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Psychopedagogical Model for Developing Students' Innovative Professional Competence in Higher Education Under Artificial Intelligence Integration: The Case of Uzbekistan

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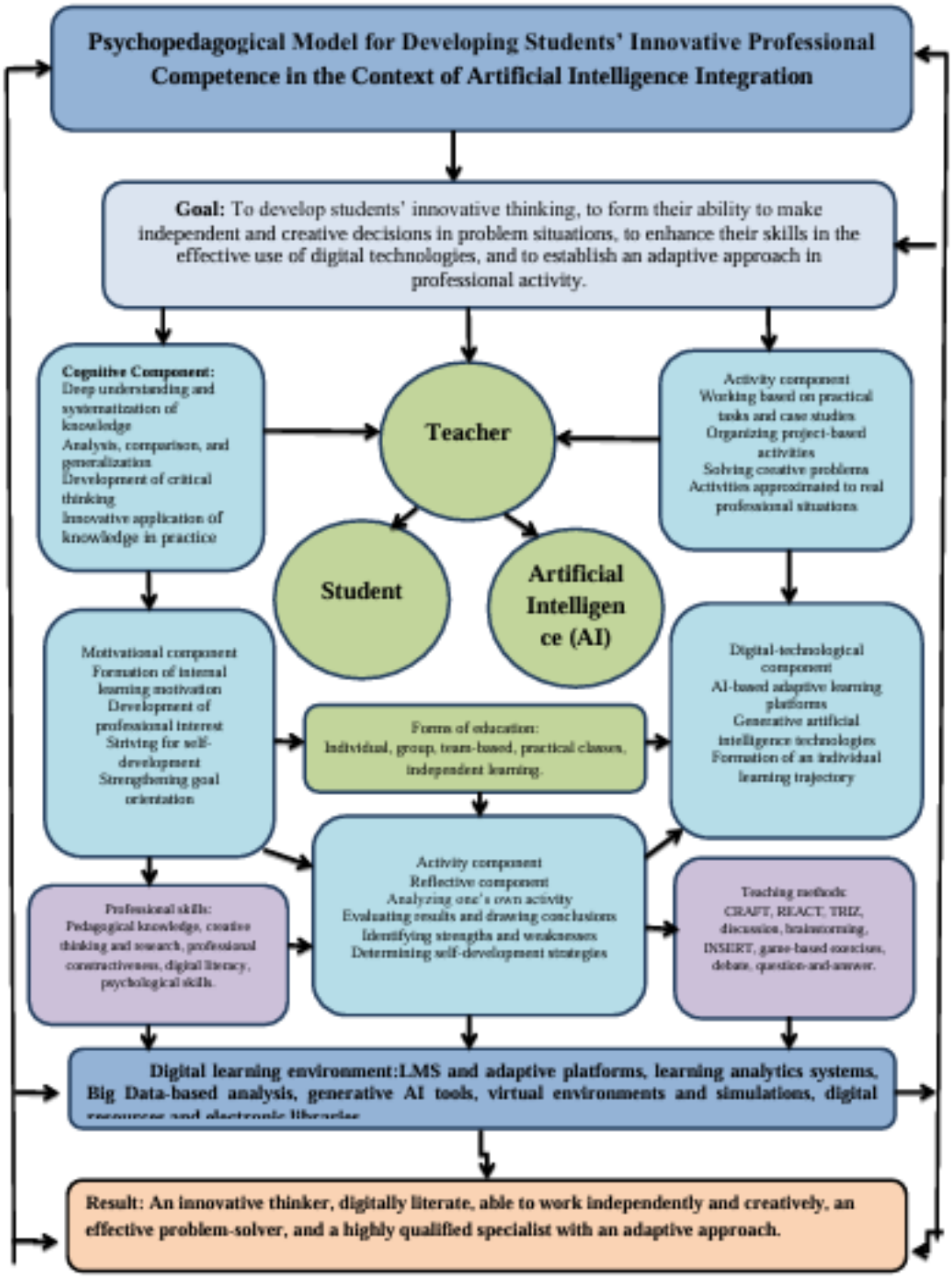
Abstract: This article examines the problem of developing students' innovative professional competence in higher education under conditions of artificial intelligence (AI) integration from a psychopedagogical perspective. Within the framework of the study, a holistic psychopedagogical model was developed, encompassing cognitive, motivational, activity-based, reflective, and digital-technological components, and its effectiveness was substantiated through experimental research. The study was organized based on a quasi-experimental design and conducted in three stages (diagnostic, formative, and control). The results obtained from the experimental and control groups were analyzed using mathematical and statistical methods.

Keywords: Artificial intelligence, innovative professional competence, psychopedagogical model, higher education, motivation, reflection, adaptive learning.

Introduction: One of the most significant transformations in the global education system today is the rapid integration of artificial intelligence (AI) technologies into higher education processes. This transformation is reshaping not only the content and methods of instruction but also the mechanisms of students' professional development. In particular, the development of innovative professional competence among future specialists has emerged as a pressing scientific issue in contemporary pedagogy and psychology. Traditional teaching models in higher education institutions are increasingly being integrated with digital and intelligent systems. AI-based educational platforms provide opportunities for personalized learning, adaptive instruction, and real-time analytics. However, such technological capabilities do not automatically ensure the development of innovative professional competence; rather, their effectiveness depends on their alignment with students' psychological readiness, cognitive engagement, and systematic pedagogical support. From this perspective, it becomes essential to examine the development of innovative professional competence not merely as a technological process, but as a psychopedagogical phenomenon.

Under conditions of AI integration, the psychopedagogical model for developing students' innovative professional competence in higher education can be conceptualized as an integrated system that organizes professional formation through the interaction of cognitive, motivational, activity-based, and digital-technological components. In this model, innovative professional competence is viewed not only as a set of knowledge and skills but as an integrated outcome of students' internal psychological capacities, pedagogical influence mechanisms, and AI-driven digital learning environments. The primary objective of the model is to foster innovative thinking, develop the ability to make independent and creative decisions in problem-solving situations, enhance the effective use of digital technologies, and promote adaptive approaches in professional practice.



The structure of the model consists of several interrelated components. The cognitive component facilitates deep understanding, analysis, and innovative application of knowledge. The motivational component strengthens intrinsic learning motivation, professional interest, and the drive for self-development. The activity-based component engages students in practice-oriented tasks, project-based learning, and creative problem-solving activities that simulate real professional contexts. The reflective component develops students' ability to analyze and evaluate their own performance and to design self-improvement strategies. The digital-technological component supports individualized learning trajectories through AI-based adaptive learning platforms, learning analytics, and generative technologies. The functional mechanism of the model is based on the interaction triad of "teacher – student – artificial intelligence system." In this triad, the teacher acts as a pedagogical facilitator

and moderator of the learning process, the student functions as an active subject constructing knowledge independently.

LITERATURE REVIEW

The integration of artificial intelligence (AI) technologies into the education system dates back to the late twentieth century, when computer-assisted instruction systems and intelligent tutoring systems began to emerge. During this period, scholarly attention was primarily focused on automating the learning process and enhancing individualized instruction. Researchers such as K. Woolf, J. Anderson, W. Nellen, and K. Koedinger substantiated the potential of intelligent tutoring systems to improve learners' individual performance and learning outcomes. Additionally, C. Reigeluth highlighted the role of technology in shaping learners as active agents through constructivist instructional design. By the early twenty-first century, AI in education began to evolve in alignment with cognitive and psychological dimensions of learning. G. Siemens, through the theory of connectivism, explained how knowledge is constructed in networked digital environments. Scholars such as K. Luckin, W. Holmes, and K. Griffin emphasized that AI not only facilitates knowledge transmission but also significantly influences learners' thinking styles and motivation. Furthermore, R. Baker and P. Inventado provided a scientific basis for the use of learning analytics to enable in-depth analysis of educational processes. From a psychological perspective, A. Bandura's theory of self-efficacy demonstrated that an individual's engagement in activities is strongly linked to their internal belief systems. L. Vygotsky, through social constructivism, established that learning is inherently shaped by social interaction and context. J. Bruner emphasized the active, discovery-based role of learners in cognitive development. E. Deci and R. Ryan, through self-determination theory, highlighted the decisive role of intrinsic motivation in learning effectiveness. B. Zimmerman developed the model of self-regulated learning, which underscores learners' ability to manage and control their own educational processes.

In recent years, the emergence of generative AI systems (such as ChatGPT, Bard, and Claude) has given rise to a new research direction in education. W. Holmes, M. Bialik, and C. Fadel have conceptualized human–AI collaboration as a new paradigm in education. Reports published by UNESCO in 2023 emphasize that artificial intelligence should be considered not only as a technological tool but also as a factor requiring a balance between psychological and pedagogical dimensions in education.

However, the analysis of existing literature indicates that comprehensive research on the development of students' innovative professional competence based on an integrated psychopedagogical model under AI integration remains insufficient. Most studies tend to focus separately on technological, cognitive, or psychological aspects, while their integration has not been adequately addressed. Among Uzbek scholars, significant contributions have also been made in this field. In particular, N. To'xtakho'jayev extensively studied issues related to the modernization of education and the development of pedagogical technologies. M. Ochilov developed the foundations of the competency-based approach. U. Mahkamov focused on the implementation of pedagogical innovations in the educational process. J. Yo'ldoshev elaborated the methodological foundations for improving instructional processes. Additionally, S. Inomov and Sh. Karimov conducted research on developing students' independent learning competencies in digital educational environments, while D. G'aniev investigated the application of innovative pedagogical technologies in education.

METHODOLOGY

This study is aimed at developing a psychopedagogical model for enhancing students' innovative professional competence under conditions of artificial intelligence integration and empirically evaluating its effectiveness. The research was conducted based on a comprehensive methodological approach. The design of the study is quasi-experimental, allowing for the assessment of the model's impact through comparison between experimental and control groups. The research was organized in three stages: diagnostic, formative, and final (control). At the diagnostic stage, a total of 60 students participated, including 31 in the experimental group and 29 in the control group. The primary objective of this stage was to determine the baseline level of students' innovative professional competence. Data were collected using questionnaires, tests, and psychodiagnostic methods to assess students' cognitive development, learning motivation, reflective abilities,

and digital competence. The results indicated no significant differences between the groups at the initial stage, ensuring the reliability of the subsequent experimental procedures.

During the formative stage, the educational process for the 31 students in the experimental group was organized based on the developed psychopedagogical model, while the 29 students in the control group were taught using traditional instructional methods. At this stage, AI-based adaptive learning platforms, learning analytics systems, and generative tools were actively implemented. In the experimental group, project-based learning, problem-oriented tasks, methods fostering creative thinking, and reflective activities (such as self-assessment and portfolio development) were systematically integrated. At the same time, the teacher functioned as a pedagogical moderator, facilitating individualized and differentiated instruction. AI systems were utilized to analyze students' learning activities, design personalized learning trajectories, and provide real-time diagnostic support.

At the final (control) stage, the same 60 students (31 from the experimental group and 29 from the control group) participated, and the results were re-measured and compared with the initial data. The same diagnostic tools were applied to identify changes in students' innovative professional competence. The results were processed using mathematical and statistical methods, including mean values, variance, standard deviation, and Student's t-test, to determine the statistical significance of differences between the groups. In assessing innovative professional competence, five key components were identified as evaluation criteria: cognitive, motivational, activity-based, reflective, and digital-technological. Each criterion was evaluated across four levels: high, medium, low, and very low. Thus, the applied methodology enabled a scientifically grounded evaluation of the effectiveness of the proposed model for developing innovative professional competence under conditions of AI integration.

Proposed assessment criteria

Mark	Criteria
5	The student's innovative professional competence is highly developed across all components (cognitive, motivational, operational, reflective, and digital-technological) and functions in a well-integrated manner. The student demonstrates deep analytical skills, makes independent and creative decisions, can evaluate their own performance, and effectively uses modern intellectual tools.
Correct answers 25-30	
4	The student's competence is sufficiently developed, with core components in place, though some aspects still require improvement. The student can apply knowledge, participates in activities, and uses digital tools, but independence and creativity are not fully demonstrated.
Correct answers 20-25	
3	The student's competence is partially developed, with insufficient integration among components. Knowledge is applied at a reproductive level, activities rely heavily on guidance, and the use of digital technologies is limited.
Correct answers 15-20	
2	The student's competence is not sufficiently developed, with core components at a low level. The student experiences difficulties in understanding knowledge, lacks independence in activities, has low motivation, and insufficient digital skills.
Correct answers 0-15	

Now we present the statistical analysis of the obtained results.

Analysis of the results at the beginning of the experimental study.

Name of the educational institution	The number of students	Average overall score according to the criteria	The number of students	Total conditional value.
RANCH university	Experimental group 31 participants	Excelent(5)	6	3,61
		Good (4)	10	
		Satisfactory(3)	12	
		Unsatisfactory (2)	3	
	Control group 29 participants	Excelent(5)	5	3,64
		Good (4)	10	
		Satisfactory (3)	11	
		Unsatisfactory (2)	3	

Based on the data in Table 2, the analysis of the initial results of the experimental testing is presented in numerical values and percentages.

Analysis of the initial results of the experimental testing (in numbers and percentages).”

Groups	The number of students	Learning outcomes (in numbers and percentages)			
		Exelent	Good	Satisfactory	Unsatisfactory
Experimental group	31	6 / 19	10 / 32	12 / 39	3 / 10
Control group	29	5 / 17	10 / 34	11 / 38	3 / 11

We present the data in a graphical form.

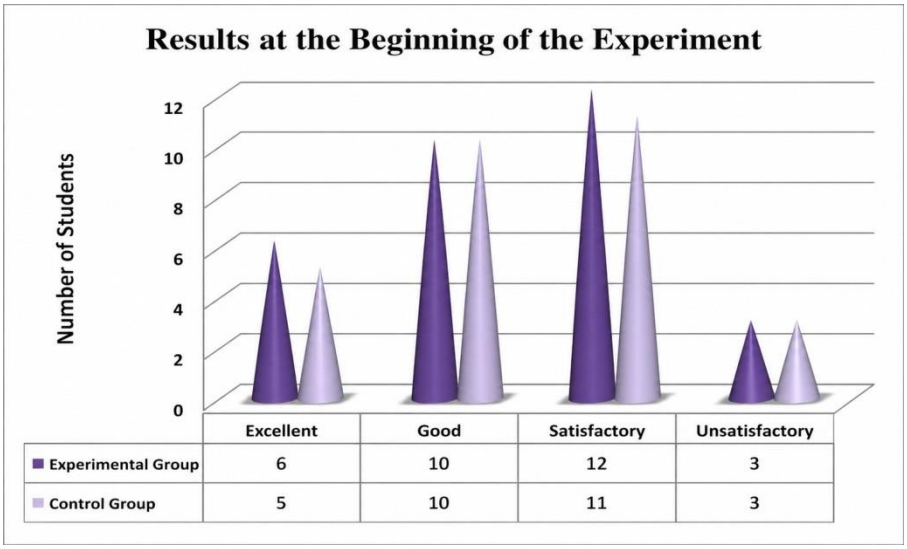


Figure 2. Results at the beginning of the experiment.

According to the results obtained prior to the experimental intervention, it was determined that there were no statistically significant differences

between the experimental and control groups in terms of learners' knowledge, skills, and competencies. This finding indicates the initial equivalence of the groups and ensures the internal validity of the subsequent experimental procedures. In order to provide an objective evaluation of this condition, a statistical analysis was conducted, as only statistically substantiated conclusions can confirm the scientific, pedagogical, technological, and methodological validity of the experimental work. To perform the statistical analysis at both the ascertaining (diagnostic) and control stages, Student's t-test was employed. This method enables the identification and objective comparison of indicators recorded in two independent groups. In accordance with the principles of mathematical statistics, the empirical data obtained from the experimental and control groups were treated as samples, and grouped variational series were constructed based on four performance levels: excellent, good, satisfactory, and unsatisfactory. For the purpose of quantitative analysis, numerical values were assigned to each performance level as follows: excellent – 5 points, good – 4 points, satisfactory – 3 points, and unsatisfactory – 2 points. The statistical indicators and the corresponding number of students in the experimental group were denoted as Xi and ni, respectively, while those in the control group were represented as Yj and mj. Based on these designations, grouped variational distributions were constructed for both groups. Subsequently, the collected numerical data were analyzed using mathematical-statistical methods, including the calculation of mean values, variance, and standard deviation. The application of Student's t-test allowed for determining the statistical significance of differences between the groups, thereby ensuring the reliability and objectivity of the research findings.

Experimental group

$$\begin{cases} x_i: & 2 & 3 & 4 & 5 \\ n_i: & 3 & 12 & 10 & 6 \end{cases}$$

Control group

$$\begin{cases} y_i: & 2 & 3 & 4 & 5 \\ m_i: & 2 & 11 & 10 & 5 \end{cases}$$

We conduct a statistical analysis of the results obtained at the end of the experimental testing. First, we determine the average achievement indicators of the obtained results and check their effectiveness.

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{4} n_i x_i = 3{,}61; \qquad \bar{Y} = \frac{1}{m}\sum_{i=1}^{4} m_i y_i = 3{,}64.$$

Thus, the results show that the average achievement level in the experimental group is identical to that of the control group, i.e., $\bar{x}=\bar{y}$. This, in turn, suggests that the assessment of learners' knowledge in the experimental group was not properly organized in comparison with the control group, meaning that the mean score does not accurately reflect the learners' actual level of knowledge acquisition.

$$D_n^2 = \frac{\sum_{i=1}^{n} n_i (x_i - \overline{X})^2}{n-1} \approx 0{,}94 \qquad D_m^2 = \frac{\sum_{j=1}^{m} m_j (y_j - \overline{Y})^2}{m-1} \approx 0{,}89$$

Based on the values of sample variances, we calculate the variation indicators for both groups:

$$V_x = \frac{\tau_n}{\bar{x}} \cdot 100\% = 28{,}51\%; V_y = \frac{\tau_m}{\bar{y}} \cdot 100\% = 27{,}90\%.$$

Based on the above considerations, it is possible to formulate a statistical hypothesis assuming that the assessment results obtained from the experimental and control groups can be regarded as samples drawn from different populations due to the variation in evaluation approaches applied to each group. In other words, we test the hypothesis concerning the equality of the population means corresponding to the experimental and control groups.

and we take the critical value from the Student's t-distribution table as t_{kr} = 1.96, then we assume the following.

$$T = \frac{\bar{X}-\bar{Y}}{\sqrt{\frac{D_n^2}{n}+\frac{D_m^2}{m}}}.$$

$$T = \frac{\bar{X} - \bar{Y}}{\sqrt{\frac{D_n^2}{n} + \frac{D_m^2}{m}}} = 0{,}175.$$

If the significance level of the statistical test is α = 0.05, According to the statistical hypothesis testing, the critical value is 1,96. Since the calculated empirical value is less than the critical value, there is no sufficient basis to reject the null hypothesis. In other words, based on the Student–Fisher distribution, the obtained t-value is significantly lower than the threshold required for

statistical significance. Therefore, at the initial stage of the experiment, the null hypothesis is accepted, indicating that there is no statistically significant difference between the experimental and control groups. This confirms the equivalence of the groups prior to the intervention. Having established the homogeneity of the groups at the baseline stage, we proceed to the statistical analysis of the results obtained at the end of the experimental process. Using the aforementioned formulas, key statistical indicators were calculated, including mean academic performance, variance (dispersion), and the coefficient of variation. These indicators provide a comprehensive quantitative assessment of both the central tendency and the distributional characteristics of the data. The calculation of the mean values allows for determining the overall level of students' achievement in each group, while variance and standard deviation reflect the degree of dispersion of individual results around the mean. The coefficient of variation, in turn, serves as an important measure of relative variability, enabling the assessment of the stability and consistency of learning outcomes across groups. Thus, the application of these statistical methods ensures a rigorous and objective evaluation of the experimental results, forming a reliable basis for comparing the effectiveness of the proposed psychopedagogical model under conditions of artificial intelligence integration.

Analysis of the results at the end of the experimental testing.

Name of the educational institution.	The number of students	Overall average score according to the criteria	The number of students	Total conditional value
RANCH university	Experimental group: 31 participants.	Excelent (5)	11	4,2
		Good (4)	16	
		Satisfactory(3)	3	
		Unsatisfactory (2)	1	
	Control group: 29 participants.	Exelent(5)	6	3,7
		Good (4)	13	
		Satisfactory (3)	8	
		Unsatisfactory (2)	2	

Analysis of the results at the end of the experimental testing (in numbers and percentages).

Groups	**The number of students**	**Learning outcomes (in numbers and percentages)**			
		Excelent	**Good**	**Satisfactory**	**Unsatisfactory**
Experimental	**31**	11 / 34	16 / 43	3 / 18	1 / 5
Control	**29**	6 / 20	13 / 30	8 / 38	2 / 13

We present the following graph

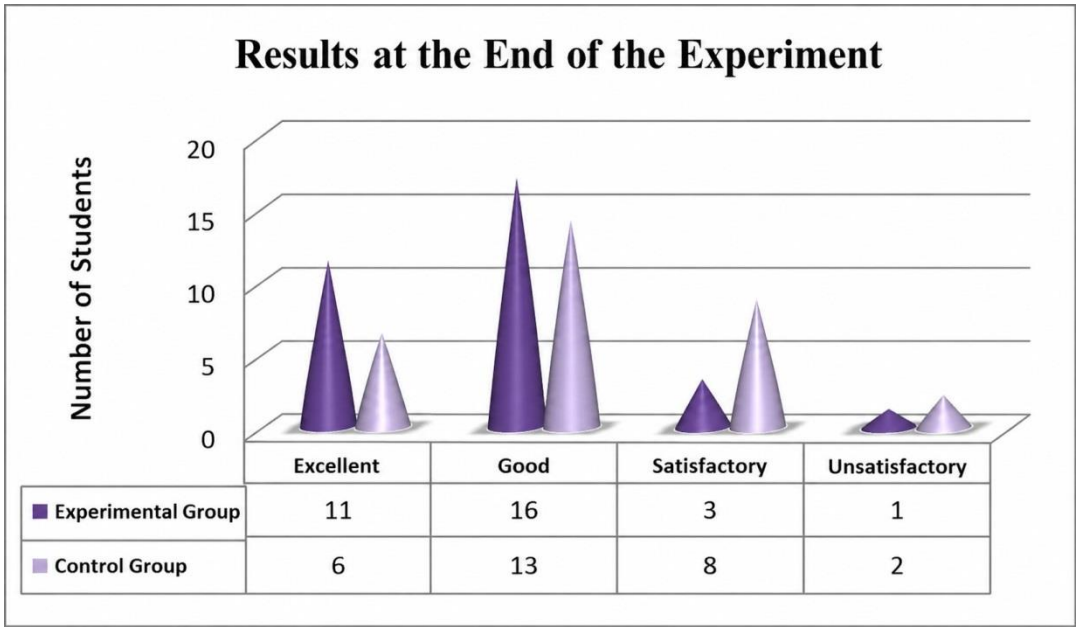


Figure 2. Results after the experiment

Experimental group Control group

Experimental group

$$\begin{cases} x_i: & 2 & 3 & 4 & 5 \\ n_i: & 1 & 3 & 16 & 11 \end{cases}$$

Control group

$$\begin{cases} y_i: & 2 & 3 & 4 & 5 \\ m_i: & 2 & 8 & 13 & 6 \end{cases}$$

Results after the experimental work

Mean		Variance		Coefficient of Variation		t-value
Experimental	**Control**	**Experimental**	**Control**	**Experimental**	**Control**	
4,2	3,8	0,71	0,90	20,77	26,58	4,58

Results and Interpretation. As evidenced in Table 3.7, the experimental group demonstrated higher mean scores, indicating that the results are both stable and balanced. The relatively low values of variance and coefficient of variation further confirm the effectiveness of the implemented experimental methodology. Moreover, the results of the Student's t-test reveal that the difference between the experimental and control groups is statistically significant. The effectiveness coefficient was calculated to be 1.135 (13.5%), which indicates a meaningful improvement in learning outcomes within the experimental group.

DISCUSSION

The findings of the study demonstrate that the psychopedagogical model developed on the basis of artificial intelligence integration is significantly effective in enhancing students' innovative professional competence. At the initial stage of the experiment, the absence of statistically significant differences between the experimental and control groups ($t < t_{(crit)}$) confirms the equivalence of baseline conditions. This served as an essential methodological foundation for ensuring the objectivity and reliability of subsequent comparisons. At the final stage, a substantial increase in the average performance of the experimental group (reaching 4.2) was observed, along with a clear advantage over the control group. In particular, the increase in the proportion of students achieving "excellent" and "good" performance levels, accompanied by a decrease in those at "satisfactory" and "unsatisfactory" levels, reflects a positive dynamic across all components of innovative professional competence. The lower coefficient of variation in the experimental group indicates the consistency and stability of the results, suggesting that the pedagogical intervention was implemented systematically and with uniform effectiveness. According to the results of Student's t-

test, the statistically significant difference between the experimental and control groups ($t > t_{(crit)}$) confirms the validity of the proposed hypothesis. Overall, these results provide strong empirical evidence that the implementation of a psychopedagogical model based on artificial intelligence integration significantly enhances students' innovative thinking, independent decision-making abilities, and digital competence within the higher education context.

CONCLUSION

The present study has demonstrated that the integration of artificial intelligence within a psychopedagogical framework provides a scientifically grounded and practically effective approach to developing students' innovative professional competence in higher education. The proposed model, which incorporates cognitive, motivational, activity-based, reflective, and digital-technological components, ensures a holistic organization of the educational process and supports students' professional formation in a systematic manner. The results of the quasi-experimental study confirmed the initial equivalence of the experimental and control groups, as no statistically significant differences were observed at the diagnostic stage. This methodological rigor ensured the reliability of subsequent findings. Following the implementation of the model, a significant improvement in the experimental group's performance indicators was identified, including higher mean scores, reduced variability, and a statistically significant difference compared to the control group. These outcomes were further validated through Student's t-test, confirming the acceptance of the research hypothesis. The positive dynamics observed across all components of innovative professional competence—particularly in students' innovative thinking, independent decision-making, and digital literacy—highlight the effectiveness of combining AI-based tools with structured pedagogical support. The decrease in lower performance levels and the increase in higher achievement categories further emphasize the model's impact on enhancing overall educational quality. In conclusion, the findings provide strong empirical evidence that the application of an AI-integrated psychopedagogical model significantly improves students' innovative professional competence. The study contributes to the theoretical advancement of AI in education and offers practical implications for the modernization of higher education systems. Future research may focus on expanding the model across diverse academic disciplines, increasing sample sizes, and exploring long-term effects of AI-supported learning environments.

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