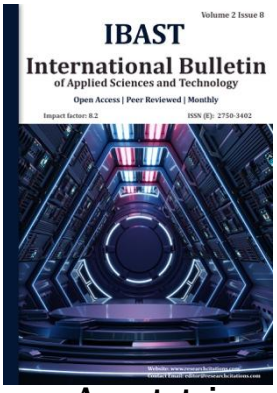

PEDAGOGICAL MODEL FOR DEVELOPING STUDENTS' PROFESSIONAL COMPETENCE THROUGH DIGITAL TECHNOLOGIES IN THE HIGHER EDUCATION SYSTEM

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Annotatsiya: Mazkur tadqiqotda oliy ta'lim tizimida talabalarning kasbiy kompetentligini raqamli texnologiyalar asosida rivojlantirishning nazariy va metodologik asoslari ishlab chiqildi hamda eksperimental jihatdan tasdiqlandi. Tadqiqot kompetensiyaviy yondashuv, raqamli pedagogika va integrativ ta'lim texnologiyalarining o'zaro integratsiyasi asosida tashkil etildi. Empirik bosqichda jami 124 nafar talaba ishtirok etdi va ular tajriba hamda nazorat guruhlariga ajratildi, har bir guruhda 62 nafardan ishtirokchi qatnashdi. Tadqiqot ikki ketma-ket bosqichda amalga oshirildi: diagnostik bosqich va tajriba-aralashuv bosqichi. Kompetentlik darajalari dinamikasi tahlili tajriba guruhida sezilarli ijobiy o'zgarishlarni ko'rsatdi. Xususan, yuqori darajadagi kompetentlikka ega talabalar ulushi 18% dan 42% gacha oshgan bo'lsa, past kompetentlik darajasiga ega talabalar ulushi 30% dan 12% gacha kamaydi. Aksincha, nazorat guruhida statistik jihatdan ahamiyatli o'zgarishlar kuzatilmadi. Olingan natijalar raqamli texnologiyalar asosida ishlab chiqilgan pedagogik model kasbiy kompetentlikning barcha tarkibiy komponentlariga kompleks va statistik jihatdan ishonchli ta'sir ko'rsatishini tasdiqlaydi.

Tadqiqot xulosalari oliy ta'limni raqamli transformatsiya qilish, adaptiv o'qitish mexanizmlarini joriy etish hamda kompetensiyaviy monitoring tizimlarini takomillashtirish uchun ilmiy-metodik asos bo'lib xizmat qiladi.

Kalit so'zlar: kasbiy kompetentlik, raqamli pedagogika, pedagogik model, eksperimental tadqiqot, matematik-statistik tahlil, oliy ta'lim, kompetensiyaviy yondashuv.

Аннотация: В данном исследовании разработаны и экспериментально подтверждены теоретико-методологические основы педагогической модели развития профессиональной компетентности студентов на основе цифровых технологий в системе высшего образования. Исследование было организовано на основе интеграции компетентностного подхода, цифровой педагогики и интегративных образовательных технологий. В эмпирическом этапе приняли участие 124 студента, разделённые на экспериментальную и контрольную группы по 62 человека в каждой. Исследование проводилось в два последовательных этапа: диагностический этап и этап экспериментального внедрения.

Анализ динамики уровней компетентности показал значительные положительные изменения в экспериментальной группе. В частности, доля студентов с высоким уровнем компетентности увеличилась с 18% до 42%, тогда как доля студентов с низким уровнем компетентности снизилась с 30% до 12%. В контрольной группе статистически значимых изменений выявлено не было. Полученные результаты подтверждают, что педагогическая модель, разработанная на основе цифровых технологий, оказывает комплексное и статистически достоверное влияние на все структурные компоненты профессиональной компетентности.

Выводы исследования служат научно-методологической основой для цифровой трансформации высшего образования, внедрения механизмов адаптивного обучения и совершенствования систем компетентностного мониторинга.

Ключевые слова: профессиональная компетентность, цифровая педагогика, педагогическая модель, экспериментальное исследование, математико-статистический анализ, высшее образование, компетентностный подход.

Abstract: This study develops and experimentally validates the theoretical and methodological foundations of a pedagogical model for enhancing students' professional competence through digital technologies in higher education. The research was grounded in the integration of competency-based approaches, digital pedagogy, and integrative educational technologies. The empirical stage involved 124 students divided into experimental and control groups, with 62 participants in each group. The study was conducted in two sequential phases: a diagnostic stage and an experimental-intervention stage. The analysis of competence-level dynamics demonstrated a substantial improvement in the experimental group, where the proportion of students with a high level of competence increased from 18% to 42%, while the percentage of students with low competence decreased from 30% to 12%. In contrast, the control group showed no statistically significant changes. The findings confirm that the pedagogical model developed on the basis of digital technologies exerts a comprehensive and statistically reliable influence on all structural components of professional competence.

The conclusions of the study provide a scientific and methodological foundation for the digital transformation of higher education, the implementation of adaptive learning mechanisms, and the improvement of competency-based monitoring systems.

Keywords: professional competence, digital pedagogy, pedagogical model, experimental research, mathematical-statistical analysis, higher education, competency-based approach.

Introduction: In the twenty-first century, globalization processes and the rapid expansion of the digital economy have imposed fundamentally new requirements on higher education systems [1]. Under conditions of a rapidly transforming labor market and the increasing digitalization of professional activities, the competitiveness of specialists is primarily determined by the degree of development of their professional competence [2]. Consequently, there is a growing necessity to reconsider the content and methodology of higher education within the framework of a competency-based approach [3].

While traditional instructional models mainly focus on the reproduction of theoretical knowledge, contemporary digital learning environments require students to develop independent thinking, problem-solving abilities, information analysis skills, and reflective practices [4]. This creates the need to organize the process of professional competence formation through the integrated development of motivational, cognitive, operational-activity, and reflective components [5]. Unless these components are systematically developed, sustainable improvement in the quality indicators of education cannot be achieved [3].

The integration of digital technologies into higher education should not be viewed solely as the technical modernization of the instructional process; it also involves the transformation of pedagogical content and methodology [6]. The use of digital platforms, interactive learning tools, and adaptive educational mechanisms enables the construction of individualized learning trajectories, the integration of theoretical knowledge with practical activities, and the implementation of competency-based monitoring systems [7].

From this perspective, the relevance of the present study is determined by the need to develop and experimentally validate a pedagogical model for fostering students' professional competence through digital technologies in higher education [8]. Within the framework of the study, the structural components of professional competence were identified, assessment criteria were developed, and the practical effectiveness of the proposed model was statistically substantiated through experimental implementation.

The empirical findings (n = 124) demonstrated that there was no statistically significant difference between the experimental and control groups at the initial stage ($p > 0.05$), thereby confirming the methodological validity of the experimental design [8]. Following the implementation of the pedagogical model, the integral indicator of professional competence in the experimental group increased by 18.6%. According to Student's t-test results ($t = 4.37$; $p < 0.05$), the obtained outcomes were statistically significant. These findings indicate that a pedagogical approach integrated with digital technologies possesses a high level of effectiveness in the development of professional competence [6].

Therefore, the systematic implementation of digital transformation in higher education, the introduction of adaptive learning mechanisms, and the improvement of competency-based assessment systems represent one of the priority directions of contemporary pedagogy [1;7]. The present research is specifically aimed at providing a scientific and practical solution to this issue.

Research methodology : This study was designed as an experimental pedagogical investigation aimed at determining the effectiveness of developing students' professional competence through digital technologies in higher education. The methodological framework of the research was based on the principles of the competency-based approach, system-structural analysis, and empirical-statistical verification.

The study employed a quasi-experimental design in which the experimental and control groups were observed in parallel. The total sample consisted of 124 students, including:

Experimental group — 62 students

Control group — 62 students

To ensure the equivalence of the groups in terms of sample size and baseline indicators, professional competence levels were measured during the diagnostic stage. Initial results revealed no statistically significant differences between the experimental group ($M = 64.3$; $SD = 6.8$) and the control group ($M = 63.9$; $SD = 7.1$) ($p > 0.05$). This finding confirmed the internal validity of the experimental conditions.

Research Stages

The experimental study was conducted in two major stages:

1.Diagnostic stage — identification of the initial level of professional competence, clarification of assessment criteria, and verification of group equivalence.

2.Experimental-intervention stage — implementation of the developed pedagogical model within the experimental group and comparative analysis of the obtained results with those of the control group.

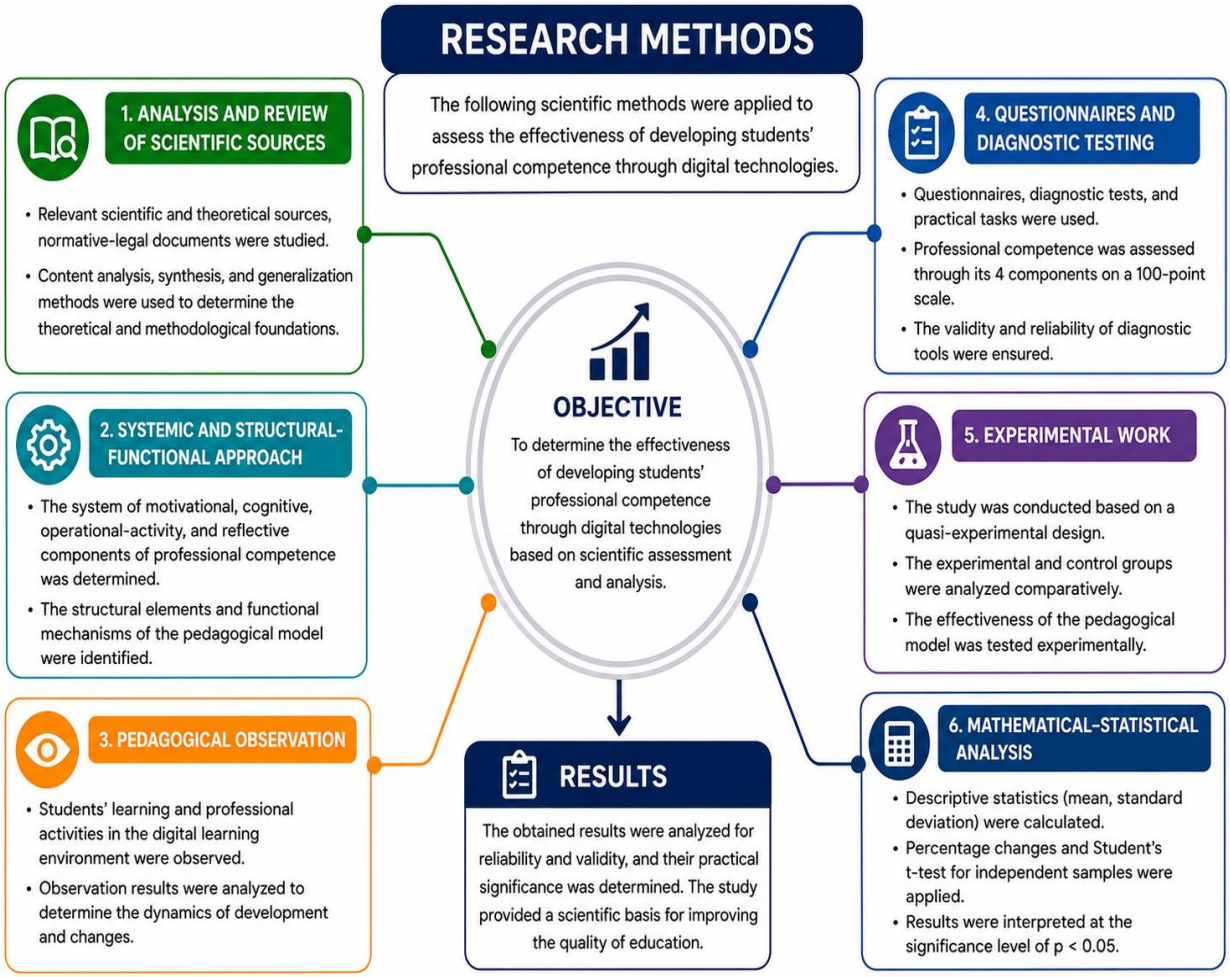
In the control group, the educational process was conducted using conventional instructional methods. In contrast, the experimental group was taught using a pedagogical model that incorporated digital platforms, interactive assignments, adaptive learning elements, and reflective assessment mechanisms.

Measurement criteria and assessment instruments. Each component of professional competence was assessed using a 100-point scale through diagnostic tests, questionnaires, observational methods, and practical assignments. The integral competence indicator was calculated on the basis of arithmetic mean values. The reliability and methodological consistency of the assessment instruments were ensured throughout the research process.

figure 1

Each component was assessed on a 100-point scale using diagnostic tests, questionnaires, observational data, and practical assignments. The final integral indicator was calculated based on the arithmetic mean value. The reliability of the assessment instruments and their application under standardized conditions were methodologically ensured.

Research Methods and Approaches **figure 2.**



Statistical data processing was performed using Student's t-test. At the final stage of the study, the mean score in the experimental group reached 76.2 (SD = 5.9), whereas the control group demonstrated a mean score of 68.1 (SD = 6.5). The calculated empirical value (t = 4.37) indicated a statistically significant difference at the level of $p < 0.05$.

In addition, the dynamics of percentage indicators were analyzed. The integral growth of professional competence in the experimental group amounted to 18.6%, while the control group demonstrated an increase of only 6.5%. These findings quantitatively confirm the effectiveness of the proposed pedagogical model.

Scientific Significance of the Methodological Framework

The research methodology was developed in strict accordance with the principles of theoretical validity, experimental verification, and statistical reliability. The equivalence of the groups, the mathematical-statistical validation of the results, and the component-based analysis of the indicators ensured both the internal and external validity of the study.

Thus, the applied methodological approach provided a scientifically grounded confirmation of the effectiveness of the pedagogical model developed on the basis of digital technologies for enhancing professional competence.

Experimental Results and Statistical Analysis

This section presents a mathematical-statistical analysis of the effectiveness of the pedagogical model developed through digital technologies based on empirical data obtained within a quasi-experimental research design. Statistical processing included descriptive

statistics (mean values and standard deviations), percentage-based changes, and Student's independent samples t-test. All calculations were interpreted at a significance level of $p < 0.05$.

A total of 124 students participated in the study, including 62 students in the experimental group and 62 students in the control group. The integral indicator of professional competence was determined by calculating the arithmetic mean of the results obtained from the motivational, cognitive, operational-activity, and reflective components assessed on a 100-point scale.

1. Initial Diagnostic Results

At the preliminary stage, the integral indicator of professional competence was measured to determine the equivalence of the experimental and control groups.

Dynamics of Competence Levels

In the experimental group, the proportion of students demonstrating a high level of competence increased from 18% to 42%, representing a positive shift of 24 percentage points. At the same time, the proportion of students with low competence levels decreased from 30% to 12%. These findings indicate a qualitative transformation in the structure of professional competence.

In the control group, the proportion of students with high competence levels reached 24%, while no substantial structural changes were observed. The percentage of students with low competence levels remained stable at 25%.

These dynamic indicators confirm that the proposed pedagogical model exerted a significant influence not only on average performance scores but also on the structural and qualitative dimensions of professional competence.

4. General Conclusions of the Statistical Analysis

The obtained empirical data reliably confirm the following conclusions:

No statistically significant differences were identified between the groups at the initial stage ($p > 0.05$), which demonstrates the methodological validity of the experimental design.

At the final stage, the indicators of the experimental group were significantly higher than those of the control group ($t = 4.37$; $p < 0.05$).

The integral growth rate in the experimental group was nearly three times higher than that observed in the control group (18.6% versus 6.5%).

The structural composition of competence levels underwent a positive qualitative transformation.

Discussion

The findings of the present study confirm that the pedagogical model developed on the basis of digital technologies exerts a significant and statistically reliable impact on the development of professional competence within the higher education system. The empirical data obtained from the sample ($n = 124$) were comprehensively interpreted using both descriptive and inferential statistical analyses.

First, the absence of statistically significant differences between the experimental group ($M = 64.3$; $SD = 6.8$) and the control group ($M = 63.9$; $SD = 7.1$) at the diagnostic stage ($p > 0.05$) demonstrates the methodological accuracy of the experimental design. This condition allows the changes identified at subsequent stages to be attributed directly to the influence of the pedagogical model.

The final results demonstrated that the integral competence indicator in the experimental group increased to 76.2 points, corresponding to an 18.6% growth rate, whereas the control group reached only 68.1 points with a 6.5% increase. The results of Student's t-test ($t = 4.37$; $p < 0.05$) confirmed the statistical significance of these differences. Consequently, the effectiveness of the model can be interpreted not as a random outcome but as the result of systematic pedagogical intervention.

Particular attention in the discussion was devoted to the dynamics of competence levels. In the experimental group, the proportion of students demonstrating high competence levels increased from 18% to 42%, while the percentage of low-level students decreased from 30% to 12%. Such changes indicate a substantial qualitative transformation of professional competence. In contrast, the control group did not exhibit comparable structural shifts (high level – 24%; low level – 25%). These findings suggest that the digital pedagogical model positively influenced not only average academic performance but also the internal structure of competence itself.

The reduction in the standard deviation within the experimental group (from 6.8 to 5.9) also represents an important methodological outcome. This indicator demonstrates increased stability in the educational process, a reduction in individual disparities among students, and the effective functioning of adaptive learning mechanisms. Thus, the digital educational environment contributed to balanced competence development through support for individualized learning trajectories.

The results further revealed the comprehensive development of all structural components of professional competence, including motivational, cognitive, operational-activity, and reflective dimensions. Interactive assignments and reflective assessment mechanisms implemented through digital platforms enhanced students' intrinsic motivation and strengthened their self-regulation and analytical skills. As a result, a substantial increase in the integral competence indicator was achieved.

Moreover, the comparative analysis of growth dynamics demonstrated that the development rate in the experimental group was nearly three times higher than that of the control group (18.6% versus 6.5%). Such differences confirm that the innovative components of the pedagogical model—adaptive learning, digital monitoring, and integrative task systems—contributed significantly to improving the effectiveness of the educational process.

From a scientific perspective, these findings indicate that the integration of competency-based approaches with digital pedagogy constitutes an effective mechanism for enhancing educational quality. Statistical reliability ($p < 0.05$) and the stability of the obtained quantitative indicators ensure the internal validity of the study. Furthermore, the sufficient sample size ($n = 124$) broadens the potential for generalizing the findings.

Thus, the discussion results demonstrate that the pedagogical model developed through digital technologies possesses systematic, comprehensive, and empirically substantiated effectiveness in the development of professional competence. This confirms the scientific necessity of implementing systematic digital transformation in higher education, expanding adaptive learning mechanisms, and improving competency-based monitoring systems.

Conclusion

The present study experimentally verified the theoretical validity and practical effectiveness of a pedagogical model aimed at developing students' professional competence

through digital technologies in higher education. The research was organized on the basis of competency-based approaches, system-structural analysis, and mathematical-statistical verification principles, involving 124 students divided equally into experimental and control groups.

The results of the diagnostic stage revealed no statistically significant differences between the experimental group (M = 64.3; SD = 6.8) and the control group (M = 63.9; SD = 7.1) ($p > 0.05$). This confirmed the equivalence of the groups' initial preparedness levels and ensured the internal validity of the experimental process.

Following the systematic implementation of the pedagogical model, the integral indicator of professional competence in the experimental group reached 76.2 points (SD = 5.9), corresponding to an 18.6% increase. In the control group, the final indicator reached 68.1 points (SD = 6.5), representing only a 6.5% increase. The empirical value calculated using Student's independent samples t-test ($t = 4.37$; $p < 0.05$) confirmed the statistical reliability of the differences between the groups. These findings scientifically demonstrate that the effectiveness of the proposed model was associated with targeted pedagogical intervention rather than random factors.

The dynamics of competence levels also revealed significant qualitative transformations. In the experimental group, the proportion of students with high competence levels increased from 18% to 42%, while the percentage of low-level students decreased from 30% to 12%. In contrast, the control group showed no substantial structural changes (high level – 24%; low level – 25%). These indicators suggest that the pedagogical model transformed not only the quantitative but also the qualitative dimensions of professional competence.

The reduction of the standard deviation in the experimental group (from 6.8 to 5.9) indicates the stabilization of educational outcomes and the adaptive character of the learning process. Therefore, the digital learning environment contributed to the balanced development of students' professional preparedness through support for individualized developmental trajectories.

The study led to the following generalized scientific conclusions:

The pedagogical model integrated with digital technologies exerts a comprehensive influence on the motivational, cognitive, operational-activity, and reflective components of professional competence.

The statistically significant growth of the experimental group indicators ($t = 4.37$; $p < 0.05$) empirically confirms the effectiveness of the model.

The integral growth rate in the experimental group was nearly three times higher than that of the control group (18.6% versus 6.5%).

The structural transformation of competence levels demonstrated the positive impact of the model on qualitative educational indicators.

The integration of digital pedagogy and competency-based approaches represents an effective scientific and practical mechanism for modernizing higher education and improving educational quality.

Thus, the findings scientifically substantiate the necessity of systematically implementing digital transformation in higher education, expanding adaptive learning mechanisms, and improving competency-based monitoring systems. The proposed model may serve as a

scientific and methodological foundation for the development of professional competence in higher education institutions.

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