LANGUAGE, CULTURE, COMMUNICATION

TRAINING COMPUTER SCIENCE TEACHERS: THE ANALYSIS OF EDUCATIONAL PROGRAMMES FOCUSING ON DATABASES

Vladyslav Bespalyi
Postgraduate Student at the Department of Computer Science,
Sumy State Pedagogical University named after A. S. Makarenko, Ukraine
e-mail: v.bespalyi@fizmatsspu.sumy.ua, orcid.org/0009-0009-0630-5183

Artem Yurchenko
Ph.D., Assistant Professor,
Sumy State Pedagogical University named after A. S. Makarenko, Ukraine
e-mail: a.yurchenko@fizmatsspu.sumy.ua, orcid.org/0000-0002-6770-186X

Olena Semenikhina
Doctor of Pedagogical Sciences, Professor,
Sumy State Pedagogical University named after A. S. Makarenko, Ukraine
e-mail: e.semenikhina@fizmatsspu.sumy.ua, orcid.org/0000-0002-3896-8151

Summary

This article examines the current state of computer science teacher training in Ukraine, with a particular focus on the study of databases as a critical component of both digital and subject-specific competencies. The relevance of this topic is substantiated in the context of the digital transformation of education, the economy, and society, as well as the growing demand for professionals capable of effectively working with information systems, databases, and cloud-based services. The study emphasizes the importance of mastering not only the fundamentals of the relational data model and SQL but also modern technologies such as NoSQL, Big Data, and data analytics tools. The methodological framework of the research includes content analysis of educational and professional programs in Ukrainian higher education institutions, elements of comparative analysis, and the synthesis of regulatory requirements with contemporary pedagogical approaches. The article presents comparative data on course duration, technologies covered, instructional platforms used, and the starting point of database instruction across several universities. Strengths and weaknesses of the educational programs are identified, including the predominance of classical DBMSs, limited coverage of emerging technologies, insufficient interdisciplinary integration, and weak alignment with real-world IT industry cases. The article discusses opportunities for improving the content of academic disciplines through updated methodological support, a strengthened practice-oriented component, alignment with international standards, and the integration of artificial intelligence and Big Data analytics elements. Recommendations are provided for the development of flexible, relevant, and technologically updated educational programs. This article may be of interest to

researchers, university instructors, educational program developers, and specialists involved in the digital transformation of education.

Key words: computer science teacher; databases; educational and professional program; SQL; NoSQL; digital competence; Big Data; cloud technologies; teacher training; digital education.

DOI https://doi.org/10.23856/7001

1. Introduction

The current stage of higher education development in Ukraine is marked by profound transformations driven by the challenges of post-war recovery and the imperative of integration into the global digital economy. In light of dynamic socio-economic changes, optimizing the functioning of higher education institutions requires a strategic revision of the content and structure of educational programs, particularly in the field of computer science teacher training *(Yurchenko et al., 2021).* As noted by S. Kalashnikova & O. Orzhel (2022), these transformations must account for the long-term needs of the state, focused on the restoration and development of human capital. O. Borodina & V. Lyashenko (2022) supports this view, emphasizing the importance of practice-oriented approaches in professional education, particularly within IT disciplines, as a means of ensuring economic stability in the post-crisis period.

With the global shift towards the Industry 5.0 paradigm, based on the integration of human-centered approaches with big data analytics, artificial intelligence, the Internet of Things, and blockchain technologies, the requirements for teachers' digital competence are significantly increasing. A computer science teacher, in particular, must possess not only foundational knowledge of digital technologies but also an understanding of data processing, analysis, storage, and protection within complex techno-humanitarian environments *(Adel, 2022).* Against this backdrop, the quality of database instruction, recognized as a key component of digital education, becomes critically important within teacher training programs, requiring a systematic analysis of how curricula align with current technological trends and digital age demands.

2. Review of literature

In the context of Ukraine's digital transformation of the educational landscape, the issue of adequately training future computer science teachers is gaining increasing relevance. The rapid development of information and communication technologies, the growing role of data in decision-making, and the intensification of societal digitalization impose new demands on the structure and content of teacher education programs. Of particular concern is the component related to database education, a foundational element of digital literacy that ensures mastery of data collection, storage, processing, interpretation, and security.

The inclusion of databases in computer science teacher training programs is formally grounded in the State Standard for Basic Secondary Education, which mandates the introduction of database management systems to school curricula *(Ministry of Education and Science of Ukraine, 2015).* Within the competency-based framework, emphasis is placed on the ability to analyze and interpret data and solve applied interdisciplinary problems by integrating knowledge from informatics, mathematics, and logic. However, an analysis of curricula in several Ukrainian universities reveals an insufficient focus on databases, both in terms of

content and pedagogical methodology *(Ministry of Education and Science of Ukraine, 2025; UNESCO, 2023; Yurchenko et al., 2020).*

According to surveys conducted among students specializing in computer science education, one of the most significant challenges is the lack of practical training. Existing courses often focus solely on SQL syntax, with limited integration of contemporary concepts such as NoSQL databases, cloud solutions, big data analytics, or data security fundamentals. As N. Ugur and M. Koç (2021) emphasize, the mere presence of a course in the curriculum does not guarantee its effectiveness if the instructional methods fail to reflect technological realities. A. Gouseti et al. (2022) also highlight that IT-related courses in teacher education institutions frequently overlook the specific interpretive needs of teaching technical content to school learners.

International experience underscores the necessity of updating educational content by incorporating tools such as MongoDB, Apache Hadoop, and Firebase into training programs and implementing project-based learning approaches. These strategies enable future teachers to simulate real-world classroom scenarios *(Mlambo et al., 2021).* Thus, a comprehensive analysis of current teacher training programs, with particular attention to the structure, content, and didactic implementation of database topics, is warranted.

In conclusion, the relevance of this study is determined by the urgent need to modernize computer science teacher education in accordance with the demands of the digital society. **The aim of the study** is to analyze teacher training programs in computer science with a specific focus on the content and instructional practices related to database education, identify existing issues, and propose directions for their improvement.

3. Methodology

This study employed a set of theoretical research methods to enable a systematic analysis of educational programs with a specific focus on preparing future computer science teachers in the field of databases. First, an analysis of regulatory documents and educational standards was conducted. This included the examination of state standards for general secondary education, model educational and professional programs of higher education institutions, requirements for the professional training of computer science teachers, and the alignment of academic courses with current trends in information technology. Second, a comparative analysis was undertaken to examine the content of courses, instructional workload, the technologies and educational platforms employed across leading Ukrainian universities. This comparison enabled the identification of shared features, key differences, and distinctive elements in the implementation of database-related curricula. Third, a content analysis of academic programs and curricula was carried out. It involved the study of course descriptions, competency-based learning outcomes, instructional methods, and forms of knowledge assessment within computer science teacher training. Particular attention was given to identifying references to contemporary technologies such as SQL, NoSQL, Big Data, and cloud services. Fourth, generalization techniques were applied to synthesize the data obtained from program analysis through systematization, classification, and deductive reasoning. This enabled the formation of a coherent understanding of the current state of teacher training in the field of databases. Finally, extrapolation was used to relate ongoing trends in the IT sector to the educational context. This included the consideration of current demands of the digital economy, Industry 4.0 and 5.0 paradigms, as well as the evolving needs of school-level computer science education, in order to develop informed recommendations for the modernization of relevant academic programs.

4. Results

An analysis of educational and professional programs implemented by leading Ukrainian higher education institutions confirmed that the topic of databases constitutes an integral part of pre-service training for future computer science teachers. However, its position within the curriculum, content depth, and instructional volume vary significantly depending on the institution. Such variability highlights the need for systematization and harmonization of educational approaches in line with the current demands of digital education.

A comparative analysis of database-related courses offered at various universities is presented in Table 1. While all programs demonstrate a shared focus on fundamental technologies (SQL, NoSQL, Big Data), the curricula differ in the number of instructional hours, the stage of study at which database instruction begins (typically in the second or third year), and the educational platforms employed.

Table 1

Characteristics of Database Courses in Leading Ukrainian Universities

University	Contact Hours (Lectures/ Practicals/ Lab)	Technologies	Educational Platforms	Course Start (Year)
Taras Shevchenko National University of Kyiv	40/40/20	SQL, NoSQL, Big Data	Moodle, Scopus	2nd year
Simon Kuznets Kharkiv National University of Economics	35/45/20	SQL, query optimization	Google Classroom, Coursera	3rd year
NTUU "Igor Sikorsky KPI"	30/50/20	SQL, NoSQL, Machine Learning	Microsoft Teams, Zoom	2nd year
Lviv Polytechnic National University	45/35/20	SQL, data analytics systems	Moodle, cloud technologies	2nd year

As shown in the table, most universities prioritize practical instruction, which constitutes at least 40–50% of total course hours. This balance ensures both theoretical understanding and the development of practical skills with a modern DBMS. However, only a few programs address current components such as Big Data or integration with Machine Learning.

In the theoretical component, students typically study the relational model, normalization, database structure, table creation, SQL queries, and schema design. The practical segment includes tasks related to database design, administration, and optimization using DBMSs such as MySQL, PostgreSQL, and MongoDB, along with simulated professional scenarios *(Dan-IT, 2024).* Several programs incorporate project-based learning, where students develop databases for educational or information system modeling purposes.

An innovative vector is the use of digital educational platforms such as Moodle, Google Classroom, and Microsoft Teams, which enable flexible learning processes, access to simulated environments, and systematic feedback. Project-based and problem-based learning methodologies also play a significant role in fostering critical thinking, collaboration, and research skills *(Behar-Horenstein & Niu, 2021).*

The analysis revealed that database curricula must align with school-level standards *(Ministry of Education and Science of Ukraine, 2015),* particularly considering future teachers'

need to teach this content. However, a noticeable gap persists between university programs and school practice requirements: insufficient attention is paid to data security, NoSQL storage, cloud solutions, data visualization, and the pedagogical interface of these technologies.

Opportunities for improving programs include the introduction of interdisciplinary modules combining database topics with web development, data analytics, and machine learning, as well as expanding collaboration with IT companies through internships, mentoring, or joint development of educational solutions. Further alignment with international practices is also essential, particularly Erasmus Mundus programs that integrate theory, practice, and research components while adhering to ECTS standards *(OECD, 2022).*

5. Discussion

The development of database-related competencies is gradually becoming a central component of the professional training of computer science teachers, driven by transformative processes in education, the economy, and industry. In the digital age, the ability to analyze, structure, and secure information has acquired not only professional but also societal significance. Future educators are expected to possess not only basic skills in SQL query construction or relational database design but also an understanding of information system administration, data visualization tools, unstructured data management, and data protection techniques *(Leng et al., 2021).*

However, the analysis of current educational programs reveals significant inconsistencies between the content of the school-level informatics curriculum and the focus of university training. While the national secondary education standard mandates the study of DBMSs in upper secondary school, including data modeling and structuring *(Ministry of Education and Science of Ukraine, 2015),* university-level courses do not always provide sufficient theoretical depth or pedagogical adaptation. Topics such as normalization, query optimization, NoSQL technologies, or big data analytics are often addressed superficially and without appropriate methodological support, complicating their classroom application *(Sangrà et al., 2022).*

The examples presented in the "Results" section indicate that leading Ukrainian universities, such as Taras Shevchenko National University of Kyiv, NTUU "Igor Sikorsky KPI," Lviv Polytechnic, and Simon Kuznets Kharkiv National University of Economics, have already integrated database courses into their curricula for future teachers. However, these courses are generally framed as general IT training rather than pedagogically adapted content. The lack of clearly defined instructional models for teaching databases creates additional challenges for novice educators, who must independently bridge both content and methodological gaps.

Additionally, the study identifies a lack of educational components familiarizing students with up-to-date data management systems, such as MongoDB, Firebase, or big data analytics tools, as well as limited integration of cloud environments. This gap between real-world technological developments and teacher training targeted at modern school needs further deepens the disconnect *(Mlambo et al., 2021; Trintina & Kotelevets, 2021; Ugur & Koç, 2021)*. Another issue lies in the absence of established criteria for assessing the development of relevant digital competencies in both higher education and school-level teacher certification systems.

Therefore, the findings underscore the importance of revising the methodological, content-related, and structural aspects of educational programs by modernizing the "Databases" course in teacher training curricula. Such revision must address both the technological and didactic modernization of course content to align with the demands of the information society and the objectives of school education.

6. Conclusions

The analysis of educational programs for pre-service computer science teachers with a focus on database instruction confirms the crucial role this subject plays in shaping both digital and disciplinary competencies. In Ukrainian universities, the study of databases generally follows a systematic structure, progressing from foundational concepts such as the relational model and SQL to more advanced technologies, including NoSQL, Big Data, and cloud-based DBMSs. Theoretical learning is complemented by practical exercises facilitated through digital platforms (e.g., Moodle, Google Classroom, Microsoft Teams) and enhanced by project-based and problem-oriented pedagogies.

Nevertheless, several challenges were identified that hinder the achievement of high-quality training. These include variability in course structures across universities, insufficient integration of innovative technologies into the curriculum, limited use of real-world examples and IT-related case studies, and a lack of pedagogical tools for adapting technical content to school-level informatics. In several programs, a disconnect exists between expected learning outcomes and the requirements of general secondary education, leading to a misalignment between higher and secondary education systems.

Improving the quality of database-focused teacher training requires strategic actions. Primarily, technological modernization of course content is needed, incorporating up-to-date solutions such as cloud DBMSs, MongoDB, and big data analysis tools. It is also advisable to strengthen interdisciplinary integration, for example, by combining database topics with machine learning, web development, and data visualization. Collaboration with IT companies through project-based learning, internships, and mentorship programs would bring training closer to real-world professional contexts. Additionally, updating pedagogical approaches to database instruction, through the development of original methodologies and teaching materials, would better prepare students for school-based teaching roles.

Future research should focus on designing models for the development of digital and subject-specific competencies among computer science teachers using modern learning platforms, simulations, gamified environments, and adapted international best practices. The integration of European approaches, particularly within the European Higher Education Area, will enhance the quality, relevance, and global competitiveness of Ukrainian educational programs.

References

1. Adel, A. (2022). The rise of Industry 5.0: The future of manufacturing and digital society. Journal of Cloud Computing, 11(1), 35. https://doi.org/10.1186/s13677-022-00314-5

2. Behar-Horenstein, L. S., & Niu, L. (2021). Problem-based learning in teacher education: A literature review. Interdisciplinary Journal of Problem-Based Learning, 15(1). https://doi.org/10.14434/ijpbl.v15i1.28861

3. Borodina, O. A., & Lyashenko, V. I. (2022). Povoienne vidnovlennia ekonomiky: svitovyi dosvid ta sproba yoho adaptatsii dlia Ukrainy [Post-War Economic Recovery: World Experience and Attempt to Adapt it for Ukraine]. Visnyk ekonomichnoi nauky Ukrainy, 1 (42), 121–134. https://doi.org/10.37405/1729-7206.2022.1(42).121-134 [in Ukrainian]

4. Dan-IT. (2024). Kursy SQL [SQL Developer Program]. https://dan-it.com.ua/uk/program/sql/ [in Ukrainian]

5. Gouseti, A., Livingstone, S., & Chaudhary, S. (2022). Mapping digital competence frameworks across education. European Journal of Education, 57(1), 69–84. https://doi.org/10.1111/ejed.12506
6. Kalashnikova, S., & Orzhel, O. (2022). Optymizatsiia merezhi zakladiv vyshchoi osvity: teoretychni osoblyvosti ta praktychni rekomendatsii [Optimisation of the Network of Higher Education Institutions: Theoretical Features and Practical Recommendations]. International Scientific Journal of Universities and Leadership, (13), 89–129. https://doi.org/10.31874/2520-6702-2022-13-89-129 [in Ukrainian]
7. Leng, J., Jiang, P., Xu, K., Liu, Q., & Wang, J. (2021). Digital twins-based smart manufacturing system design in Industry 4.0: A review. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 51(1), 367–380. https://doi.org/10.1109/TSMC.2020.3040789
8. Ministry of Education and Science of Ukraine. (2015). Prohrama «Informatyka» dlia 5 – 9 klasiv [Computer science program for grades 5–9]. https://mon.gov.ua/static-objects/mon/sites/1/zagalna%20seredn ya/programy-5-9-klas/onovlennya-12-2017/programa-informatika-5-9-traven-2015.pdf [in Ukrainian]
9. Ministry of Education and Science of Ukraine. (2025). Prohrama «IT Studio» dlia shkil ["IT Studio" program for schools]. https://mon.gov.ua/uk/osvita/it-studiy [in Ukrainian]
10. Mlambo, V., Siluma, P. M., & Mavhungu, T. R. (2021). Preparing teachers for the digital future: A curriculum mapping approach. International Journal of Education and Development using ICT, 17(1), 91–106.
11. OECD. (2022). Strengthening teacher education systems in the 21st century: Trends and challenges. https://www.oecd.org/education/teacher-education-systems.htm
12. Sangrà, A., Vlachopoulos, D., & Cabrera, N. (2022). Developing digital teaching competence in teacher education: A review of literature. Education and Information Technologies, 27(3), 3453–3473. https://doi.org/10.1007/s10639-021-10716-x
13. Trintina, N., & Kotelevets, S. (2021). Informatsiini tekhnolohii v yurydychnii diialnosti [Information technologies in legal activity]. Physical and Mathematical Education, 27(1), 89–93. https://doi.org/10.31110/2413-1571-2021-027-1-014 [in Ukrainian]
14. Ugur, N. G., & Koç, M. (2021). Examining ICT skills of pre-service teachers: Curriculum gaps and challenges. Education and Information Technologies, 26(6), 6907–6925. https://doi.org/10.1007/s10639-021-10645-9
15. UNESCO. (2023). Digital learning for educators: Global report on teacher digital competence. https://unesdoc.unesco.org/ark:/48223/pf0000384903
16. Yurchenko, A. O., Semenikhina, O. V., Rudenko, Y. O., & Shamonia, V. G. (2020). The digital technology in IT-education: the view of Ukrainian university. Collection of Scientific Publications NUS, 4, 129–133. https://doi.org/10.15589/znp2020.4(482).15
17. Yurchenko, A., Drushlyak, M., Sapozhnykov, S., Teplytska, A., Koroliova, L., & Semenikhina, O. (2021). Using Online IT-Industry Courses in Computer Sciences Specialists' Training. International Journal of Computer Science and Network Security, 21(11), 97–104. https://doi.org/10.22937/IJCSNS.2021.21.11.13