

# Using Python programming to foster students' scientific thinking

Nadezhda Gallini<sup>1</sup>, Anatoliy Kazak<sup>1</sup>, Nataliya Gorbunova<sup>1</sup>, Victor Gallini<sup>1</sup>, Anisa Atik<sup>1</sup>,  
Elena Sergeeva<sup>2</sup>

<sup>1</sup>Department of Mathematics and Informatics, Humanitarian and Pedagogical Academy, V.I. Vernadsky Crimean Federal University, Simferopol, Russian Federation

<sup>2</sup>Department of Management, Service, and Tourism, Institute of Management and Law, Kherson State Pedagogical University, Kherson, Ukraine

## Article Info

### Article history:

Received Apr 7, 2025

Revised Mar 1, 2026

Accepted Mar 28, 2026

### Keywords:

Algorithmic reasoning

Digital engineering

Higher education

Programming in education

Scientific thinking

TPACK framework

## ABSTRACT

This paper explores the role of programming not only as a technical skill but also as a method for developing students' scientific thinking. The study is based on an experiment involving 258 university students who completed a course designed to foster logical, analytical, and project-based cognitive strategies. The experiment was conducted at V.I. Vernadsky Crimean Federal University, Humanities and Education Science Branch, Yalta, Russia. The proposed model integrates elements of the technological pedagogical content knowledge (TPACK) framework with a custom-designed pedagogical approach, treating programming as a universal structure for processing and representing information. The data suggest that systematic engagement with programming enhances students' ability to solve complex problems, conceptualize, decompose tasks, and apply reflective design. The findings emphasize the need to rethink the role of programming in higher education curricula across disciplines, beyond purely technical training.

*This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.*



## Corresponding Author:

Nadezhda Gallini

Department of Mathematics and Informatics, Humanitarian and Pedagogical Academy

V.I. Vernadsky Crimean Federal University

Simferopol, Russia Federation

Email: [gallini.nadi@yandex.ru](mailto:gallini.nadi@yandex.ru)

## 1. INTRODUCTION

Modern university education faces the urgent need to rethink both the content and methods of instruction. The rapid advancement of digital technologies, the increasing complexity of the information and technological environment, and the growing importance of engineering and technological competencies have made traditional forms of professional training insufficient. One of the most pressing challenges is the development of students' scientific thinking – the ability to systematically analyze information, design solutions, and think in terms of algorithms, models, and processes.

In recent years, there has been a growing interest in integrating programming into non-specialized academic courses and research practices. Pilot initiatives, elective modules, and interdisciplinary experiments have shown promising results, yet they remain fragmented and often lack theoretical grounding. At the same time, empirical evidence is limited regarding how programming actually contributes to the development of thinking strategies and digital literacy, especially in non-science, technology, engineering, mathematics (STEM) domains. Therefore, there is a clear need for systematic research that can provide robust evidence to support the integration of programming across various curricular areas and inform instructional practices.

The research question of the study is: how does systematic engagement with Python programming influence the development of students' scientific thinking across analytical, reflective, and verification processes? Specifically, what measurable cognitive changes can be identified as a result of sustained participation in a structured programming course? Additionally, how do these cognitive improvements translate into students' broader academic performance and interdisciplinary competence? Hypothesis: participation in the course based on the proposed model will result in measurable improvement in students' ability to analyze complex problems, verify solutions, and reflect on their reasoning strategies. It is expected that structured and consistent exposure to Python programming will significantly enhance the quality of students' analytical, evaluative, and reflective thinking. Furthermore, such improvements will positively impact their academic confidence and interdisciplinary integration skills.

## 2. THE COMPREHENSIVE THEORETICAL BASIS AND/OR THE PROPOSED METHOD/ALGORITHM

Recent studies highlight the growing importance of programming as a means to develop students' cognitive and interdisciplinary skills. In particular, research on the effect of educational games such as CodeCombat on cognitive load in Python programming demonstrates the high effectiveness of gamified approaches in reducing overload and increasing student engagement [1]. Programming is also considered a tool for regional development of the digital industry and education, especially through the practice of competitive programming [2]. The increasing popularity of chatbots and generative AI in educational settings has driven the development of new strategies for teaching programming [3]. A comparison of manual and AI-based feedback from ChatGPT in collaborative projects showed improvements in learning outcomes [4]. The integration of visual tools and program code comparison methods further confirms the effectiveness of such approaches in collaborative learning environments [5].

Scientific thinking is regarded as a key cognitive strategy required in the digital age. According to Jackson [6], a scientific approach involves systemic reasoning, hypothesis formulation, and solution testing. In educational practice, this is often implemented through design thinking and bibliometric methods, which foster innovation and creativity [7], [8]. In the context of digital transformation, engineering thinking and sustainable IT competencies are becoming essential components in the training of future professionals [9], [10]. However, challenges related to ethics, academic integrity, and inclusivity call for new pedagogical approaches [11], [12].

One of the emerging solutions involves rethinking traditional education models through education technology (EdTech) and adaptive technologies [13], [14]. The use of virtual and augmented reality, optimization algorithms, and big data analysis contributes to improving the quality of higher education [15], [16]. Engineering education increasingly relies on digital immersive technologies and game-based approaches, as confirmed by several experimental studies [17], [18]. Digital transformation affects not only teaching methodologies but also students' literacy across various domains [19]. Moreover, technical advancements in parallel computing and algorithm optimization offer additional opportunities to enhance programming education. For instance, Sofranac *et al.* [20] developed an efficient graphics processing unit (GPU)-parallel algorithm that illustrates the application of advanced computational methods in real-time problem-solving contexts, an approach that aligns with the development of algorithmic reasoning in educational settings.

Particular attention is given to the technological pedagogical content knowledge (TPACK) framework, which supports the integration of digital tools into pedagogical practices. Research shows that successful implementation of TPACK requires a systematic understanding of the interconnections between content, pedagogy, and technology [21], [22]. For instance, Zhang [23] explored how TPACK competencies shape university instructors' digital teaching skills, reinforcing the importance of such frameworks in designing effective higher education curricula. Similarly, Alemán-Saravia and Deroncele-Acosta [24] conducted a systematic review highlighting the framework's role in guiding technology integration strategies across educational contexts. Wang *et al.* [25] demonstrated how Python teaching supports the development of computational thinking, aligning well with TPACK's emphasis on content-technology integration.

The quality of educational programs is increasingly evaluated not only in terms of formal learning outcomes but also through the development of higher-order cognitive competencies. Contemporary research highlights the growing role of advanced assessment methods in programming education, including AI-based behavioral analysis and eye-tracking technologies, which allow for a deeper understanding of students' cognitive processes during problem-solving [26], [27]. At the same time, technology-enhanced instructional designs – such as internet of things (IoT)-based learning activities – have been shown to significantly promote computational thinking and structured reasoning among learners [28]. Collaborative and digitally mediated programming environments further contribute to students' reflective abilities and analytical performance by fostering peer interaction and iterative feedback mechanisms [29]–[31]. These approaches

collectively support the idea that programming education can serve as a structured framework for developing scientific thinking beyond purely technical skill acquisition.

### 3. METHOD

This experiment was conducted in 2023-2024 using a mixed-methods approach based on Python. The theoretical foundation of the study combined the principles of digital pedagogy, the TPACK framework, and a cognitive model of scientific thinking that includes analytical, verification, and reflective components. The TPACK framework was used as a foundational lens to design and deliver the instructional course content. Specifically, it guided the integration of technological tools (Python programming), pedagogical strategies (project-based learning, reflection activities), and domain-specific content (scientific thinking processes). Nearly 300 students from V.I. Vernadsky Crimean Federal University, studying at its Yalta branch in the fields of pedagogy, humanities, and information technology, volunteered for the experiment. All these young participants completed a specialized course in “Programming with Python”.

#### 3.1. Research procedure

The experiment consisted of sequentially linked stages, as shown in Figure 1. Specifically, it guided the integration of technological tools, pedagogical strategies, and domain-specific content. This ensured a balanced alignment between what was taught (content), how it was taught (pedagogy), and the technology used to support learning. The course materials and assessments were developed with explicit attention to these intersections.

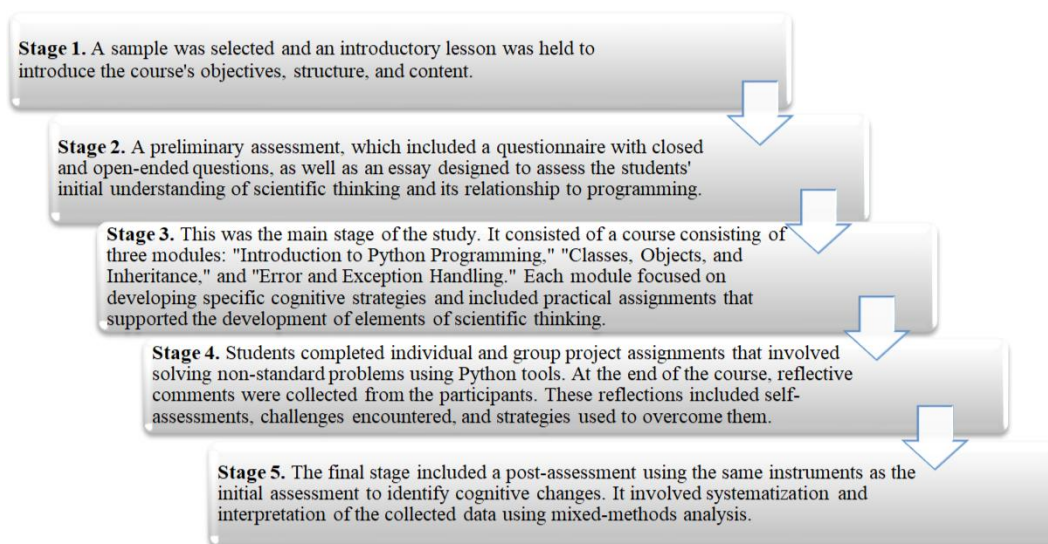


Figure 1. Sequentially linked stages of the experiment

#### 3.2. Analysis methods

Along with the qualitative characteristics of this experiment, quantitative indicators were also obtained using questionnaires and expert assessments. Typically, studies of this type utilize descriptive statistics (primarily for data visualization using charts) and Cronbach's alpha test (suitable for the humanities, sociology and psychology). Confirmatory factor analysis (CFA) was used to validate the process and ensure its proper functioning. CFA tests how well observed variables represent latent constructs: in this case, evaluation and verification (EV), analytical thinking (AN) and cognitive reflection (CR), as seen in Figure 2. Typically, multiple observed indicators measure only one construct.

The questionnaire developed for the student survey used twelve indicators, Plt1-Plt12, as shown in Figure 3. Indicators 1-4 assessed students' analytical abilities, while indicators 9-12 - their ability to justify and interpret process implementation, while 5-8 assessed their ability to self-assess and adjust the chosen strategy. Each indicator was ranked on a three-point scale. The assessment criteria were developed in advance and discussed with the instructors involved in delivering the course. To verify the internal consistency of the diagnostic tools, Cronbach's alpha reliability coefficient was calculated.

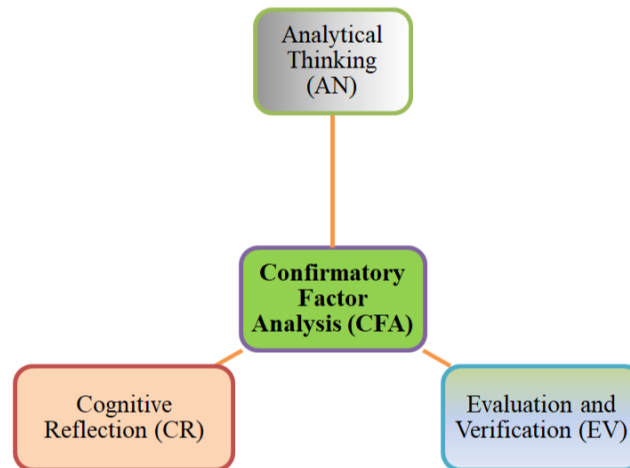


Figure 2. CFA tests how well observed variables represent latent constructs: EV, AN, and CR

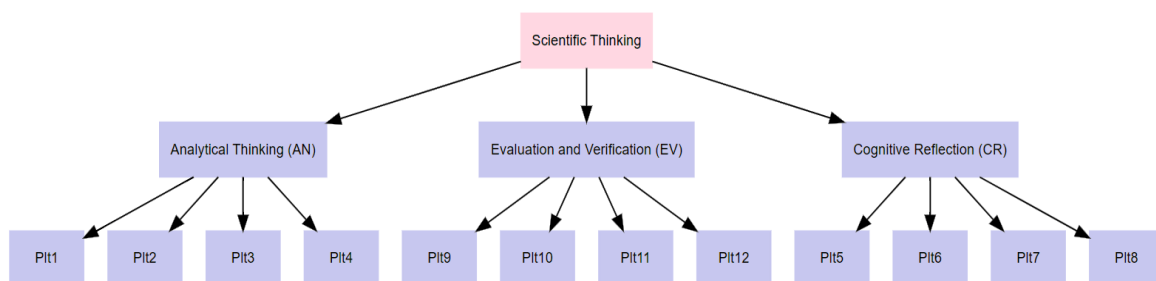


Figure 3. Structure of the cognitive model of scientific thinking and distribution of indicators

The cognitive model underlying the course represents a structured system of interrelated components that reflect the development of students' scientific thinking during the programming learning process. It includes five key stages: problem formulation, hypothesis construction, choice of implementation tools, implementation and debugging, as well as reflection and adjustment. Each of these stages corresponds to specific cognitive actions, allowing programming to be viewed not only as a technical skill but also as an intellectual and research-oriented process.

Thus, the research methodology enabled not only the assessment of changes in students' cognitive development but also the identification of relationships between programming-related thinking structures and components of scientific reasoning. A mixed-methods approach was applied, with particular emphasis on analyzing the dynamics of scientific thinking formation. The questionnaire consisted of 12 items aimed at assessing students' cognitive skills. Participants rated their agreement with each statement on a 0–3 scale (0 – strongly disagree; 3 – strongly agree). Sample items included: “I can effectively analyze a complex task by breaking it into smaller components,” “I find it easy to formulate hypotheses and test them through programming,” and “when solving problems, I regularly check the correctness of each step.” Qualitative data were drawn from student essays and reflective comments, illustrating shifts toward more analytical and reflective problem-solving approaches.

#### 4. RESULTS AND DISCUSSION

The internal consistency of the diagnostic tools was verified through Cronbach's alpha reliability coefficient, which was calculated to be 0.714, exceeding the acceptable threshold and indicating satisfactory reliability. The Cronbach's alpha coefficient (0.714) indicates an acceptable internal consistency of the diagnostic tool, making it suitable for assessing cognitive changes. The average task difficulty of 0.52 reflects a balanced level of complexity – most students were able to complete the tasks, while they were not overly simple. The discrimination index of 0.47 confirms that the tests effectively differentiate students with varying levels of scientific thinking development.

The experiment demonstrated the development of scientific thinking in students who mastered the programming discipline using Python. A comparison of the scores obtained for the indicators of scientific thinking dynamics before and after the experiment revealed a positive trend in the improvement of their logic, outlook, and systems skills. It is especially worth highlighting the significant success of most students in developing and implementing project assignments. As can be seen in Table 1, the factor loadings of the cognitive model components correspond to critical limits, and indicators 2, 9, and 12 reached values above average. At the same time, the CR values indicate the need for a more differentiated approach to the component of CR, suggesting the expansion of relevant tasks and the integration of self-analysis methods into the course.

**Table 1. Factor loadings of components in the cognitive model**

Construct	Indicator	Factor loading	CR	AVE	$\alpha$	Decision
AN	Plt1	0.79	0.883	0.685	0.861	Achieved
	Plt2	0.89				
	Plt3	0.68				
	Plt4	0.76				
CR	Plt5	0.69	0.851	0.590	0.832	Achieved
	Plt6	0.87				
	Plt7	0.75				
	Plt8	0.64				
EV	Plt9	0.90	0.917	0.751	0.912	Achieved
	Plt10	0.63				
	Plt11	0.78				
	Plt12	0.98				

Figure 4 presents the CFA model based on experimental data obtained during the programming course. The model illustrates the structure of students' scientific thinking by identifying three latent cognitive components: AN, CR, and EV. These constructs were validated through observed indicators, with all factor loadings exceeding the significance threshold ( $\lambda > 0.5$ ), indicating strong alignment between the theoretical model and empirical data.

The model comprises three latent constructs: AN, CR, and EV. AN reflects students' ability to analyze and decompose problems (Plt1–Plt4; loadings 0.55–0.89); CR captures self-evaluation and strategic adjustment processes (Plt5–Plt8; loadings 0.56–0.69); and EV relates to hypothesis testing and result interpretation (Plt9–Plt12; loadings 0.51–0.98). All factor loadings exceeded the significance threshold ( $\lambda > 0.5$ ), confirming strong alignment between the theoretical model and empirical data. Although a weak negative correlation was observed between AN and CR ( $r = -0.06$ ), the constructs demonstrated functional autonomy. Overall, the CFA results confirm the structural validity of the proposed cognitive model.

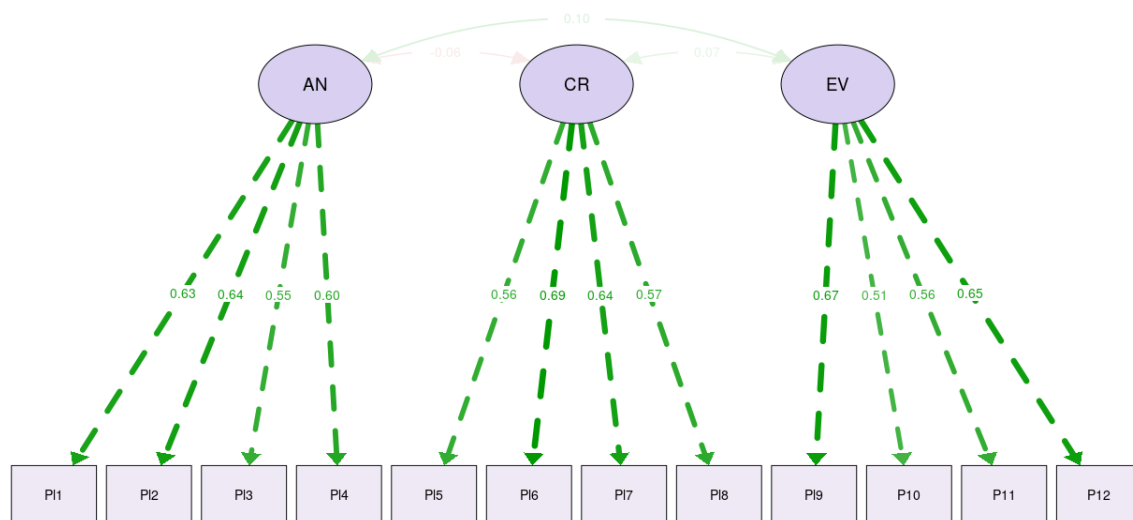


Figure 4. CFA model of cognitive components of students' scientific thinking

These findings support the hypothesis that programming serves as an effective tool for fostering scientific thinking at the university level. The results are consistent with prior research demonstrating that coding activities enhance analytical reasoning, reflection, and structured thinking [1], [3], [4], [6], [7], [25]. Similar effects have been observed in studies on AI-supported and collaborative programming environments, which promote evaluative and reflective competencies [26]–[29], as well as in research emphasizing immersive and technology-enhanced learning contexts [17], [19], [30], [31]. Together, these findings reinforce the broader applicability of the proposed model across interdisciplinary settings.

## 5. CONCLUSION

This study confirmed the effectiveness of the proposed model for developing students' scientific thinking through systematic engagement with Python programming. The experiment demonstrated the development of scientific thinking in students who mastered the programming discipline using Python. A comparison of the scores obtained for the indicators of scientific thinking dynamics before and after the experiment revealed a positive trend in the improvement of their logic, outlook, and systems skills. It is especially worth highlighting the significant success of most students in developing and implementing project assignments. From a practical perspective, the results suggest that programming courses can be intentionally designed not only to develop technical competencies but also to cultivate higher-order cognitive strategies. The proposed model may serve as a framework for curriculum development in interdisciplinary university programs and for teacher training initiatives aimed at integrating programming as a cognitive tool rather than solely a technical skill.

Despite these positive outcomes, the study has several limitations. The sample was restricted to one university, which may limit the generalizability of the findings. In addition, part of the data relied on self-assessment measures, which may introduce subjective bias. The study was conducted within a single academic year and did not include longitudinal tracking to evaluate the long-term sustainability of cognitive development. Future research should expand the empirical base by including multiple institutions, cross-cultural samples, and longitudinal designs. Comparative studies involving different programming languages and instructional models may further clarify the mechanisms through which programming contributes to the development of scientific thinking.

## ACKNOWLEDGMENTS

The authors would like to thank the teaching staff and academic coordinators of the Humanities and Education Science Academy (branch) of V.I. Vernadsky Crimean Federal University for their assistance in organizing and facilitating the educational experiment.

## FUNDING INFORMATION

Authors state no funding involved.

## AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Nadezhda Gallini	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Anatoliy Kazak						✓		✓	✓	✓	✓	✓	✓	✓
Nataliya Gorbunova	✓	✓					✓			✓		✓	✓	✓
Victor Gallini	✓			✓	✓				✓		✓	✓		
Anisa Atik	✓				✓					✓				✓
Elena Sergeeva		✓				✓		✓		✓		✓		

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

## ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

## DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [NG], upon reasonable request.





## REFERENCES

- [1] W. C. Choi and I. C. Choi, "Investigating the effect of the serious game CodeCombat on cognitive load in python programming education," in *2024 IEEE World Engineering Education Conference (EDUNINE)*, Mar. 2024, pp. 1–6, doi: 10.1109/EDUNINE60625.2024.10500551.
- [2] A. Galkin, A. Miroshnikov, D. Saprnov, and E. Skarzhinskaya, "Sports programming as a tool for regional development of the digital industry and higher education," in *2024 4th International Conference on Technology Enhanced Learning in Higher Education (TELE)*, Jun. 2024, pp. 64–68, doi: 10.1109/TELE62556.2024.10605704.
- [3] S. H. Tanvir and G. J. Kim, "WIP: generative and custom chatbots in computer programming education and their effectiveness a systematic literature review," in *2024 IEEE Frontiers in Education Conference (FIE)*, Oct. 2024, pp. 1–5, doi: 10.1109/FIE61694.2024.10893425.
- [4] F. Ouyang, M. Guo, N. Zhang, X. Bai, and P. Jiao, "Comparing the effects of instructor manual feedback and ChatGPT intelligent feedback on collaborative programming in China's higher education," *IEEE Transactions on Learning Technologies*, vol. 17, pp. 2173–2185, 2024, doi: 10.1109/TLT.2024.3486749.
- [5] T. H. Nguyen, H. Kiyomitsu, Y. Sun, T. Nishida, and K. Ohtsuki, "Collaborative learning in programming education with the programmed visual contents comparison method," in *2024 12th International Conference on Information and Education Technology (ICIET)*, Mar. 2024, pp. 467–471, doi: 10.1109/ICIET60671.2024.10542766.
- [6] M. C. Jackson, "The scientific method," in *Critical Systems Thinking: A Practitioner's Guide*, M. C. Jackson, Ed., Hoboken, NJ: John Wiley & Sons, Inc., 2024, pp. 1–18, doi: 10.1002/9781394203604.ch1.
- [7] A. Dadashi and G. Wende, "Integrating bibliometrics with design thinking to enhance technological innovation," in *2024 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD)*, Nov. 2024, pp. 1–7, doi: 10.1109/ICTMOD63116.2024.10878178.
- [8] R. Jyothsna, K. S. Kumar, Y. L. M. Latha, N. Shailaja, B. Madhuri, and S. Katta, "Cutting-edge scientific innovations: bridging interdisciplinary research and technological advancements," in *2024 International Conference on Intelligent Computing and Emerging Communication Technologies (ICEC)*, Nov. 2024, pp. 1–6, doi: 10.1109/ICEC59683.2024.10837172.
- [9] X. Xu, "The sustainable competency oriented computing education for IT-shape elites and new forms of digital education in the future," in *2024 36th International Conference on Software Engineering Education and Training (CSEE&T)*, Jul. 2024, pp. 1–2, doi: 10.1109/CSEET62301.2024.10663030.
- [10] S. Li and Y. Xie, "Pathway study of labor education in Chinese vocational undergraduate education based on 'three-level' smart education platform," in *2024 14th International Conference on Information Technology in Medicine and Education (ITME)*, Sep. 2024, pp. 545–549, doi: 10.1109/ITME63426.2024.00113.
- [11] W. Ali, R. Alami, M. A. K. Alsmairat, and T. AlMasaeid, "Consensus or controversy: examining AI's impact on academic integrity, student learning, and inclusivity within higher education environments," in *2024 2nd International Conference on Cyber Resilience (ICCR)*, Feb. 2024, pp. 1–5, doi: 10.1109/ICCR61006.2024.10532968.
- [12] P. Vázquez-Villegas, M. del P. García-Chitiva, D. Valdes-Ramirez, C. I. R. Peraza, C. A. de Haro, and G. Zavala, "WIP: implementing and deploying artificial intelligence solutions in higher education institutions," in *2024 IEEE Frontiers in Education Conference (FIE)*, Oct. 2024, pp. 1–5, doi: 10.1109/FIE61694.2024.10893121.
- [13] S. S. Gulyamov, E. Egamberdiev, and A. Naem, "Practice-oriented approach to reforming the traditional model of higher education with the application of EdTech technologies," in *2024 4th International Conference on Technology Enhanced Learning in Higher Education (TELE)*, Jun. 2024, pp. 340–343, doi: 10.1109/TELE62556.2024.10605684.
- [14] X. Chen and G. Dong, "Research on the evaluation model combining AHP and PSO algorithms for higher education," in *2024 7th International Conference on Education, Network and Information Technology (ICENIT)*, Aug. 2024, pp. 29–33, doi: 10.1109/ICENIT61951.2024.00014.
- [15] L. Qiang and D. Weinan, "Research on the integration and application of virtual reality technology in interdisciplinary experimental teaching of higher education," in *2024 International Conference on Computers, Information Processing and Advanced Education (CIPAE)*, Aug. 2024, pp. 908–912, doi: 10.1109/CIPAE64326.2024.00172.
- [16] M. Zhao, M. Liu, and S. Li, "Comprehensive evaluation of high-quality development of higher continuing education based on entropy method and cluster analysis method," in *2024 IEEE 7th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)*, Mar. 2024, pp. 917–921, doi: 10.1109/IAEAC59436.2024.10503614.
- [17] H. Al-Juboori and G. Noonan, "Leveraging the power of digital immersive technologies to enhance engineering education and learning," in *2024 IEEE Global Engineering Education Conference (EDUCON)*, May 2024, pp. 1–5, doi: 10.1109/EDUCON60312.2024.10578667.





- [18] R. M. K. R. Rosli and A. F. Zakaria, "Innovative pedagogy in engineering ethics: a digital game-based approach for Malaysian pre-university students," in *2024 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Dec. 2024, pp. 1241–1245, doi: 10.1109/IEEM62345.2024.10857174.
- [19] I. Farkas, A. Kovari, and M. Rajcsanyi-Molnar, "The impact of the digital transformation of education on literacy," in *2024 IEEE 7th International Conference and Workshop Óbuda on Electrical and Power Engineering (CANDO-EPE)*, Oct. 2024, pp. 71–76, doi: 10.1109/CANDO-EPE65072.2024.10772854.
- [20] B. Sofranac, A. Gleixner, and S. Pokutta, "Accelerating domain propagation: an efficient GPU-parallel algorithm over sparse matrices," in *2020 IEEE/ACM 10th Workshop on Irregular Applications: Architectures and Algorithms (IA3)*, Nov. 2020, pp. 1–11, doi: 10.1109/IA351965.2020.00007.
- [21] Y. Teng and F. Xie, "The deep integration of digital technology with teacher education and teaching within the TPACK framework in the digital intelligence era," in *2024 14th International Conference on Information Technology in Medicine and Education (ITME)*, Sep. 2024, pp. 630–634, doi: 10.1109/ITME63426.2024.00129.
- [22] P. Luik and M. Taimalu, "Professional knowledge clusters of student teachers based on the TPACK framework," in *2023 11th International Conference on Information and Education Technology (ICIET)*, Mar. 2023, pp. 433–437, doi: 10.1109/ICIET56899.2023.10111442.
- [23] L. Zhang, "Model of university teachers' informatization teaching ability based on TPACK framework," in *2021 International Symposium on Advances in Informatics, Electronics and Education (ISAIEE)*, Dec. 2021, pp. 87–92, doi: 10.1109/ISAIEE55071.2021.00029.
- [24] A. C. Alemán-Saravia and A. Deroncele-Acosta, "Technology, pedagogy and content (TPACK framework): systematic literature review," in *2021 XVI Latin American Conference on Learning Technologies (LACLO)*, Oct. 2021, pp. 104–111, doi: 10.1109/LACLO54177.2021.00069.
- [25] X. Wang, X. Zou, W. Yin, Q. Li, L. Zhang, and L. Hong, "Research and application of computational thinking on Python teaching," in *2021 IEEE 3rd International Conference on Computer Science and Educational Informatization (CSEI)*, Jun. 2021, pp. 311–314, doi: 10.1109/CSEI51395.2021.9477758.
- [26] Z. Li and D. Holly, "Assessing programming proficiency through eye gaze analysis using fine-tuned large language model," in *2024 10th IEEE International Conference on High Performance and Smart Computing (HPSC)*, May 2024, pp. 7–12, doi: 10.1109/HPSC62738.2024.00009.
- [27] I. Pesovski, D. Vorkel, and V. Trajkovik, "AI-powered education: rethinking the way programming is taught using AI tools and reversed Bloom's Taxonomy," in *2024 21st International Conference on Information Technology Based Higher Education and Training (ITHET)*, Nov. 2024, pp. 1–6, doi: 10.1109/ITHET61869.2024.10837604.
- [28] S. Sonsilphong, A. Sonsilphong, D. Hormdee, and P. Sae-Joo, "A design and development of internet of things (IoT) system and learning activity to promote computational thinking," in *2022 7th International STEM Education Conference (iSTEM-Ed)*, Jul. 2022, pp. 1–4, doi: 10.1109/iSTEM-Ed55321.2022.9920899.
- [29] A. R. Carvalho and C. Santos, "The impact of a digitally enhanced peer learning program on peer teacher students' academic performance: a study developed under educational design research," in *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)*, Jun. 2020, pp. 24–27, doi: 10.23919/CISTI49556.2020.9141111.
- [30] K. Gong, H. Zhu, and T. Yang, "Computational thinking, object-oriented programming to role-based collaboration," in *2025 1st International Symposium on E-CARGO and Applications (E-CARGO)*, Jul. 2025, pp. 32–38, doi: 10.1109/E-CARGO65996.2025.11139209.
- [31] R. Herrero-Álvarez, R. Arnay, E. Segredo, G. Miranda, and C. León, "Using RoblockLLY in the classroom: bridging the gap in computer science education through robotics simulation," *IEEE Transactions on Learning Technologies*, vol. 18, pp. 39–52, 2025, doi: 10.1109/TLT.2024.3520329.

## BIOGRAPHIES OF AUTHORS






**Nadezhda Gallini**     is a senior lecturer at the Department of Mathematics and Informatics, Humanities and Pedagogical Academy (branch) of V.I. Vernadsky Crimean Federal University, Yalta. Her research interests include digital pedagogy, programming in education, cognitive strategy development, project-based learning, and digital literacy. In this study, she was responsible for model development, course implementation, and the collection and analysis of experimental data. She can be contacted at email: [gallini.nadi@yandex.ru](mailto:gallini.nadi@yandex.ru).






**Anatoliy Kazak**     is an associate professor at the Department of Management and Tourism, Humanities and Pedagogical Academy (branch) of V.I. Vernadsky Crimean Federal University, Yalta. His research interests include innovation, investment, international economics, econometric modeling, and public-private partnerships. In this study, he contributed to resource support, data interpretation, drafting, editing, visualization, project administration, and consulting on the publication structure. He can be contacted at email: [kazak\\_a@mail.ru](mailto:kazak_a@mail.ru).






**Nataliya Gorbunova**    is a Doctor of Pedagogical Sciences, professor, Corresponding Member of the Russian Academy of Education (Division of Philosophy of Education and Theoretical Pedagogy), Director of the Humanities and Pedagogical Academy (branch) of V.I. Vernadsky Crimean Federal University, Yalta. Her research interests include vocational education and training, education and upbringing, innovative educational technologies, educational practices, teaching methods, environmental approach, noospheric education, innovative university environments, academic tutoring, and student research. In this study, she contributed to the development of the concept and methodology, as well as participated in data interpretation, visualization, project supervision, and publication preparation. She can be contacted at email: [natalya-gor2008@yandex.ru](mailto:natalya-gor2008@yandex.ru).






**Victor Gallini**    is a student in the Applied Informatics program at the Humanities and Pedagogical Academy (branch) of V.I. Vernadsky Crimean Federal University, Yalta. His research interests focus on artificial intelligence technologies. In this study, he developed the key software components for model implementation, performed functionality validation, and provided technical support for the visual part of the research. He can be contacted at email: [tmart9582@gmail.com](mailto:tmart9582@gmail.com).



**Anisa Atik**    is an associate professor at the Department of History and Philosophy, Humanities and Pedagogical Academy (branch) of V.I. Vernadsky Crimean Federal University, Yalta. Her research interests include global challenges of modern civilization, socio-philosophical analysis of culture, dialogue of cultures, and intercultural interaction as a subject of socio-philosophical study. In this study, she participated in writing the original text, editing, and preparing the publication. She can be contacted at email: [anisatun@mail.ru](mailto:anisatun@mail.ru).



**Elena Sergeeva**    is an associate professor, head of the Department of Management, Service, and Tourism at Kherson State Pedagogical University. Her research interests focus on the development of models for transforming higher education through innovative technologies. In this study, she provided resource support, participated in data interpretation, visualization, preparation, and administration of the publication. She can be contacted at email: [s-elene@ya.ru](mailto:s-elene@ya.ru).