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METHODOLOGICAL STRATEGIES FOR CREATING AN INTEGRATED INFORMATION ENVIRONMENT IN A DIGITAL UNIVERSITY

Summary

The article explores a methodological approach to establishing an integrated information environment within a digital university in the context of the Fourth Industrial Revolution. The main challenge is the need for universities to transform in response to modern labor market demands and to boost their capacity for innovation. Key issues are identified, notably the limited integration of innovations across various sectors and the absence of effective mechanisms for university startup development. The article proposes creating digital platforms to foster productive collaboration among universities, businesses, and the state, thereby enabling universities to advance innovative projects to high levels of technological readiness. The results of the study show that implementing such platforms can significantly enhance university competitiveness, support the growth of scientific disciplines, and ensure the sustainable development of educational institutions in the digital era.

Introduction

In the context of the ongoing global technological revolution, transforming higher education has become essential to drive society's innovative development. The integration of educational activities with research and innovation processes positions universities as key centers for generating and applying new knowledge. Modern universities not only transmit knowledge but actively create it, serving as integrators of scientific and innovative endeavors. This role is especially critical given the rapid economic shifts influenced by emerging technologies.

The technological revolution, in turn, has led to profound changes in the organization and functioning of the higher education system, impacting both internal processes (education, research, innovation, and management) and external factors (funding, collaboration with the state, business, and

international partners). To remain competitive and address contemporary challenges, universities must adopt new management approaches and engage with key stakeholders in the technology and education markets.

One of the key areas for adapting higher education to new conditions is the creation of an integrated information environment within a digital university. Such an environment not only facilitates access to knowledge but also fosters research, innovation, and active collaboration with business and international partners. This, in turn, establishes a foundation for the university's sustainable development and enhances its role in the digital economy, an increasingly crucial factor in global competitiveness.

At the same time, the existing higher education model and university organizational structure should not be drastically altered. Preserving the strengths that support the educational system's functionality is essential. The evolution of an innovative university and the implementation of mechanisms for innovation development do not contradict the traditional model; rather, they build upon the university's foundational research activities, which are integral to innovation. Thus, fostering innovation within modern universities should serve as a natural extension of their core scientific mission, ensuring continuity and enhancing the effectiveness of educational and research activities.

Chapter 1. Educational Models and the Landscape of Universities and Educational Organizations

Educational models and the landscape of universities and organizations shaping professional education should be examined through the lens of the successive waves of industrial revolutions. Historically, there have been four such waves:

– the Zero Industrial Revolution is associated with advancements in shipbuilding, printing, and the use of water mills;

– the First Industrial Revolution is linked to the development of steam engines, the emergence of railroads, and the onset of the hydrocarbon era;

– the Second Industrial Revolution is associated with the mass production of automobiles powered by internal combustion engines, the development of atomic energy, and advancements in radio and television broadcasting;

– the Third Industrial Revolution is polycentric and characterized by the development of end-to-end digital technologies.

The system of higher education represents a gradual transition from the scholastic model (Figure 1) of universities (1000–1700) to the technical model (1500–2000), then to the research model (1750-present), and finally to the innovative model (1950-present) [1; 2].

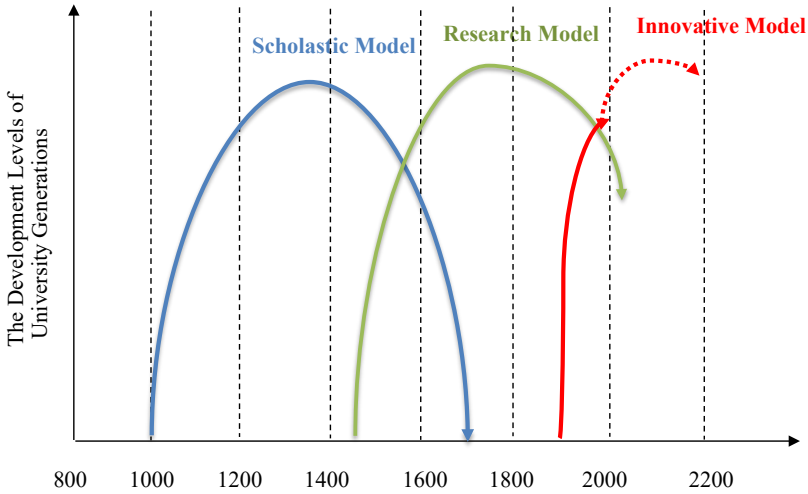

Figure 1. Transformation of University Models

Source: generated by the author

The transition from the scholastic to the research model of the university was fraught with significant difficulties. Society, on the brink of the First Industrial Revolution, required new knowledge and competencies in technology and mechanisms to facilitate the shift from an agrarian to an industrial economy. This transformation contributed to the emergence of an industrial society. However, universities continued to emphasize theological and dogmatic disciplines that did not align with the practical needs of the time. In this new educational paradigm, universities evolved into centers of knowledge production that are relevant to societal development [3, p. 1223].

The transformation of universities from a scholastic to a research-based model can be viewed as a consequence of competitive development driven by the growth of productive forces within large industrial sectors and the consolidation of capitalism as the dominant global economic system. In this new environment, universities serve as centers for research and education, generating new knowledge and technologies. The current stage of transitioning to an innovative university model involves transforming these institutions into spaces for innovative development, stimulating the creation of new market segments and entrepreneurial initiatives.

There are three main models for assessing the stages of university development. The first model categorizes universities based on the level of societal development: “University 1.0” corresponds to the pre-industrial phase,

"University 2.0" to the industrial phase, "University 3.0" to the post-industrial phase, and "University 4.0" to the cognitive phase. Each phase defines the roles and positions of both the teacher and the student [4, p. 110].

The second model differentiates universities based on the primary functions they perform: "University 1.0" focuses on education, "University 2.0" emphasizes research, and "University 3.0" centers on innovation and commercialization, serving as a hub for creating innovations [5, p. 28].

The third model of university development is based on the concept of the waves of industrial revolutions. "University 1.0" addressed the challenges and needs of the First Industrial Revolution, gradually evolving with each subsequent wave of technological advancement. This model posits that the role of higher education has grown significantly alongside the industrial revolutions, generating the intellectual and technical resources necessary to support economic and social transformations.

Since the primary aim of our study is to transform the university in alignment with societal needs – emphasizing proactive responses to socio-economic development – the key aspect is to analyze the future tasks and challenges that the university of the future will face. Accordingly, for further research, we will concentrate on the second and third models of development, which focus on the methodology of establishing the concept of the "University as a Center of Innovation" (Table 1).

Today, a university can be defined as a research and education center focused on creating and implementing innovations. Acting as a center of innovation, the university fosters an environment for the emergence of new markets and the engagement of change leaders. Its research and innovation activities are grounded in the principles of open innovation, which serve as the foundation for the implementation of educational programs and the development of society.

Here we examine the key factors that will influence the development of higher education in the near future:

1. Digitalization of university services, particularly through the partial digitalization of teacher-student interactions and the use of avatars. The extent of digitalization in educational programs will depend on their nature and requirements. Universities that do not implement timely changes or delay transformations risk losing market positions and gradually becoming obsolete. It is also crucial to establish clear boundaries for digitalization to maintain a balance between traditional and digital learning.

2. Increasing importance of innovation activities within universities. Higher education institutions (HEIs) should evolve into scientific and educational centers for the development and implementation of innovations. As competition intensifies, businesses will seek developments that demonstrate a high level of technological readiness, which is a direct outcome of innovation

activities. The University 2.0 model should be replaced by a model in which the university focuses on innovation and commercialization.

3. Territorial development should become a key priority for higher education institutions, which must serve as anchors of scientific and technological progress not only within their respective industries but also in regional development. Beyond supplying industries with qualified personnel, universities can attract young professionals to remote areas through mechanisms for the territorial assignment of graduates. Expanding this model to other educational institutions will further strengthen regional development.

4. The introduction of electronic and remote work forms will lead to a reduction in staff, particularly among low-skilled workers. The digitalization of the educational process will result in the automation of various functions, such as issuing certificates, providing consultations, and conducting intermediate assessments, all of which will be integrated into students' personal electronic accounts. Traditional deans' offices will be replaced by electronic counterparts, while the roles of methodologists and technical staff will be transitioned to computer programs and algorithms.

5. Emergence of new professions as a direct result of changing educational program specifications. As the educational process shifts toward more effective methods, there will be an increasing demand for new roles such as game teacher, tutor, moderator of scientific events, and developer of interactive educational programs, among others.

6. Increase in the multidisciplinary nature of universities, including sectoral institutions. Heightened competition in the educational services market will drive higher education institutions to experiment with new educational programs, particularly those focused on emerging professions in the digital economy.

7. Cancellation of state accreditation for educational programs. Amidst declining interest in higher education, employers are increasingly prioritizing high-quality training. Consequently, the prestige of diplomas from leading technical universities is expected to rise. In this context, state accreditation, which traditionally served as a guarantee of quality education by ensuring that the content and quality of graduate training met educational standards, is losing its relevance. Programs that are highly regarded by the public and employers may not necessarily be state accredited. Instead, the role of accreditation by employers' associations is expected to grow in importance [6; 7].

Table 1

Evolution of Universities

Factor	University 1.0	University 2.0	University 3.0	University as a center of innovation
Concept	University: A Hub for Transferring Accumulated Knowledge	University: Advancing Knowledge Through Research	University: Development and Implementation of Innovations for Knowledge-Based Education	University: Fostering New Market Development and Attracting Change Leaders
Science and Innovation	Absent as processes	Science is the basis for educational programs and innovation development	Science and innovation are successive processes, with science serving as the foundation of educational programs	Science and innovation are two successive processes, representing a model of open innovation with varying levels of technology readiness
Education	Reading, discussing, forming interpretations	Building competencies while participating in research	Building competencies through team participation, innovation, individual trajectories, and platform learning	Customization of education, separation of the educational process and certification, the utilization of digital footprints and Big Data, and the formation of educational requests
Training Practices	Involvement in the in the process through understanding	Delving into the process, gaining new knowledge together with teachers	Meta-professional, participation in research and project activities	Metaprofessional, leadership in change and development of territories
Key Stakeholders	Church power and secular authorities training centers	State, business	State, business, population	State, business, population, municipalities

Source: generated by the author

Thus, a modern university should play a pivotal role not only in the educational process but also in introducing innovations, fostering the development of new markets, and training specialists equipped to meet the challenges of the fourth industrial revolution. Digitalization, the integration of

cutting-edge technologies, and the adaptation of educational programs to labor market needs are becoming essential components of its operations. The university of the future, focused on innovation and leadership, will be a crucial determinant in the socio-economic development of both individual regions and society as a whole.

Chapter 2. Creating an Integrated Information Environment for a Digital University

The main current problems hindering the development and implementation of innovations by universities include the lack of a well-established market for innovations, poor integration of innovative developments into various sectors, and the absence of effective mechanisms for developing endowments and their involvement in the innovation infrastructure of universities. Supporting and enhancing the research and innovation activities of universities is a crucial tool for the socio-economic growth of territories.

A striking example of successful integration of research and innovation in universities is the so-called Cambridge phenomenon. While similar processes have been observed at institutions such as Stanford and Massachusetts, it was Cambridge that gave this phenomenon its name. The essence of the phenomenon lies in the active development of science and innovation at the university, which stimulated the emergence of high-tech companies in its vicinity. These companies subsequently became the driving force behind socio-economic changes in the region, leading to the growth of key economic indicators [8, p. 99].

The consequences of the aforementioned problems reveal a contradiction: universities' capabilities in creating innovations are typically limited to the stages of prototyping or developing technical solutions, while businesses are willing to finance projects only at the prototype stage or once developed design documentation is available [9, p. 7]. The dynamics of university capabilities and business interests are often opposing. At the initial stages of development, universities have extensive capabilities for generating ideas, selecting them, discussing them, and presenting them at conferences. However, as technology progresses, these opportunities diminish due to the need for significant financial investments without a guaranteed return. Conversely, businesses find projects appealing only at later stages of development, when the time to launch a product on the market and realize a profit is shorter. This creates what is known as an "innovation gap," where the university's capabilities are exhausted, and businesses are not yet ready to finance the project.

To overcome the "innovation gap" in universities, it is essential to establish mechanisms that facilitate the generation of ideas and advance them to the level of technological readiness required by businesses. The following mechanisms should be developed (Figure 2):

– business incubation of projects: creating "greenhouse" conditions for long-term project development (1–2 years);

– acceleration of projects: rapid development of projects to the required phase that is attractive to businesses (1–2 months);

– support for startups through a grant system;

– formation of technology parks to attract research teams for startup development;

– development of internal tech broker groups, and so on.

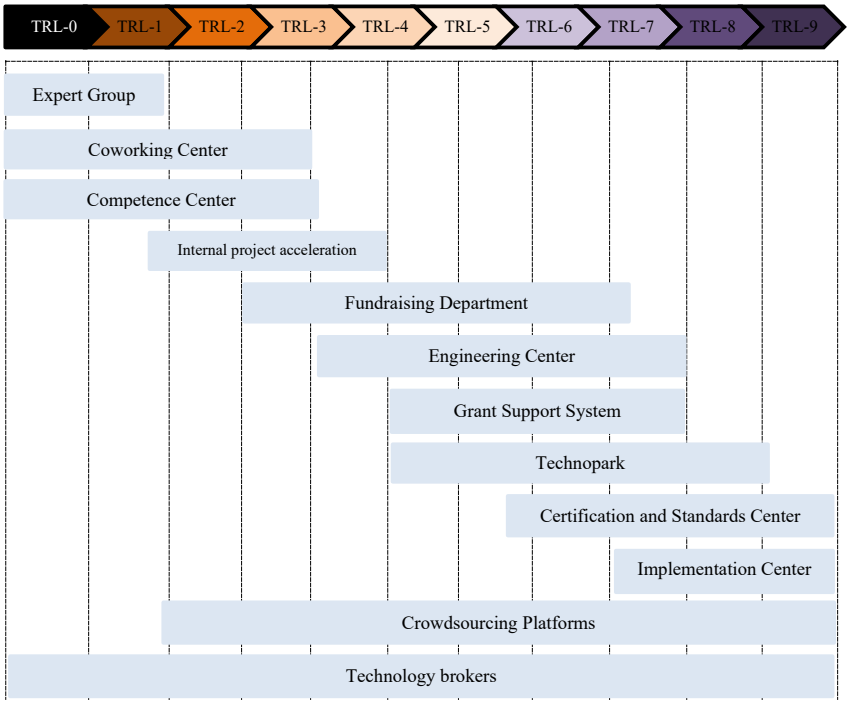

Figure 2. Mechanisms Formation for Overcoming the "Innovation Gap"

Source: generated by the author

As illustrated in Figure 2, one of the mechanisms for addressing the problem is the creation of information management crowdsourcing platforms. These cross-sectoral information and management platforms (hereinafter referred to as digital platforms) are automated information systems equipped with a range of digital services. Here, "services" refers to the capabilities of customers and

competence centers to address tasks related to the development and implementation of innovations.

Such digital platforms can be developed both on a sectoral basis (e.g., healthcare, transportation, mining) and as cross-sectoral digital platforms.

Tasks of the digital platform:

1) provide expert and technical support for the effective functioning of business and scientific organizations;

2) offer B2B solutions for active market participants who may lack a clear understanding of the technological operations required to complete their tasks and/or the associated costs of these services [10, p. 314].

In addition to services, the interaction among the competence centers of digital platform participants should be governed by both internal regulations (existing within the participants) and external regulations (established by the digital platform). This framework will create optimal conditions for working with customers.

The primary task of the digital platform is to provide expert and technical support for the effective functioning of universities and businesses. To achieve this, the platform must enable its digital management team to quickly configure the competence centers to fulfill contracts efficiently.

The second task of the platform is to offer a B2B solution for active market participants who lack a clear understanding of the technological operations required to complete their tasks and/or the associated costs. To address this, the platform should enable customers to place orders online, select the best execution options based on various parameters, and provide a preliminary cost estimate through a filtering system.

All elements of the system should adhere to a unified quality management system. The competence centers of the digital platform must align their business processes with the requirements of this quality management system.

The digital platform accommodates the following potential participant roles (see Figure 3): customer, competence center, and digital platform administrator.

The participants of the university's digital platform interact as illustrated in the right part of Figure 3. Universities configure their competence centers to meet the needs of customers, ensuring the most effective outcomes through a flexible contractor configuration system that leverages available competence centers and fosters competition among them.

The university's digital platform offers specialized services tailored to the various roles of participants. The collaboration among participants within the system is governed by procedural regulations. A summary of the services and regulations associated with the university's digital platform is presented in Table 2.

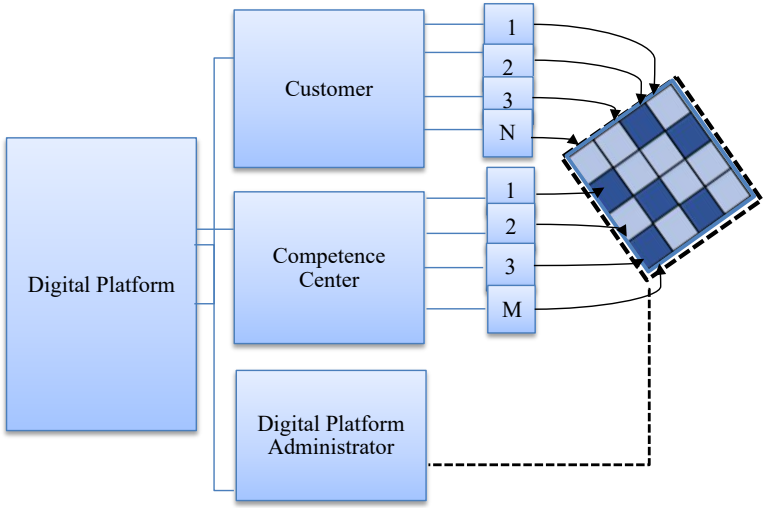

Figure 3. Roles of Participants in the University's Digital Platform

Source: generated by the author

Table 2

Summary of Services and Regulations for the University Digital Platform

№ п/п	Role	Service	Regulations
1	2	3	4
1.1	Customer	Initial registration and maintenance of one's the profile	Regulations for Client Relationship Management (CRM)
1.2	Customer	Review of the complete database of available competencies, portfolio of completed projects	Regulations for Client Relationship Management (CRM)
1.3	Customer	Description of the order in a structured format	Order management regulations
1.4	Customer	Review of possible execution options for the order, clarification of requirements and optimization criteria, submission of the order	Order management regulations
1.5	Customer	Monitoring the logistics of the order execution process – stages of execution, composition of performers, their obligations regarding deadlines and quality, interim results	Order management regulations
1.6	Customer	Working communication with the Management Company (digital format)	Regulations for Client Relationship Management (CRM)

End of Table 2

2.1	Competence Center	Initial registration, creation of one's profile, and description of one's competence in a structured view	Regulations for Client Relationship Management (CRM)
2.2	Competence Center	Description of one's capabilities and availability schedule	Production management regulations
2.3	Competence Center	Ability to refuse subcontracting (taking reliability rating into account)	Regulations for managing contract interaction
2.4	Competence Center	Possibility of accepting subcontracting on a temporary and main basis (when there are multiple competence centers of the same competence)	Regulations for managing contract interaction
2.5	Competence Center	Monitoring the logistics of the order execution process – stages of execution, composition of performers, their obligations regarding deadlines and quality, interim results	Regulations for managing engineering and design works
2.6	Competence Center	Receiving and transferring the results of work to other participants in the technological chain in a documented form	Regulations for Client Relationship Management (CRM)
2.7	Competence Center	Working communication with the Single Window and, with permission from the Managing Company, with other Competence Centers and the Customer	Regulations for Client Relationship Management (CRM)
2.8	Competence Center	Conclusion and support of contract	Regulations for managing contract interaction
3.1	Administrator	Management of data directories (types of competencies, technologies, equipment, groups of values, etc.) and business rules	Regulations for working with data directories and business rules
3.2	Administrator	Entering the parameters of the technical assignment for electronic bidding into the system, activating the order adjustment procedure	Regulations for interaction with electronic trading platforms
3.3	Administrator	Automated assessment of the feasibility of execution, preliminary logistical planning, and participation in technical tours	Order management regulations
3.4	Administrator	Making adjustments to the order, performing new calculations	Order management regulations
3.5	Administrator	Conclusion and support of contracts with clients	Regulations for managing contract interaction
3.6	Administrator	Conclusion and support of contracts with competence centers	Regulations for managing contract interaction
3.7	Administrator	Monitoring the progress of order fulfillment	Order management regulations

End of Table 2

3.8	Administrator	Maintaining a structured portfolio of completed projects	Regulations for Client Relationship Management (CRM)
4.1	Administrator	Obtaining big data from the digital platform for further data analytics	All regulations
4.2	Administrator	Management of access and rights of participants in the digital platform	Information security management regulations
4.3	Administrator	Ensuring the information security of services	Information security management regulations

Source: generated by the author

The digital platform addresses the issue of research and innovation projects failing to reach the decision-making stage due to inadequate funding. Several factors contribute to this, including businesses' reluctance to finance early-stage projects, insufficient market research, inadequate risk assessment during project launch decisions, and others.

To illustrate how a university's digital platform functions, consider the creation of innovative solutions that necessitate resources from multiple competence centers, such as laboratories and research centers. However, the levels of competence among universities vary, influenced by factors like research and laboratory infrastructure and the qualifications of specialists. This situation can be visually represented in a diagram (Figure 4) that highlights the heterogeneity of university competence centers.

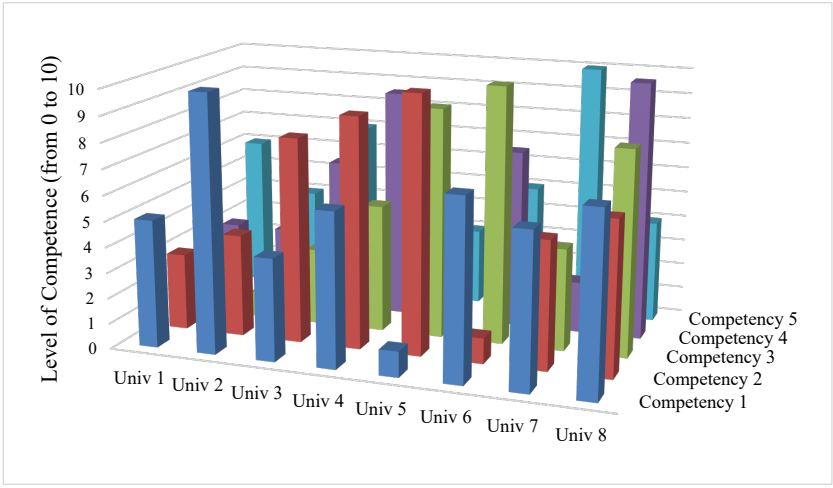

Figure 4. Heterogeneity of University Competence Centers

Source: generated by the author

The X and Y scales on the diagram represent higher education institutions (HEIs) and their respective competence centers. The Z scale indicates the level of competence within a particular HEI. A quantitative assessment is conducted through expert analysis, utilizing forms designed for expert evaluation. The assessment process involves calculating the average value of the results from expert assessments on a 10-point scale.

Simultaneously, the customer requires a transparent innovation management system that is comprehensible to partners and facilitates the assessment of the progress in developing an innovative solution. Figure 5 illustrates a model of innovation creation that involves multiple competence centers.

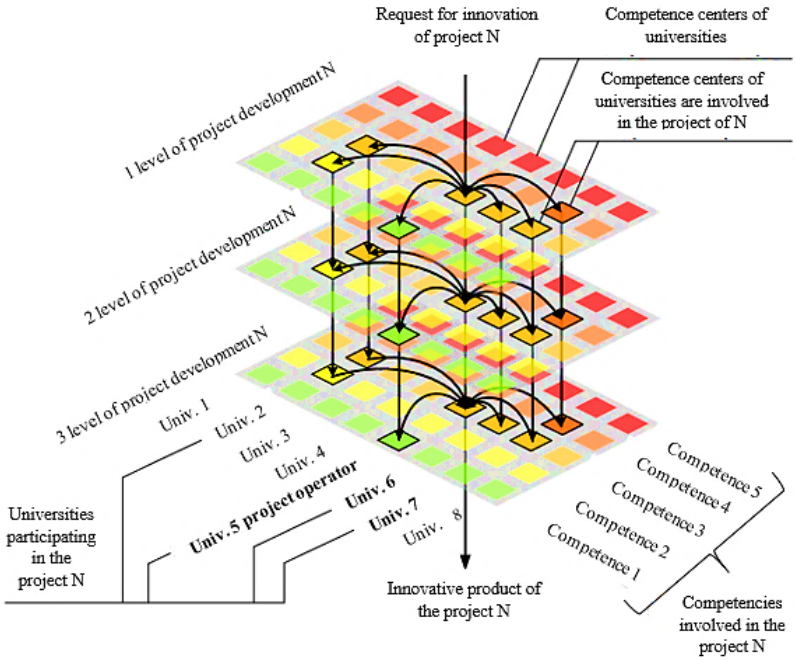

Figure 5. Block Diagram of the Digital Platform

Source: generated by the author

For example, as indicated in the legend, an innovation request enters the university under the conditional number 5, with competence number 3 being essential for this work. The project implementation phase consists of three stages, during which competence centers from other universities are engaged. This collaboration involves four universities and three types of competence

centers (e.g., energy, IT, etc.), enhancing both the efficiency of project execution and the quality of product development.

Thus, the presented digital platform will enable participants to collaborate in developing and implementing innovations through a unified methodological approach to university development, primarily focused on:

– the development and implementation of comprehensive scientific research and integrated science and technology programs;
– the commercialization of obtained results;
– the accelerated design and implementation of innovative products.

An experimental regulatory platform is an important tool for developing digital universities. It serves as a mechanism allowing for the temporary suspension of certain regulations to test the effectiveness of new technologies or devices in real-world conditions. Ministries, agencies, or other governmental entities can act as the regulators with the authority to suspend these regulations.

Thus, the methodological approach to developing the university's digital platform focuses on establishing two systems within the HEI – internal and external. The internal system is designed to develop mechanisms that bring innovative projects to a high level of technological readiness (TRL 7 – TRL 9), meeting the demands of the business sector.

The external system focuses on forming effective scientific and innovative collaborations, where university competence centers, rather than HEIs themselves, serve as the main operational units. These competence centers guide the development of the university's scientific schools, forming the foundation of all scientific activity, while administrative bodies play a secondary role. Universities provide resources and services to support competence centers, and these scientific schools serve as the basis for creating educational programs rooted in the latest research.

In this model, the university functions as a platform where scientific schools are developed under the leadership of renowned scientists. Scientific and pedagogical staff supporting these schools play a critical role in transforming acquired knowledge into innovative developments and educational program elements, thereby fostering the integration of science and education within the university environment.

Below these core elements are competence centers, graduate and postgraduate students, as well as innovative enterprises co-founded by the university. These enterprises form the backbone of the innovation ecosystem, where their effective development drives the socio-economic impact in the region, akin to the Cambridge phenomenon.

Digital platforms are a cornerstone of an external system dedicated to fostering scientific and innovative collaborations. As tools for generating high-readiness-level innovations aligned with business needs, these platforms enhance corporate sector interest in research aimed at new, applicable

knowledge for innovative solutions. They also ensure transparency in government funding of scientific projects, enabling a targeted allocation of resources. In the future, such platforms could serve as integrative hubs, bringing together global scientific and educational centers, university research schools, and business accelerators' innovation initiatives, thereby bridging mutual interest gaps among these parties.

Conclusions

In the context of the Fourth Industrial Revolution, universities must adapt to new challenges and evolve into centers of innovation and research activity. The traditional educational model no longer meets the demands of contemporary society and the economy, which necessitate the rapid generation and implementation of new technologies. Transforming universities to create an integrated information environment is essential for ensuring their competitiveness and addressing the challenges of modern technological development.

In the context of the Fourth Industrial Revolution, universities must adapt to new challenges and evolve into centers of innovation and research. The traditional educational model no longer meets the needs of modern society and the economy, which demand the rapid generation and implementation of new technologies. Therefore, transforming universities to create an integrated information environment is essential for ensuring their competitiveness and addressing the challenges of contemporary technological development.

The methodological approach to creating university digital platforms proposed in this article facilitates the integration of scientific research, educational activities, and innovations into a unified information environment. This integration fosters active collaboration between universities, businesses, and government entities, creating synergy among various participants in the innovation process. Through such platforms, universities can transcend the limitations of the traditional model of innovation activity, enhancing their capacity to advance projects to a level of technological readiness that is appealing to businesses.

One of the significant problems that the proposed model addresses is overcoming the "innovation gap" that arises during the transition from idea generation to commercialization. Digital platforms enable universities to collaborate effectively with competence centers, thereby accelerating the implementation of innovative projects while providing essential technological and financial support. This collaboration not only enhances the scientific research base but also increases the attractiveness of university innovations for potential investors.

Thus, the implementation of an integrated information environment within universities via digital platforms will not only foster the development of

scientific schools and innovative activities but also enhance the overall competitiveness of universities on a global scale. Future research prospects lie in exploring the role of universities as key drivers of scientific and technological progress, particularly their capacity to influence the socio-economic development of regions and facilitate the integration of innovations across various sectors of society.

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