

## DEVELOPMENT OF PROFESSIONAL QUALITIES OF ENGINEERS THROUGH UNIVERSITY-PRODUCTION INTEGRATION IN A DIGITAL EDUCATIONAL ENVIRONMENT

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### **Abstract**

This article is aimed at developing the theoretical and methodological foundations for the development of professional competencies of future engineers in a digital educational environment. The study substantiated the need to modernize engineering education in the context of globalization and digital transformation processes. Based on the Design Science Research (DSR) methodology, a conceptual model was proposed, including the environment of relevance, the environment of scientific validity, and the stages of developing an iterative methodology. The model substantiates the relationship between the level of transformation of digital education and the evolution of professional competencies.

### **Keywords**

Engineering education; professional competence; pedagogical competence; digital transformation; Design Science Research; iterative methodology; university-industry integration; evolution of competencies; innovative educational model.

## РАЗВИТИЕ ПРОФЕССИОНАЛЬНЫХ КАЧЕСТВ ИНЖЕНЕРОВ ПОСРЕДСТВОМ ИНТЕГРАЦИИ УНИВЕРСИТЕТ-ПРОИЗВОДСТВО В ЦИФРОВОЙ ОБРАЗОВАТЕЛЬНОЙ СРЕДЕ

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### **Аннотация**

Данная статья направлена на разработку теоретико-методологических основ развития профессиональных компетенций будущих инженеров в цифровой образовательной среде. В исследовании обоснована необходимость модернизации инженерного образования в условиях процессов глобализации и цифровой трансформации. На основе методологии Design Science Research (DSR) предложена концептуальная модель, включающая в себя среду актуальности, среду научной обоснованности и этапы разработки итеративной методики. Модель обосновывает взаимосвязь между уровнем трансформации цифрового образования и эволюцией профессиональных компетенций.

### **Ключевые слова**

Инженерное образование; профессиональная компетенция; педагогическая компетенция; цифровая трансформация; Design Science Research; итеративная методика; интеграция университет-промышленность; эволюция компетенций; инновационная образовательная модель.

## **RAQAMLASHTIRILGAN TA'LIM MUHITIDA UNIVERSITET-ISHLAB CHIQRARISH INTEGRATSIYASI ORQALI MUHANDISLARINING KASBIY SIFATLARINI RIVOJLANTIRISH**

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### **Annotasiya**

Ushbu maqolada raqamlashtirilgan ta'lim muhitida bo'lajak muhandislarning kasbiy kompetensiyalarini rivojlantirishning nazariy-metodologik asoslarini ishlab chiqishga qaratilgan. Tadqiqotda globallashuv va raqamli transformatsiya jarayonlari sharoitida muhandislik ta'limini modernizatsiya qilish zarurati asoslab berildi. Design Science Research (DSR) metodologiyasi asosida dolzarblik muhiti, ilmiy asoslanganlik muhiti hamda iterativ metodika ishlab chiqish bosqichlarini o'z ichiga olgan konseptual model taklif etildi. Model raqamli ta'lim transformatsiyasi darajasi va kasbiy kompetensiyalar evolyutsiyasi o'rtasidagi o'zaro bog'liqlikni asoslaydi

### **Kalit so'zlar**

Muhandislik ta'limi; kasbiy kompetensiya; pedagogik kompetensiya; raqamli transformatsiya; Design Science Research; iterativ metodika; universitet-sanoat integratsiyasi; kompetensiyalar evolyutsiyasi; innovatsion ta'lim modeli.

**INTRODUCTION:** The modernization of the higher education system in the Republic of Uzbekistan, the widespread introduction of modern information and communication technologies into the educational process, and improving the quality of personnel training are defined as priority areas. In the Law "On Education" and regulatory legal acts on reforms in the field of education, the tasks of widespread implementation of a competency-based approach, development of digital infrastructure, and transformation of the educational process are specifically noted. This increases the need to develop innovative methodological models in the system of engineering education.

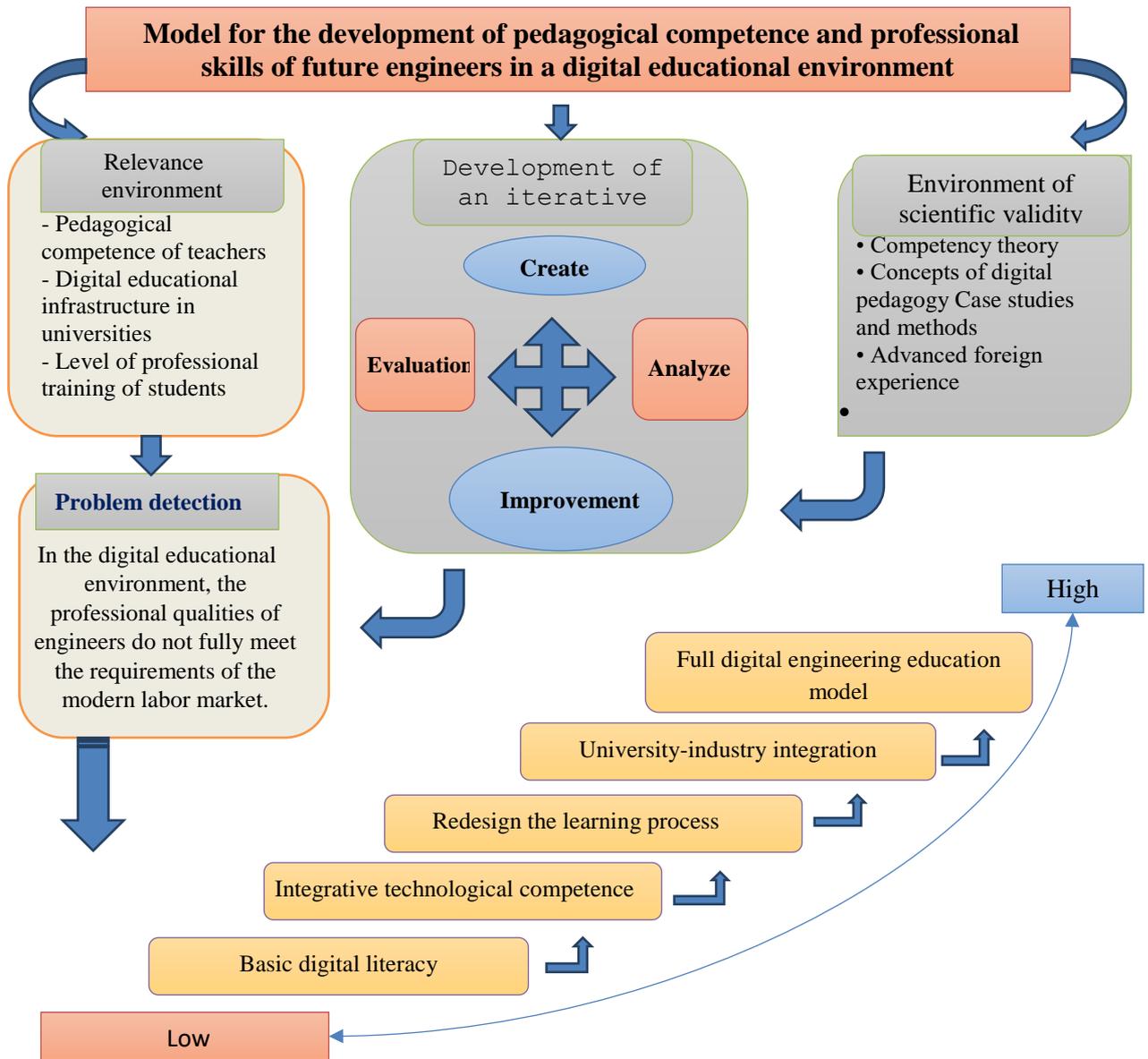
The study develops the theoretical foundations for the development of professional competencies of future engineers in a digital educational environment and proposes an iterative model based on the Design Science Research (DSR) methodology. This model includes an environment of relevance, an environment of scientific validity, and a mechanism for the gradual improvement of the methodological artifact. The model conceptually substantiates the relationship between the level of transformation of digital education and the evolution of professional competencies.

The purpose of the research is to develop a theoretical and methodological model for the development of professional competencies of future engineers in a digital educational environment and to empirically substantiate its effectiveness.

- Research objectives:  
- analysis of digital transformation processes in engineering education;  
- clarification of the structure of professional competencies;  
- Development of an iterative methodological model based on the DSR methodology;

**Methods:** Analysis shows that in many cases, digital technologies are introduced into the educational process in fragments, but they are not connected with the mechanism of systematic and integrative formation of professional competencies. As a result, the competencies of graduates do not fully meet the requirements of the modern labor market. Therefore, the relevance of the model forms the following scientific problem: In the digital educational environment, the professional qualities of future engineers are not formed on the basis of a

systematic and transformational approach. This problem justifies the need to develop a model.



**Figure 1. Model for the development of pedagogical competence and professional skills of future engineers in a digital educational environment**

**The relevance environment of the model** - The relevance environment of the model is a component that determines the practical necessity of research and relies on existing problems in the real higher education system. In this block, existing gaps in the process of forming the professional competencies of future engineers in a digital educational environment are identified.

The relevance environment includes the following elements:

- ❖ Level of pedagogical competence of teachers;
- ❖ The state of development of the digital education infrastructure in universities;
- ❖ Level of professional training of students.

**Problem identification stage** - Based on the context of relevance, the main problem of the research is formulated. This stage is the first step in the DSR methodology, and the problem is determined based on empirical observations and theoretical analysis.

The model describes the problem as follows:

- ✚ There is a digital educational environment, but it is not directly integrated with the development of professional competencies;
- ✚ Pedagogical approaches have not been updated in accordance with the level of digital transformation;
- ✚ Competencies are formed not evolutionarily, but episodically.
- ✚ This stage creates the scientific basis of the model.

**Development of an iterative methodology** - the central part of the model is an iterative mechanism built on the basis of the DSR (Design Science Research) methodology.

It includes the following steps:

- Creation (Build) - development of a methodological model for the development of professional competencies.
- Assessment - determining the content completeness of the model through expert analysis.
- Evaluate - test the effectiveness of the model based on an experiment.
- Improvement (Refine) - elimination of identified shortcomings.

This process is iterative, and each cycle increases the theoretical and practical perfection of the model. The proof is that the model is developed not as a theoretical concept, but as an empirically substantiated artifact through experimentation.

**Environment of scientific validity** - the environment of scientific validity of the model represents its theoretical basis. This block is based on:

- ✓ Competency theory;
- ✓ Concepts of digital pedagogy;
- ✓ Case studies and modern models;
- ✓ Advanced foreign experience.

These elements ensure the scientific legitimacy of the model and substantiate its conceptual integrity.

**Results and Discussion:** The mechanism of competency evolution - the lower part of the model reflects the relationship between the level of digital transformation and the development of professional competencies. The development trajectory is as follows:

- Basic digital literacy;
- Integrative technological competence;
- Re-design of the educational process;
- University-production integration;
- Complete digital engineering education model.

These stages prove that as the level of digital transformation increases, competencies become more complex and rise to a strategic level.

**Conclusion:** The presented conceptual model represents the process of developing the professional competencies of future engineers in a digital educational environment based on a systematic, integrative, and phased mechanism. The research results show that as the level of transformation of digital education increases, the professional competencies of future engineers also become more complex and evolve from basic digital literacy to competencies at the innovative and strategic levels. This process is carried out not randomly, but on the basis of a methodologically justified mechanism, confirmed by experimental verification. Thus, the developed model offers a theoretically substantiated, methodologically sound, and practically applicable mechanism for the development of professional competencies of future engineers in a digital educational environment.

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