



IDENTIFYING KEY BARRIERS TO DIGITAL COMPETENCY DEVELOPMENT AMONG OIL AND GAS UNIVERSITY STUDENTS

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Abstract. *This study focuses on the challenges impeding the development of digital competencies in students of oil and gas higher education institutions. The theoretical frameworks underlying digital competence formation are analyzed. Special attention is given to the practical aspects of digital competencies peculiar to students specializing in the oil and gas field.*

Keywords: *digitalization, competence, digital competencies, oil and gas industry, communicative competence, information and communication technologies*

Introduction.

The modern oil and gas industry is constantly evolving, driven by a series of transformative changes. A key factor influencing the direction of this transformation is the digitalization of the economy, which has introduced fundamental shifts in both the ideology and operational processes within the sector. In this context, higher education systems must adapt to meet the evolving needs of the industry and harness the advantages offered by digital innovation.

Industry leaders, including executives, representatives of corporate universities, HR professionals, university rectors, and educational experts, are actively debating which models of digital competencies should be implemented in practice. The academic community is increasingly focused on critical issues such as: developing competency models for the digital economy within the framework of lifelong learning; redefining the role of educators in imparting digital skills; exploring innovative educational models and pedagogical technologies; and balancing digital, professional, and soft skills competencies.

Thus, the relevance of “digital competencies” has become indisputable. It is essential, therefore, to establish a clear understanding of the terminology surrounding digital transformation, as this provides a comprehensive foundation for developing digital skills and leveraging the benefits of digitalization within the oil and gas sector. Without this understanding, it is impossible to develop effective strategies for fostering digital competencies (DC), establishing models for their formation, and creating methodologies for their development and evaluation. A holistic approach to the challenges of cultivating digital skills, as well as a thorough examination of the processes involved in updating and refining DC, is crucial for the sustained growth and success of the industry.

As emphasized by the President of the Republic of Uzbekistan, Shavkat Mirziyoyev, in his numerous addresses, one of the core objectives of the country’s socio-economic development is the widespread implementation of information and communication technologies (ICT) and digital technologies. This sector is seen as a powerful tool capable of driving substantial reforms across various economic and social spheres. Digital transformation has emerged as a primary trend shaping the future of modern nations, fundamentally altering nearly every aspect of the economy and social systems.

The COVID-19 pandemic, while severely impacting multiple industries, also catalyzed the rapid development of the information technology sector. It underscored the critical importance of integrating ICT and digital technologies into the operations of government institutions, private enterprises, and public organizations. In response, the leadership of Uzbekistan is increasingly prioritizing international collaboration, particularly in the fields of innovation and the adoption of advanced technologies.

In this regard, it is essential to recognize the valuable experiences of Eastern nations, many of which have exhibited impressive rates of GDP growth. Regional leaders such as China, India, and Vietnam have become pivotal drivers of the global

economy. Similarly, Japan and South Korea continue to lead in various domains of innovation and high-tech production. Singapore, Malaysia, and Thailand stand out for their remarkable achievements in global trade, particularly in the export of goods and services. Meanwhile, countries like the United Arab Emirates, Qatar, and Saudi Arabia are making significant strides in alternative energy, financial innovation, and space exploration. These examples highlight the potential benefits of adopting and adapting successful models of digital transformation and technological advancement for Uzbekistan's future development.

Literature Review. In Uzbekistan, the development of the oil and gas industry is closely intertwined with the integration of innovative technologies at every stage of its operations. Today, the oil sector serves as a driving force for digitalization and technological innovation. Modern industrial production facilities have become so complex that their operations are nearly impossible without the use of digital technologies, automation, advanced equipment, and continuous modernization and re-equipment.

The application of digital technologies spans the entire spectrum of the industry, from geophysics and seismic exploration to the drilling of oil and gas wells, the automation of production processes, pipeline management, and the oversight of transport infrastructure. Additionally, the digitalization of product accounting, export tracking, and the management of foreign exchange and tax revenues are all integral to the functioning of the sector. Achieving these goals requires not only digital transformation but also a high level of energy efficiency and an optimal capital-labor ratio.

Contemporary digital technologies play a pivotal role in enhancing the operational efficiency of oil and gas companies. Innovations such as smart fields and digital twins of oil refineries are at the forefront of this transformation, positioning companies as leaders in the implementation of digital solutions. These advancements are central to the industry's overall competitiveness.

For this reason, it is essential that students in related academic programs gain proficiency in industry-specific software during their studies. These professional tools form the foundation of the automated workstations used by industry engineers, and equipping students with this knowledge is crucial for fostering a workforce capable of supporting the ongoing digital evolution of the oil and gas sector.

A comprehensive understanding of concepts related to digitalization, particularly within the context of education, is crucial for fostering the dynamic development of digital communities. Such an understanding not only supports the flexible formation of these communities but also drives the continuous evolution and updating of digital skills. Ultimately, this process contributes to increased employment opportunities and enhanced productivity.

The phenomenon of digitalization has brought about significant changes in higher education, reshaping both the content and delivery of learning. Terms such as *digitalization*, *digital electronic environment*, *digital competencies*, *digital skills*, *digital literacy*, *digital content*, *digital footprint*, *digital twin*, *digital shadow*, and *digital tutor* have become increasingly prevalent in academic discourse. Initially, "digitalization" referred to the conversion of analog information into digital formats. However, in a broader sense, digitalization now encompasses social and economic transformations driven by information technologies, alongside corresponding shifts in business models.

As digitalization continues to advance, questions arise not only about the organization of education but also about the psychology of individuals' attitudes toward it. These shifts in education are further compounded by the implications of digitalization for broader economic development. According to preliminary estimates from the McKinsey Global Institute, China's GDP could rise by up to 22% by 2025 due to the widespread implementation of Internet technologies. In the United States, digital technologies are expected to generate an increase in value of between 1.6 to 2.2 trillion USD by 2025. In Russia, the potential economic impact

of digitalization could result in a GDP increase of 4.1 to 8.9 trillion rubles, accounting for approximately 19% to 34% of the expected overall growth. Given these developments and the ongoing shift in the educational paradigm, it is essential to gain a deeper understanding of the digitalization trend. It is equally important to develop consistent approaches that maximize the benefits of digitalization, ensuring that educational practices are aligned with the demands of the evolving digital economy.

The term “digital literacy” emerged at the end of the 20th century and gained widespread popularity in 1997 through P. Gilster’s book *Digital Literacy* (Gilster, 1997) [8]. The concept of “digital literacy” has been extensively studied in numerous international research studies (Gilster, 1997; Martin & Madigan, 2006; Ilomäki, Kantosalo, & Lakkala, 2011). According to P. Gilster, digital literacy refers to "the ability to critically understand and use information obtained through computers in various formats from a wide range of sources" (Gilster, 1997).

Expanding on Gilster’s definition, A. Martin provides a more specific interpretation of digital literacy, describing it as the awareness, attitudes, and ability of individuals to appropriately use digital tools and resources for the identification, access, management, integration, evaluation, analysis, and synthesis of digital resources. It also involves the construction of new knowledge systems and communication with others for constructive social actions within specific life contexts [10].

In their study, Chetty K., Wenwei L., Josie J., and Shenglin B. (2017) employ approaches formulated in the G20 Summit Communiqué of 2017 [5]. Previous G20 communiqués in 2015 and 2016 had emphasized the need to bridge the digital divide [6, 7]. In the 2017 communiqué, given the lack of universally accepted and comparable indicators of digital literacy, recommendations were made to develop a standardized, multidimensional definition of digital literacy and a standardized

method for measuring the digital literacy index. There was also a call to align the demand and supply of digital skills.

Chetty K., Wenwei L., Josie J., and Shenglin B., acknowledging the dynamic nature of the concept of digital skills and the absence of universally accepted approaches, recommended the identification of five key dimensions: information literacy, computer literacy, media literacy, communication literacy, and technological literacy. According to the researchers, each dimension is further influenced by three aspects: cognitive, technical, and ethical. These five dimensions and three aspects, the researchers argue, should broadly form the basis for conceptual definitions, measurements, and the teaching of digital literacy. However, it is noted that a person may possess a high level of digital literacy but simultaneously have a low level of formal education. Therefore, industries that are knowledge-intensive require specialists who are not only adept at working with big data but also skilled in extracting data and interpreting the results of big data analysis [5].

International scholars Liisa Ilomäki, Anna Kantosalo, and Minna Lakkala have broadened the understanding of *digital literacy* by addressing the concept of *digital competence* (DC). They consider skills related to 21st-century literacy as closely aligned with DC, as these skills enable active participation in digital communities. Their work references the research of N. Jenkins, K. Clinton, R. Purushotma, A.J. Robinson, and M. Weigel, who argue that 21st-century literacy skills encompass the following:

- *Play* (the ability to experiment with the environment as a form of problem-solving);
- *Productivity* (the ability to assume alternative identities to improvise or discover new solutions);
- *Modeling* (the ability to interpret and create dynamic models of real-world processes);
- *Tasking* (the capacity to apply and design remixes of media by adding, removing, or modifying parts of elements);

- *Multitasking* (the ability to scan the environment and shift focus between tasks);
- *Distributed cognition* (the ability to meaningfully interact with tools that enhance cognitive abilities);
- *Collective intelligence* (the capacity to aggregate knowledge and compare it with others to achieve shared goals);
- *Judgment* [9, 11].

In addition, Ilomäki, Kantosalo, and Lakkala (2011) assert that the concept of *digital competence* is still evolving and is closely tied to technological advancements, as well as political objectives and expectations regarding citizenship in a knowledge society. Digital competence comprises a broad range of skills and competencies, spanning several areas such as media and communication, technology, and informatics. Accordingly, they conceptualize digital competence as consisting of:

1. *Technical skills* in using digital technologies;
2. The *ability to use digital technologies in meaningful ways* for work, study, and everyday life across various activities;
3. The *capacity to critically assess digital technologies*;
4. The *motivation to engage in digital culture*.

While digital competence is recognized as a foundational element in policy documents, there is still no standardized, universally accepted concept in research [9]. Earlier, K. Ala-Mutka, Y. Punie, and C. Redecker (2008) provided a theoretical basis for key competencies [4]. In alignment with their ideas, the European Union (2010) established a framework for key competencies for lifelong learning in the knowledge society, identifying eight core competencies. These include:

1. Communication in the native language;
2. Communication in foreign languages;
3. Mathematical competence and basic scientific and technological literacy;
4. Digital competence;

5. Learning to learn;
6. Social and civic competence;
7. Sense of initiative and entrepreneurship;
8. Cultural awareness and self-expression.

Thus, while the theoretical foundation of digital competence remains underdeveloped, it is nonetheless recognized as one of the eight key competencies. The development of the concept of digital competence has focused primarily on authentic concepts and the skills associated with technology, including digital technologies.

Analysis and Results Discussion. In 2017, the European Commission (EC) launched the DigCompEdu project, within which digital competence is defined as the ability of individuals to apply ICT in a safe, critical, and creative manner.

According to G.U. Soldatova, digital competence is an individual's ability, grounded in continuous acquisition of knowledge, skills, motivation, and responsibility, to critically, effectively, and safely select and apply digital technologies across various life domains [2, p. 152]. Soldatova identifies four types of digital competence:

1. **Information and media competence:** Knowledge, skills, motivation, and responsibility related to searching for, understanding, organizing, archiving digital information, critically analyzing it, and creating materials using digital resources (textual, visual, audio, and video);
2. **Communicative competence:** Knowledge, skills, motivation, and responsibility necessary for online communication in various forms (email, chats, blogs, forums, social networks, etc.);
3. **Technical competence:** Knowledge, skills, motivation, and responsibility enabling the effective and safe use of computers and related software to solve various tasks;
4. **Consumer competence:** Knowledge, skills, motivation, and responsibility enabling the resolution of everyday tasks using a computer to satisfy various needs [2, p. 153].

Research and practical developments in the field of digital competence (DC) propose different formulations and classifications of digital skills and competencies. The emerging classification in the EU includes three main categories of digital skills and competencies:

1. **Digital competence (digital literacy);**
2. **Specialized digital skills for specific professions** (a set of digital skills for those whose work involves the use and maintenance of digital tools);
3. **Digital skills for ICT-related professions.**

The Higher School of Oil and Gas cannot remain indifferent to the challenges posed by digital transformation. Digitalization demands entirely new competencies, distinct from those possessed by university graduates. Moreover, according to G.L. Tulchinsky, the digital competence of university graduates should exceed the current nomenclature of competencies in order to stay ahead of the situation. The primary function of education, he argues, is to “teach how to learn”, to be ready for change, to work on more complex projects, to adopt advanced, including foreign, practices, and to broaden horizons by tracking trends in other industries and professions [3, p. 126].

The effectiveness of the educational process depends on how it is implemented with the use of digital technologies and which pedagogical principles and strategies are employed to help students unlock their creative potential [12, p. 85].

In Uzbekistan, the development of the oil and gas industry is inextricably linked to the introduction of innovations at all stages. The oil industry today serves as the driving force for digitalization and the implementation of technological innovations. Modern industrial production complexes are so complex that operating them without digital technologies, automation, modeling, advanced equipment, modernization, and re-equipment is virtually impossible. Starting with the application of digital technologies in geophysics and seismic exploration, to drilling

oil and gas wells, automating oil and gas production processes, managing pipelines, and overseeing transport infrastructure - not to mention the accounting of production, export, foreign currency, and tax revenues from the industry - all of this can only be achieved through digitalization, high energy efficiency, and optimal capital-labor ratios.

Currently, cutting-edge digital technologies help companies achieve high levels of operational efficiency. Smart fields and digital twins of oil refineries are leaders in adopting digital innovations, which, in essence, form a core element of overall competitiveness. For this reason, it is of critical importance that students at our Branch study professional software products, based on which the automated workstations of industry engineers function, throughout their academic training.

In his Address to the Oliy Majlis, the President specifically emphasized the importance of deepening the study of geology. This sets a major task for us at the Branch to enhance the teaching of geological disciplines. In line with this, the Branch of the Russian State University of Oil and Gas named after I.M. Gubkin in Tashkent inaugurated an Innovation Center for Scientific Research. Equipped with over 30 modern computers and workstations, this scientific platform facilitates the integration of all aspects of oil and gas studies. It provides the capacity for laboratory and practical sessions, as well as applied research. These include geological and geophysical studies, data interpretation, 3D modeling, hydrodynamic modeling, risk calculations, statistical data analysis, and the processing of large data sets, all aimed at fulfilling industry-specific tasks.

Additionally, simulators for drilling operations are widely used to train highly qualified specialists in demand within the industry. Effective training of drill rig operators for open-pit mining is crucial for optimizing productivity, improving safety, and minimizing operational costs. Errors made during the drilling cycle lead to significant cost increases at all subsequent stages of extraction and processing. Given this, the educational process extensively utilizes open-pit drilling simulators

to ensure training, retraining, and certification of drilling machine operators in the context of open-pit mining operations.

The operator of an open-pit drilling simulator is presented with a virtual environment displayed across three large projection screens with high resolution, positioned around the operator's cabin. This immersive setup enables the operator to efficiently perform movements and drilling operations. The cabin of the drilling rig is replicated with high accuracy, and all instruments and controls for drilling and movement are appropriately arranged around the operator's workspace.

Example of the Use of the “Drilling Rig Operator” Simulator:

- The participant, navigating the location and following the navigator's indicator on the right, is required to approach the designated object (the location or object is indicated by a bouncing green vertical arrow).
- Upon reaching the object, the participant must press the “use” button, after which the object will be displayed in the information space.
- When the cursor arrow is hovered over a segment of the object being studied, it will be highlighted in yellow. Clicking the left mouse button will open a panel with information about the segment.
- The user is required to complete all tasks according to the specified conditions, which include carrying out drilling operations and advancing the drilling process to avoid damaging the equipment.

During the training cycle of movement and drilling, the drilling rig operator performs all actions that would be carried out on real equipment. The drilling rig models move and rotate realistically, and the precise dynamics of the drilling module's behavior, including its interaction with rocks of specified characteristics (strength and drillability), simulate the drilling experience. This provides a clear demonstration of work safety and operational efficiency.

Conclusion. The digitalization of both the economy and education has placed universities at the center of ongoing discussions regarding how to effectively and

constructively respond to the demands of the digital economy. A key participant in the shift towards a digital economy is the university graduate, equipped with the skills necessary to work with information and digital technologies. Mastery of digital competence (DC) has become a critical factor determining the employability of graduates in the modern labor market.

The need to develop approaches to the formation and enhancement of digital competence among graduates of oil and gas universities calls for a thorough examination, justification, and research. It is essential to build models of digital competencies tailored to specific educational programs, as well as to design tools for supporting and updating these competencies.

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