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Vitalii Svyrydiuk, Doctor of Philosophy,
Research Fellow of the Department of Content
and Technologies of Vocational Education
Institute of Vocational Education of the
National Academy of Educational Sciences of Ukraine,
Kyiv, Ukraine

FORMATION OF DIGITAL COMPETENCIES IN FUTURE SKILLED WORKERS OF THE CONSTRUCTION INDUSTRY TO ENSURE ENERGY EFFICIENCY OF FACILITIES

Анотація. У статті досліджено актуальну проблему формування цифрових компетентностей у здобувачів професійної (професійно-технічної) освіти будівельного профілю в умовах повоєнної відбудови України. Проаналізовано ключові інституційні та технологічні бар'єри, що перешкоджають впровадженню інформаційних технологій моделювання (BIM) та енергоефективних рішень на рівні безпосередніх виконавців будівельних робіт. Обґрунтовано необхідність оновлення освітніх стандартів для підготовки конкурентоспроможних кваліфікованих робітників.

Ключові слова: професійна освіта, цифрові компетентності, енергоефективність, BIM-технології, будівельна галузь, кваліфіковані робітники..

Abstract. This paper explores the urgent problem of developing digital competencies among students of vocational education and training (VET) in the construction sector amid Ukraine's post-war reconstruction. Key institutional and technological barriers hindering the implementation of Building Information Modeling (BIM) and energy-efficient solutions at the level of direct construction workers are analyzed. The necessity of updating educational standards to train competitive skilled workers is substantiated.

Keywords: vocational education, digital competencies, energy efficiency, BIM technologies, construction industry, skilled workers.

The post-war reconstruction of Ukraine, coupled with the global trend of transitioning to a "green" economy, poses unprecedented challenges for the domestic construction industry. In the Ukrainian context, the process of thermal modernization and the construction of energy-efficient buildings is complicated by the systemic problem of

a shortage of highly qualified personnel, which directly affects the macroeconomic development of the state. [1]

In scientific discourse, the issue of digitalization and energy efficiency in construction (in particular, the implementation of Building Information Modeling – BIM technologies) is traditionally considered through the prism of training design engineers and architects. [2] At the same time, the critical link determining the final quality of an energy-efficient facility remains the skilled worker – a graduate of a vocational education and training (VET) institution. High-precision calculations by engineers lose their meaning if the direct executor on the construction site lacks the digital competencies to read data from electronic models, set up heat recovery systems, or control the airtightness of structures using digital devices.

An analysis of current literature and reports from international organizations (European Training Foundation, UNDP) allows identifying a number of specific barriers that hinder the process of forming digital "green" skills in vocational education students [3, 4]:

Lack of a unified training system and outdated standards. Currently, VET educational standards only fragmentarily cover the issues of energy efficiency and digital tools, which creates a gap between the graduate and the technological requirements of a modern construction site. [5]

Lack of practical skills and infrastructural limitations. The mismatch between theoretical training and real production processes is the most frequent limiting factor [6,7]

Financial and regulatory constraints. High capital costs for purchasing modern digital equipment for VET workshops often become an insurmountable obstacle, which requires wider involvement of ESCO (Energy Service Company) mechanisms for innovative training and practical centers. [4]

Professional inertia and resistance to innovation. The introduction of digital tools for calculating energy efficiency often faces psychological resistance from foremen and masters, which requires targeted ecologically-oriented training. [8,.7]

Overcoming these barriers is vital to ensure the macroeconomic stability of the state. According to research, the deficit of digital and practical competencies among workers leads to a significant decrease in the overall energy-saving potential in the construction industry. [7]

An effective digital transformation of construction-related vocational education institutions requires the implementation of several strategic vectors. First of all, this is the scaling up of the idea of "Energy Innovative Hubs", which function in Ukraine with the support of European partners. [3] An important step is the ecologically-oriented training of construction industry specialists, which allows forming a systemic understanding of energy efficiency in future workers.⁸ According to the results of systematic reviews of the Scopus and Web of Science scientometric databases, the most promising innovative direction for improving efficiency is the implementation of BIM modeling at all stages of the building's life cycle, which makes basic skills in working with such systems a critical requirement for blue-collar workers. [2]

The second vector is the mandatory integration of elements of an interdisciplinary approach. A modern worker must understand not only the mechanics of their specific task but also how their actions affect the overall energy balance of the building, which is impossible without basic digital data analysis skills [1,.8]

The third and most important step is the full-scale deployment of the dual form of education. Synchronizing the educational process with the technological leaders of the construction market will allow students to master digital competencies directly while working with real building information models (BIM) and high-tech materials.

Thus, the training of future skilled workers in the construction industry must go beyond purely manual skills. The formation of digital competencies to ensure and monitor energy efficiency is a basic condition for creating a sustainable, carbon-neutral housing

stock during the post-war reconstruction of Ukraine. The absence of systemic steps in this direction threatens not only economic losses but also a loss of competitiveness of the national construction industry in the European market.

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