CURRENT RESEARCH JOURNAL OF PEDAGOGICS (ISSN: 2767-3278)

**VOLUME:** Vol.07 Issue02 2026
**DOI: -** 10.37547/pedagogics-crjp-07-02-10
**Page: - 42-47**
RESEARCH ARTICLE OPEN ACCESS

# Pedagogical Foundations For Forming Research Competence In Pre-Service Computer Science Teachers In A Digital Learning Environment

**Axatqulov Anvar Almasovich**

Lecturer at Jizzakh State Pedagogical University, Uzbekistan

**Received:** 14 December 2025 **Accepted:** 07 January 2026 **Published:** 09 February 2026

## ABSTRACT

Preparing pre-service computer science (CS) teachers for contemporary schooling requires more than mastery of programming and didactics; it also demands research competence that enables future teachers to diagnose learning needs, evaluate digital tools, interpret educational data, and improve instruction through evidence-informed inquiry. This article develops a pedagogically grounded framework for forming research competence in pre-service CS teachers within a digital learning environment. Drawing on the teacher-as-researcher tradition, pedagogical content knowledge, technology integration models, and inquiry-oriented learning theory, the paper conceptualizes research competence as an integrated construct that unites epistemic understanding of research, methodological skills, digital-data literacy, ethical responsibility, and reflective professional judgment. The digital learning environment is considered not merely as a set of technologies but as a didactic ecosystem that amplifies authentic inquiry through access to open resources, collaboration networks, analytics, virtual laboratories, and reproducible workflows. Methodologically, the study follows an integrative conceptual approach that synthesizes peer-reviewed scholarship and international competence frameworks to derive design principles and pedagogical conditions for teacher education programs. The results include a coherent model of pedagogical foundations that links learning outcomes, learning activities, mentorship patterns, and assessment logic, and it identifies how scaffolding, community presence, and research–teaching integration can be operationalized through digital platforms. The discussion highlights implementation risks, including superficial tool use, unequal access, and ethical challenges, and proposes mitigation through curriculum alignment, staged inquiry, and transparent assessment criteria. The article concludes that sustainable formation of research competence depends on a program-level design in which digital affordances are intentionally matched to inquiry cycles, professional identity development, and the epistemic culture of computer science education.

**Keywords:** Research competence, pre-service computer science teachers, digital learning environment, inquiry-based learning, TPACK, teacher as researcher, learning analytics, evidence-informed pedagogy.

## INTRODUCTION

Digital transformation in education has intensified expectations for teachers to work with complex learning technologies, produce and interpret data, and adapt instruction to rapidly changing curricula and labor-market demands. For computer science teachers, this challenge is particularly acute because the subject itself evolves quickly, and pedagogical decisions often depend on evidence about learners' misconceptions, code comprehension, computational thinking progressions, and the effectiveness of digital tools. In this context, research competence becomes a core professional resource. It allows future teachers to formulate educational problems as researchable questions, select appropriate methods, collect and analyze evidence, and translate findings into instructional improvement. At the same time, teacher education increasingly takes place in digitally mediated environments where learning management systems, virtual labs, repositories, collaborative platforms, and analytics tools shape both learning processes and outcomes.

International frameworks emphasize the importance of teacher competence in using information and communication technologies as part of professional practice and lifelong development. UNESCO's ICT Competency Framework for Teachers positions ICT competencies as integral to teacher preparation and professional growth, linking technology use to pedagogy, curriculum, assessment, and professional learning. Likewise, the European DigCompEdu framework articulates educator-specific digital competences, including professional engagement, teaching and learning, assessment, and empowering learners, providing a structured lens for program design. These frameworks do not replace research competence, but they underscore that digital competence and inquiry capacity increasingly overlap in practice, especially when teachers are expected to evaluate digital resources, interpret learning evidence, and design improvements.

This article addresses the following problem: how can teacher education programs intentionally use the didactic opportunities of a digital learning environment to form research competence in pre-service CS teachers? The goal is to establish pedagogical foundations that connect theory to implementable program design. The paper offers a conceptual model that explains what research competence entails for pre-service CS teachers, why digital environments are uniquely suited to support its development, and which pedagogical conditions enable sustainable outcomes.

The concept of teacher knowledge has long been understood as more than generic pedagogy or disciplinary mastery. Shulman's formulation of pedagogical content knowledge highlights how teachers transform subject matter into teachable forms through representations, explanations, and anticipations of learner difficulties. In CS education, this transformation includes selecting suitable code examples, debugging strategies, formative assessment practices, and scaffolds for algorithmic thinking. Research competence complements this knowledge base by providing a disciplined way to test instructional assumptions, document learner progress, and refine representations through evidence.

Technology integration further complicates the professional knowledge landscape. The TPACK framework extends the logic of PCK by emphasizing that effective teaching with technology requires an interplay of content, pedagogy, and technological knowledge rather than isolated tool skills. For pre-service CS teachers, TPACK suggests that research competence should be cultivated within authentic teaching-with-technology contexts, where digital tools are not add-ons but integral to inquiry tasks such as code-tracing investigations, learning analytics interpretation, or iterative design of digital learning materials.

Inquiry-oriented learning theories provide a second pillar for understanding how research competence can be formed. Problem-based and inquiry learning approaches argue that learners develop deeper understanding when they work with authentic problems, while scaffolding makes complex inquiry manageable and reduces unproductive cognitive load. In teacher education, this implies that research competence is not acquired through abstract methods courses alone, but through staged cycles of investigation embedded in pedagogical practice, supported by mentoring and structured feedback.

Digital learning environments can strengthen inquiry learning by enabling collaborative knowledge building, persistent documentation of process, and access to data and tools for analysis. The Community of Inquiry framework, which conceptualizes effective online learning as the interaction of teaching presence, social presence, and cognitive presence, supports this view by explaining how digital communities can sustain deep engagement and meaning-making. From this perspective, the pedagogical challenge is not simply to place research tasks online, but to design an online environment where facilitation, interaction norms, and cognitive challenge align with inquiry goals.

Teacher learning scholarship also emphasizes that research competence is tied to professional identity and community participation. Cochran-Smith and Lytle describe teacher learning as a relationship between knowledge and practice where teachers can generate knowledge through systematic inquiry in communities. This tradition aligns with the "teacher as researcher" perspective associated with curriculum inquiry and reflective practice, in which teachers treat classrooms as sites of disciplined investigation. In such a framing, research competence is not a purely technical skill set; it is a habit of mind and a professional stance that values evidence, transparency, and iterative improvement.

Finally, research–teaching integration literature argues that learning improves when students are positioned as

participants in communities of inquiry rather than passive recipients of content. Healey's work on the research–teaching nexus emphasizes the contested but productive relationships between research and teaching and the need to design learning so that students engage with inquiry and knowledge construction. For pre-service CS teachers, this points to curriculum designs where future teachers not only learn research methods but enact them in digital teaching scenarios, including microteaching, lesson-study formats, and action research.

This paper uses an integrative conceptual methodology that combines theoretical analysis, synthesis of peer-reviewed scholarship, and interpretation of international competence frameworks to derive a pedagogically coherent model. The approach is appropriate because the central aim is to articulate foundations and design logic rather than to test a single intervention in a specific institutional setting. The analysis proceeds through three steps. First, research competence is defined in a way that is specific to pre-service CS teachers, accounting for the epistemic culture of computer science, digital tool use, and classroom inquiry demands. Second, the didactic affordances of a digital learning environment are examined as mediating conditions that can either support or hinder research competence formation, depending on how they are pedagogically orchestrated. Third, design principles and pedagogical conditions are formulated by aligning inquiry learning theory, teacher knowledge models, and online learning frameworks with expected learning outcomes and assessment logic.

To increase practical relevance, the derived model is articulated at the program-design level, specifying how research competence can develop across stages of teacher education through progressive inquiry cycles. In line with design-based research thinking, the model is presented as a set of testable design conjectures that can guide implementation and subsequent empirical evaluation.

The synthesis suggests that research competence in pre-service CS teachers can be conceptualized as an integrated capability that joins epistemic, methodological, digital, ethical, and reflective dimensions. The epistemic dimension concerns how future teachers understand what counts as evidence in education and how claims are justified, including awareness of validity threats, bias, and the limits of generalization. The methodological dimension includes the ability to formulate questions, select designs appropriate to educational contexts, build instruments, collect data, and apply analysis strategies ranging from qualitative coding of classroom interactions to quantitative interpretation of performance measures. The digital dimension includes data literacy, tool fluency for capturing and organizing evidence, and the capacity to use reproducible workflows for analysis and reporting, which is increasingly important when evidence is generated by digital platforms. The ethical dimension includes privacy, informed consent, responsible data stewardship, and fairness, particularly when learning analytics and student data are involved. The reflective dimension involves interpreting results in relation to instructional goals, revising teaching decisions, and communicating findings to professional communities.

Within a digital learning environment, these dimensions can be developed through a staged inquiry architecture that aligns didactic opportunities with the developmental trajectory of pre-service teachers. Early stages focus on guided inquiry, where students learn to observe classroom phenomena in structured ways, interpret existing research, and use digital tools for documentation. Middle stages emphasize co-designed inquiry, where students collaborate to design small-scale studies, implement digital interventions, and analyze evidence with scaffolded support. Advanced stages support autonomous inquiry, where students conduct capstone investigations that integrate CS pedagogy, technology design, and evidence-based evaluation. Scaffolding is essential throughout, because inquiry without support may lead to cognitive overload and superficial conclusions; carefully designed prompts, templates, and mentoring enable meaningful problem solving and methodological rigor.

The model further indicates that digital environments contribute didactic value through four interrelated affordances. First, digital environments support authenticity by providing access to real artifacts of learning, including code submissions, version histories, discussion traces, and assessment data that can serve as evidence for inquiry. Second, they enable collaboration and community-building by connecting pre-service teachers with peers, mentors, and broader professional networks, which strengthens research identity and knowledge sharing. Third, they provide structured visibility of learning processes through logs, dashboards, and feedback systems, enabling formative evaluation and iterative improvement. Fourth, they promote openness and resource-rich inquiry through access to open educational resources, policy documents, and research repositories,

which helps pre-service teachers ground their inquiries in established knowledge and adapt materials responsibly. UNESCO's work on ICT competence and open educational resources supports the view that access, quality, and responsible use of digital resources are program-level conditions rather than optional enhancements.

A key pedagogical foundation is the intentional coupling of research competence with technology-integrated pedagogy. TPACK provides a practical lens for curriculum alignment by encouraging teacher education programs to design learning tasks where technological choices are evaluated through pedagogical criteria and evidence rather than convenience or novelty. In the proposed model, research competence is developed by repeatedly asking pre-service teachers to justify instructional and technological decisions with evidence collected from learners and digital traces, thereby building an inquiry habit that is inseparable from teaching practice.

Another foundation concerns the social organization of inquiry in digital contexts. The Community of Inquiry framework helps explain why a mere collection of online tools does not automatically yield deep inquiry; teaching presence is needed to structure tasks and feedback, social presence is needed to sustain engagement and trust, and cognitive presence is needed to move learners from exploration to integration and resolution. When these presences are intentionally designed, pre-service CS teachers can develop a research stance through community-supported critique, peer review of methods, and collaborative interpretation of findings.

The model also emphasizes the research–teaching nexus as a programmatic condition. When teacher education positions pre-service teachers as producers of pedagogical knowledge, not only consumers, inquiry tasks become identity-forming and professionally meaningful. This aligns with scholarship on teacher learning in communities, where knowledge is generated through practice-centered inquiry and shared reflection. It also aligns with research–teaching integration perspectives that argue for curricular designs that induct students into disciplinary and professional inquiry cultures.

Finally, the results of the synthesis indicate that assessment must be aligned with inquiry goals. Research competence cannot be validly assessed solely through tests of terminology or isolated method knowledge. Instead, assessment should focus on the quality of problem formulation, coherence between questions and methods, transparency of evidence handling, adequacy of interpretation, and reflexive translation into teaching decisions. Digital environments support such assessment by enabling portfolio-based evaluation, where artifacts of inquiry, analysis logs, and reflective narratives provide a richer view of competence development than single-event examinations.

The proposed foundations suggest practical implications for teacher education program design. One implication is that digitalization should be treated as an epistemic and pedagogical redesign rather than an infrastructural upgrade. Programs that simply add a learning management system or require online submissions risk creating procedural compliance without cultivating inquiry. Research competence grows when digital tools are embedded in inquiry cycles that demand justification, evidence, and reflection.

A second implication concerns equity and access. Digital environments can widen gaps if students have uneven access to devices, connectivity, or prior digital literacy. Frameworks like DigCompEdu emphasize the educator's capacity to use technology to empower learners, which implies that teacher education programs should model inclusive digital practices and provide structured support for those who enter with limited experience. For pre-service CS teachers, equity also includes ensuring that research tasks do not privilege only those with advanced programming skills; inquiry should be scaffolded so that methodological reasoning and pedagogical insight are valued alongside technical performance.

Ethical challenges are particularly salient when research competence formation includes learning analytics or student data. Future CS teachers may have strong technical skills but limited preparation in educational ethics, privacy, and responsible data use. Therefore, ethics should be integrated into inquiry tasks, requiring explicit decisions about data minimization, anonymization, consent logic, and fairness in interpretation. This is not merely a compliance issue; it is part of professional judgment in a data-rich educational landscape.

A third implication is the need for mentorship structures. Teacher research engagement literature indicates that teachers' participation in research depends on supportive conditions, manageable workloads, and meaningful

incentives, not only on motivation. In pre-service programs, mentorship can be designed as a layered system that combines course instructor guidance, peer review routines, and supervised field-based inquiry. Digital environments facilitate this by enabling continuous feedback, asynchronous consultation, and transparent tracking of inquiry progress, but the pedagogical intention remains decisive.

The model also benefits from a design-based research orientation. Treating curricular interventions as designs that embody theoretical claims enables iterative refinement and contextual adaptation. For example, a program may pilot a digital portfolio approach to inquiry assessment, examine evidence of student learning, and adjust scaffolds and rubrics across iterations. Such iterative cycles mirror the very research competence that the program seeks to cultivate.

Despite its strengths, the conceptual nature of this article imposes limitations. The proposed model should be empirically tested across diverse institutional contexts, including variations in practicum arrangements, digital infrastructure, and student preparedness. Future research could operationalize the dimensions of research competence into validated instruments, track developmental trajectories over time, and compare outcomes across alternative digital inquiry designs.

Research competence is an essential professional outcome for pre-service computer science teachers because it supports evidence-informed instruction, responsible use of educational data, and continuous pedagogical improvement in rapidly changing digital contexts. This article has articulated pedagogical foundations for forming research competence through the didactic opportunities of a digital learning environment. The proposed framework conceptualizes research competence as an integrated capability that includes epistemic understanding, methodological skill, digital-data literacy, ethical responsibility, and reflective judgment. It argues that digital environments contribute not simply by providing tools, but by enabling authentic evidence access, collaborative inquiry communities, visible learning processes, and openness to resources and knowledge networks. Sustainable implementation depends on curriculum alignment with technology-integrated pedagogy, scaffolded inquiry cycles, mentorship and community presence, and assessment approaches that foreground inquiry quality and reflective translation into teaching. The framework offers a coherent basis for program design and provides testable conjectures for future empirical studies that can refine and validate effective pathways for preparing teacher-researchers in computer science education.

## REFERENCES


1. Shulman, L. S. Those who understand: Knowledge growth in teaching // Educational Researcher. 1986. Vol. 15, No. 2. P. 4–14. DOI: 10.3102/0013189X015002004.

2. Mishra, P., Koehler, M. J. Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge // Teachers College Record. 2006. Vol. 108, No. 6. P. 1017–1054. DOI: 10.1111/j.1467-9620.2006.00684.x.

3. Garrison, D. R., Anderson, T., Archer, W. Critical inquiry in a text-based environment: Computer conferencing in higher education // The Internet and Higher Education. 2000. Vol. 2, No. 2–3. P. 87–105.

4. Garrison, D. R., Anderson, T., Archer, W. Researching the Community of Inquiry framework: Review, issues, and future directions // The Internet and Higher Education. 2007. Vol. 10, No. 3. P. 157–172.

5. Hmelo-Silver, C. E., Duncan, R. G., Chinn, C. A. Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006) // Educational Psychologist. 2007. Vol. 42, No. 2. P. 99–107. DOI: 10.1080/00461520701263368.

6. Cochran-Smith, M., Lytle, S. L. Relationships of knowledge and practice: Teacher learning in communities // Review of Research in Education. 1999. Vol. 24. P. 249–305.

7. Borg, S. Language teacher research engagement // Language Teaching. 2010. Vol. 43, No. 4. P. 391–429.

8. Healey, M. Linking research and teaching: Disciplinary spaces // In: Barnett, R. (ed.) Reshaping the University: New Relationships between Research, Scholarship and Teaching. Maidenhead: Open University Press, 2005. P. 30–42.

**9.** UNESCO. UNESCO ICT Competency Framework for Teachers. Version 3. Paris: UNESCO, 2018. 68 p. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000265721 (accessed: 07.02.2026).

**10.** Redecker, C., Punie, Y. European Framework for the Digital Competence of Educators: DigCompEdu. Luxembourg: Publications Office of the European Union, 2017. (JRC Science for Policy Report). Available at: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC107466/pdf_digcomedu_a4_final.pdf (accessed: 07.02.2026).

**11.** Siemens, G. Connectivism: A learning theory for the digital age. 2005. Available at: https://www.elearnspace.org/Articles/connectivism.htm (accessed: 07.02.2026).

**12.** UNESCO. Recommendation on Open Educational Resources (OER). Paris: UNESCO, 2019. Available at: https://www.unesco.org/en/legal-affairs/recommendation-open-educational-resources-oer (accessed: 07.02.2026).

**13.** The Design-Based Research Collective. Design-based research: An emerging paradigm for educational inquiry // Educational Researcher. 2003. Vol. 32, No. 1. P. 5–8, 35–37. DOI: 10.3102/0013189X032001005.

**14.** Reeves, T. C. Design research from a technology perspective // In: van den Akker, J., Gravemeijer, K., McKenney, S., Nieveen, N. (eds.) Educational Design Research. London: Routledge, 2006. P. 52–66.

**15.** OECD. The Future of Education and Skills: Education 2030. OECD Learning Framework 2030. P