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Science in Higher Pedagogical Education System: Realities and Perspectives

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Abstract:
This article examines the integration of scientific inquiry within Higher Pedagogical Education (HPE) and argues that research competence is essential for preparing reflective, evidence-based teachers. Drawing on contemporary scholarship, it analyzes structural, methodological, and cultural barriers that limit scientific productivity across Material, Social, and Semantic spaces. The study highlights how institutional misalignments—such as high teaching loads, insufficient infrastructure, weak research incentives, and fragmented methodological understanding—hinder the development of research-informed teachers. It further explores how digital transformation, including Learning Analytics, AI tools, and advanced modeling technologies, reshapes pedagogical research and enhances instructional capacity. Emphasis is placed on the importance of university–school partnerships, co-designed practice environments, and sustained professional development to ensure that research meaningfully informs teaching practice. The article concludes that a coordinated, system-wide strategy is required to build a sustainable research culture within HPE.

Keywords:
research-informed teaching, higher pedagogical education, digital transformation, teacher competence

I. Introduction

1.1. Contextualizing Research as the Cornerstone of Professional Pedagogy

The integration of scientific inquiry into higher pedagogical education (HPE) is not merely an institutional ideal but an operational necessity for preparing reflective practitioners capable of addressing the complexities of modern educational systems. The relationship between teaching and research has long been assumed rather than critically articulated, which has often led to its insufficient practical implementation. As noted in recent discussions, research is frequently positioned as inherently connected to university teaching simply because both activities coexist within the same institutional space—a misconception that has historically prevented meaningful progress beyond maintaining the status quo (Research as a pedagogical tool in higher education programmes, n.d.).

A contemporary perspective requires recognizing research as a foundational element of professional competence, demanding that instruction actively model inquiry-oriented thinking

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characteristic of disciplinary expertise. When this research–teaching alignment is not made explicit, future educators risk developing significant gaps in analytical, investigative, and evidence-based reasoning skills. Research functions as a potent pedagogical tool, providing opportunities for designing interventions, analyzing educational problems, and making informed decisions grounded in empirical findings (Research as a pedagogical tool in higher education programmes, n.d.). Embedding research into the curriculum ensures that the university's research mission permeates the entire educational process, shaping student teachers not as passive recipients of knowledge but as critical investigators capable of evaluating and generating evidence for inclusive practice (Research-informed teaching, n.d.; Facilitating research-informed educational practice for inclusion, 2022).

1.2. Literature Landscape and Rationale for Systemic Analysis

Existing scholarship on the research–teaching nexus highlights a persistent tension between these core academic functions. While higher education institutions often emphasize their interdependence rhetorically, practical implementation—especially within pedagogical faculties—tends to separate them due to high teaching loads, limited resources, and inconsistent institutional expectations (Impact of teaching workload on scientific productivity, 2023). A systemic analysis is therefore required to move beyond generic acknowledgments of these challenges and examine the structural constraints that impede progress.

Recent theoretical models emphasize the importance of examining the interplay between three interdependent domains: the Material Space (infrastructure and digital tools), the Social Space (collaboration networks, including school–university partnerships), and the Semantic Space (diverging understandings of the role of research in teacher preparation) (Learning analytics and educational data mining, 2024). Understanding how these spaces intersect provides a more comprehensive framework for diagnosing why transformation remains limited and what forms of coordinated reform are necessary for cultivating a research-rich pedagogical culture.

1.3. Thesis and Article Structure

This article argues that fully harnessing the potential of scientific inquiry within higher pedagogical education requires an integrated reform agenda spanning institutional policy, professional development, curriculum design, digital transformation, and global academic publishing standards. Achieving systemic transformation depends on coordinated action across five strategic pillars: **Institutional Capacity**, **Curriculum and Competence**, **Digital Integration**, **Collaborative Ecosystems**, and **Quality Assurance in Publishing**. The following sections examine each pillar in detail, outlining both current realities and prospective pathways for strengthening the role of scientific inquiry in pedagogical education.

II. The Foundational Nexus: Research as a Pedagogical Imperative and Professional Identity

2.1. Defining the Research-Informed Teacher (RIT)

The concept of the Research-Informed Teacher (RIT) has become central in modern higher pedagogical education, requiring educators to ground their professional practices in robust disciplinary and educational research. Research-informed teaching frameworks emphasize that

faculty must model inquiry by posing critical questions, making their thinking visible through deliberate "thinking-aloud" demonstrations, and engaging students as collaborators in the co-construction of knowledge (Research-informed teaching, n.d.). Instruction in pedagogical institutions therefore extends beyond content delivery; it demands explicit alignment between learning goals, evaluative criteria, and constructive feedback practices (Research-informed teaching, n.d.).

Central to the RIT model is the cultivation of an "enquiry stance"—a professional mindset that moves beyond technical knowledge of research methods toward a sustained disposition of critical evaluation and reflective decision-making (Supporting pre-service teachers in developing research competence, 2023). Without this disposition, educators risk adopting untested or fashionable pedagogical interventions that lack empirical grounding, thereby weakening instructional quality. Research-rich preparation programs thus must ensure that pre-service teachers are not only consumers of educational research but also active users and evaluators of evidence who apply empirical insights to complex pedagogical challenges, including inclusive education (Facilitating research-informed educational practice for inclusion, 2022). In this way, research engagement becomes directly linked to enhanced professional identity and improved classroom outcomes.

2.2. Research and the Development of Pedagogical Content Knowledge (PCK)

The engagement of pre-service teachers with authentic scientific practices plays a decisive role in developing Pedagogical Content Knowledge (PCK), particularly through activities that require active construction of understanding. Research in science teacher education shows that PCK comprises multiple interrelated components, including orientations toward teaching, curriculum knowledge, instructional strategies, and knowledge of student cognition (Developing pre-service teachers' pedagogical content knowledge, 2023). Instructional approaches such as project-based learning have demonstrated measurable improvements in science learning by equipping students with cognitive tools that support inquiry-driven knowledge construction (Developing pre-service teachers' pedagogical content knowledge, 2023).

A critical dynamic within PCK development is the relationship between procedural knowledge—skills derived from practical experience—and declarative knowledge—conceptual understanding of theory. Procedural knowledge, shaped through teaching practice and reflective analysis, strongly influences the formation and refinement of declarative knowledge (The impact of procedural knowledge on the formation of declarative knowledge, 2021). This progression underscores that the most effective research training occurs within authentic teaching contexts where reflection acts as a catalyst for metacognitive development and sustained professional motivation (The impact of procedural knowledge on the formation of declarative knowledge, 2021).

Nevertheless, research indicates that pre-service teachers often exhibit uneven development across the dimensions of PCK. While growth appears in instructional and curricular knowledge, teacher candidates frequently struggle to link these competencies to assessment literacy, particularly regarding scientific literacy evaluation (Developing pre-service teachers' pedagogical content knowledge, 2023). This reveals a structural gap in research training: its disconnection from

assessment theory and quality assurance practices. Addressing this requires explicit integration of research as a tool for measuring and improving student learning. When pre-service teachers understand research as the evidentiary foundation for instructional decision-making, they develop more comprehensive PCK and enhance their capacity for reflective, metacognitive practice (The impact of procedural knowledge on the formation of declarative knowledge, 2021).

III. Systemic Realities: Barriers to Scientific Productivity in HPE

A research-rich pedagogical environment is often constrained by entrenched institutional and cultural barriers across material, policy, and semantic dimensions. Analyzing these obstacles is crucial for designing targeted and sustainable reforms.

3.1. Infrastructure and Material Constraints

The Material Space—comprising digital resources, physical infrastructure, and access to scholarly tools—constitutes a major obstacle to research integration in teacher education. Limited or outdated university infrastructure and insufficient access to high-quality research materials substantially restrict faculty capacity to enact research-based pedagogical innovation (Learning analytics and educational data mining, 2024). Historical challenges also include inadequate administrative mechanisms for managing research grants, further impeding the ability of institutions to expand their research activities sustainably (Key strategies for building research capacity, 2017).

These constraints extend to science-related learning environments. Although higher education ideally encompasses classrooms, laboratories, and field sites, these environments often lack the facilities necessary for robust research. Existing studies frequently rely on inventory-based methods that fail to capture the interplay between psychosocial and physical dimensions of learning, thereby missing the complexity inherent in authentic educational environments (Science learning environments in higher education, 2024). Implementing integrated, mixed-method research approaches—while desirable—clashes directly with the shortage of modern facilities and limited institutional support (Learning analytics and educational data mining, 2024). Consequently, weak infrastructure diminishes faculty research productivity and undermines their ability to mentor pre-service teachers in acquiring research competence (Key strategies for building research capacity, 2017).

3.2. Institutional Policy and Faculty Workload Misalignment

Institutional policy frameworks often fail to align faculty incentives with research expectations, thereby relegating research to a secondary priority behind teaching obligations. Persistent obstacles include heavy teaching loads, absence of graduate programs, and shortages of graduate assistants—conditions that significantly restrict faculty research output (Key strategies for building research capacity, 2017). Additionally, institutional evaluation systems have historically placed minimal emphasis on research productivity in tenure and promotion, thereby failing to reward scholarly contributions essential for institutional development (Key strategies for building research capacity, 2017).

Empirical evidence further complicates assumptions about workload reform. Studies demonstrate that the number of teaching groups alone does not significantly influence productivity; instead, productivity is shaped by structural variables such as institutional status and support systems (Impact of teaching workload on scientific productivity, 2023). These factors suggest that meaningful progress requires systemic redesign of incentive structures, research support systems, and workload policies rather than isolated reductions in teaching hours.

The organizational culture is also a powerful determinant of success. Supportive decision-makers within institutions are essential for fostering a research environment that consistently generates academic output, even amidst significant administrative workload and institutional restrictions (The impact of a national crisis on academic research productivity, 2024). Institutional leadership must recognize the strategic value of investing in retaining talented staff and recruiting research-active faculty. When leadership signals a clear, sustained commitment to research through investment and administrative support, it creates a "win-win" scenario for the institution and for middle managers who rely on a robust research base for internal legitimacy and external reputation (The impact of a national crisis on academic research productivity, 2024).

Conversely, a lack of administrative commitment—such as failure to secure adequate post-award staff support for grants—forces faculty to divert significant time to non-research administrative duties, thereby undermining the intended benefits of reduced teaching loads and illustrating that structural support is a principal determinant of whether research is prioritized (Key strategies for building research capacity of university faculty, 2017).

3.3. Methodological and Cultural Impediments

The Semantic Space refers to the shared understanding and methodological capacity within pedagogical departments. Research integration is severely challenged by divergent and sometimes conflicting interpretations of the role of research in the teaching profession (Science learning environments in higher education, 2024). This methodological and cultural fragmentation restricts the coherence of any systematic, research-based teacher education model (Science learning environments in higher education, 2024).

A profound practical consequence of this fragmentation is the limited methodological competence of many teacher educators, which subsequently constrains the development of prospective teachers' inquiry-based teaching skills (Science learning environments in higher education, 2024). This deficit has a direct pedagogical impact in the classroom, particularly in the teaching of research methods. Learners frequently develop negative attitudes toward research methodology courses, often due to instructors' difficulty in effectively conveying methodological concepts, resulting in restricted and superficial understandings of methodological knowledge (Teaching and learning research methodologies in education, 2023).

These systemic misunderstandings between teachers and learners necessitate proactive institutional action to cultivate a coherent, research-oriented scientific culture that promotes inclusive pedagogical practices in which faculty and students function collaboratively as researchers (Teaching and learning research methodologies in education, 2023). Additionally, widespread academic challenges—such as insufficient literature reviews, outdated sources, weak

theoretical foundations, and overall deficiencies in academic rigor—highlight a deeper institutional deficit in foundational research skills that must be addressed at the policy and training levels (Challenges of the HOW Journal in spreading teachers' works, 2017).

IV. Perspectives I: Building Institutional Capacity and Faculty Competence

Addressing the systemic barriers detailed previously requires targeted, simultaneous interventions across institutional policy and human capital development.

4.1. Policy Reform and Structural Incentivization

Effective transformation begins with structural policy reforms that prioritize and reward scientific activity. Solutions include securing active administrative commitment to the research mission, modifying tenure and promotion criteria to explicitly recognize research productivity, and strategically hiring research-active faculty who receive reduced teaching loads (Key strategies for building research capacity of university faculty, 2017). These changes indicate a clear institutional shift away from the historic tendency to prioritize teaching volume over scholarly output (Key strategies for building research capacity of university faculty, 2017).

A powerful operational strategy for research growth is **Cluster Hiring** and resource leveraging (Key strategies for building research capacity of university faculty, 2017). A research cluster consists of a multidisciplinary team of faculty members focused on a shared research theme. This approach is particularly advantageous for institutions striving to strengthen their research standing, as it allows them to leverage regional strengths, share limited material resources, and maximize opportunities for faculty and students (Key strategies for building research capacity of university faculty, 2017). Through such strategies, institutions transition from passive administration to active development of their research profiles.

Table 1. Strategic Policy Interventions for Enhancing Research Productivity

Dimension of Reform	Key Institutional Action	Supporting Academic Rationale	Underlying Impact
Faculty Load Management	Hiring research-active faculty with reduced teaching obligations	Mitigates historic barriers and shifts emphasis from teaching volume to research quality (Key strategies…, 2017)	Increases time allocation for research, signaling administrative commitment (Research as a pedagogical tool…, 2018)
Institutional Assessment	Revising tenure and promotion criteria to prioritize measurable research output	Aligns incentives with institutional goals, reinforcing scholarly activity (Key strategies…, 2017)	Strengthens motivation, increases retention of research-active staff (Key strategies…, 2017)
Expertise Development	Structured, context-specific Teacher Professional Development (TPD)	Addresses methodological capacity deficits in the Semantic Space (Science learning environments…, 2024)	Enhances applied research competence and long-term integration (Research capacity-building…, 2025)
Infrastructure Investment	Expanding access to research databases, post-award support, and up-to-date facilities	Mitigates outdated infrastructure and administrative burden (Key strategies…, 2017)	Improves research feasibility, supports grant-funded and collaborative projects

4.2. Formalized Faculty Professional Development (TPD) and Mentorship Programs

To cultivate research excellence, capacity building must occur at individual, organizational, and systemic levels (Research capacity-building in teacher education, 2025). Effective Teacher Professional Development must move beyond single-session trainings toward long-term, context-specific initiatives. Evidence shows that impactful TPD includes collaborative learning, hands-on training, mentoring, and strong institutional support—conditions that positively influence teachers' confidence, motivation, and competence (A systematic review on teacher professional development…, 2025).

A crucial strategy for sustaining institutional research output is **formalized mentorship**, especially for early-career faculty. Structured mentorship supports junior academics as they navigate the complexities of institutional expectations for tenure and promotion (Key strategies…, 2017). Importantly, initial research success alone rarely guarantees long-term retention. Research-active faculty—particularly those with strong external funding—are often actively recruited by competing institutions. Thus, mentorship must include explicit pathways for leadership, professional advancement, and institutional recognition (Key strategies…, 2017).

Mentorship must also align the work of early-career researchers with broader institutional priorities by connecting them with experienced academic supervisors (Key strategies…, 2017). This ensures continuity of research infrastructure and sustainability of research culture beyond the lifespan of individual grants (Key strategies…, 2017).

4.3. Developing Research Competence in Initial Teacher Education

The primary objective of Initial Teacher Education (ITE) is to develop reflective practitioners capable of driving educational innovation (Developing research competence of pre-service EFL teachers, 2022). Research competence emerges not from passive learning but from pedagogical models that foster an **inquiry stance** and sustained participation in research processes.

Action Research has proven especially effective, providing a flexible methodology for improving teaching quality while simultaneously contributing to broader educational development (Developing research competence…, 2022). Through Action Research, pre-service teachers gain awareness of methodological challenges, learn strategies to address them, and understand the long-term relevance of research for professional practice (Developing research competence…, 2022).

To achieve full competency, pre-service teachers must conduct their own research or participate in substantive parts of a research process. Such engagement fosters perceived competence, demonstrates the real-world value of inquiry, and supports the transfer of research skills to future professional settings (Supporting pre-service teachers…, 2023). Research training must therefore be practice-oriented, context-specific, and aligned with school environments to strengthen motivation and emotional engagement (Supporting pre-service teachers…, 2023).

By centering procedural inquiry—such as Action Research and critical reflection on teaching practice (The impact of procedural knowledge…, 2021)—HPE addresses the methodological deficits characteristic of the Semantic Space (Science learning environments…, 2024). This

integration enhances metacognitive development, strengthens cognitive self-assessment, and increases motivation among future educators (Supporting pre-service teachers…, 2023).

V. Perspectives II: Integrating Modern Digital Research Methodologies

The digital transformation of higher education necessitates a fundamental shift in pedagogical research methodologies. Institutions must strategically embrace advanced digital tools to enhance both research capacity and instructional efficacy.

5.1. Digital Transformation as a Methodological Shift

Digital transformation in higher education constitutes a comprehensive restructuring of organizational culture, administration, infrastructure, and instructional practices (Transforming pedagogy…, 2024). Effective use of academic technology is consistently associated with improved instructional efficiency and student performance (The role of technology-based education…, 2022). Despite this promise, substantial gaps remain in understanding how lecturers adapt to digital learning environments (Transforming pedagogy…, 2024).

Therefore, institutional professional development must explicitly prioritize digital competence and research-informed digital methodologies to ensure future teachers can integrate technology effectively into their practice (Digital competence in higher education research…, 2022).

5.2. Leveraging Learning Analytics (LA) and Data-Driven Inquiry

The expansion of digital education platforms has generated extensive behavioral data, enabling a new research paradigm grounded in Learning Analytics (Educational research & learning analytics, n.d.). These platforms capture granular activity logs that reveal how learners engage with materials, providing unprecedented opportunities for evidence-based instructional research (Educational research & learning analytics, n.d.). As digital education grows, researchers increasingly employ data-driven methodologies to enhance learning effectiveness (Learning analytics and educational data mining…, 2014).

Learning Analytics serves as a powerful catalyst for instruction-focused research. It allows educators to quantify instructional impact in real time and utilize data dashboards that respond to learners' needs for explicit scaffolding (How does technology challenge teacher education?, 2022). Training faculty to use LA therefore represents training them in a high-volume, modern research methodology—one that enables movement from subjective impressions toward prescriptive, optimized instructional models (Learning analytics and educational data mining…, 2014).

5.3. Advanced Modeling through Technology (Eye-Tracking and Simulation)

Beyond traditional data sources, advanced technologies such as eye-tracking are reshaping pedagogical research. Eye-tracking has been successfully used to analyze how teachers notice and attend to relevant classroom events, offering groundbreaking methods for studying and training professional noticing (How does technology challenge teacher education?, 2022).

The strength of eye-tracking lies in its capacity to objectively model expert performance. By quantifying visual attention, researchers can translate intuitive pedagogical judgments—such as

detecting disengagement or identifying optimal intervention moments—into measurable patterns (How does technology challenge teacher education?, 2022).

This enables the design of targeted, evidence-based training practices that accelerate the development of Pedagogical Content Knowledge (PCK). By revealing discrepancies between expert and novice attention patterns, eye-tracking supports systematic development of expertise and refines the cognitive architecture underpinning high-quality teaching.

5.4. Ethical and Pedagogical Framing of Artificial Intelligence (AI)

Artificial Intelligence (AI) is rapidly transforming higher education, influencing assessment, feedback, content generation, and institutional policy (Artificial intelligence in higher education…, 2025). However, research demonstrates that AI's impact depends not on the technology itself but on its ethical guidance, pedagogical framing, and administrative support (Artificial intelligence in higher education…, 2025). Poorly integrated AI risks bias, shallow learning, and over-reliance.

Responsible implementation requires comprehensive frameworks such as the I-TPACK model, which intentionally integrates AI into teaching, learning, and assessment (Integrating artificial intelligence into pedagogy…, 2024). AI integration must remain human-centered, supporting learner agency, motivation, and self-regulated learning while mitigating shallow engagement (Artificial intelligence in higher education…, 2025).

Current limitations in understanding effective AI integration further underscore the need for focused research (Artificial intelligence in higher education…, 2025).

VI. Collaborative Ecosystems: Strengthening University–School Partnerships

A major impediment to embedding scientific inquiry in pedagogical practice lies within the **Social Space**—the limited collaboration between universities and schools (Science learning environments…, 2024). Robust collaborative ecosystems are essential for ensuring that research outcomes meaningfully influence educational practice.

6.1. The Criticality of the Social Space and Practical Relevance

Teacher education must ensure that future teachers acquire professional knowledge relevant to the demands of daily teaching practice (The importance of teachers' pedagogical-psychological knowledge…, 2024). Learning outcomes from teacher education should reliably predict instructional quality and student success (The importance of teachers' pedagogical-psychological knowledge…, 2024).

When university–school collaboration is weak, academic research risks remaining theoretically rich but practically irrelevant (Science learning environments…, 2024). Conversely, practical teaching experience during initial training shows strong positive correlations with motivational factors, professional identity development, and long-term career satisfaction (Importance of pedagogical practice in teaching satisfaction…, 2025). These developmental trajectories highlight the necessity of strengthening practice-embedded training.

6.2. Implementing Co-Designed Partnership Models

School–university partnerships provide essential structures for bridging research and practice. They enable researchers and teachers to collaboratively test, validate, and refine pedagogical innovations (Leveraging a school-university partnership model…, 2024). These partnerships also enhance professional experience placements for pre-service teachers (Leveraging a school-university partnership model…, 2024).

Scholarly practice identifies several collaboration models, including traditional peer-based models, consultant models, and mentoring structures (Models of inter-institutional collaboration…, 2007).

The most effective model, however, is the **co-designed partnership**, in which university educators and school practitioners collaboratively construct knowledge, mentor pre-service teachers, and co-develop instructional innovation (Leveraging a school-university partnership model…, 2024).

Critical factors for successful partnerships include:

- reinforcing relational agency among pre-service teachers
- adopting coaching approaches by school-based mentors
- embedding collaboration in long-term institutional planning

By formalizing these ecosystems, institutions create ongoing, real-world research laboratories where pedagogical theory and practice continuously inform each other. This alignment ensures that academic research remains relevant, actionable, and grounded in authentic learning environments.

VII. Conclusion

The analysis demonstrates that the integration of scientific inquiry into the Higher Pedagogical Education (HPE) system is not a supplementary enhancement but a foundational requirement for preparing competent, reflective, and research-informed teachers. The realities mapped across the Material, Social, and Semantic spaces reveal that systemic challenges—ranging from outdated infrastructure and misaligned institutional policies to methodological fragmentation and limited university–school collaboration—continue to hinder the effective realization of a research-rich pedagogical culture. Addressing these barriers requires coordinated institutional reforms that align incentives, strengthen faculty research capacity, modernize digital competencies, and cultivate a shared professional identity grounded in evidence-based practice.

Digital transformation and the expansion of new research technologies, including Learning Analytics, eye-tracking, and artificial intelligence, provide profound opportunities to elevate scientific productivity and pedagogical innovation. However, their successful adoption depends on ethical integration, sustained professional development, and institutional structures that support long-term engagement. Likewise, strengthening collaborative ecosystems through co-designed university–school partnerships ensures that academic research maintains practical relevance and directly contributes to improved teacher competence, instructional quality, and student learning outcomes.

Overall, a research-informed HPE system requires a holistic and future-oriented strategy: one that simultaneously builds institutional capacity, strengthens faculty expertise, embeds inquiry into curriculum design, and leverages modern technologies responsibly. When these efforts converge, they form the basis of a sustainable scientific culture capable of advancing pedagogical knowledge, supporting teacher professionalism, and ensuring that educational systems remain responsive to the evolving demands of contemporary teaching and learning.

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