграції знань, активної діяльності, рефлексії та компетентнісного підходу. У статті детально описано механізми реалізації кожного принципу: виконання лабораторних робіт на сучасному промисловому обладнанні, розробка проектів автоматизації технологічних процесів, вирішення кейсів із реального виробництва, стажування на підприємствах, застосування програмного забезпечення для промислових систем. Практична складова контекстного навчання реалізується через проектне навчання, дуальну освіту, кейс-методи, використання інформаційних технологій, виробничу практику та стажування. Студенти активно залучаються до розробки та тестування пристроїв, моделювання виробничих процесів, участі у науково-дослідних роботах та інженерних змаганнях, що сприяє формуванню професійних навичок та компетентностей. У статті визначено ключові чинники ефективної організації контекстного навчання. Зроблено висновок, що впровадження контекстного навчання у технічних університетах України, зокрема у КПІ, забезпечує підготовку конкурентоспроможних фахівців, здатних ефективно працювати у сучасних умовах приладобудівної та робототехнічної галузі, а також сприяє інтеграції освіти, науки та виробництва, розвитку інноваційних освітніх програм і формуванню ключових професійних компетентностей у студентів інженерних спеціальностей.

Ключові слова: *контекстне навчання, компетентнісний підхід, професійна спрямованість, студенти-прибористи, дуальна освіта, міждисцмплінарний підхід, компетентність, приладобудівна галузь.*

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