Digital Education Technologies in the Development of Professional Competencies of Future Educators: A Framework for LMS-Integrated Learning Environments

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Keywords: Learning Management Systems, E-Learning Platforms, Professional Competencies, Teacher Education, Digital Pedagogy, Virtual Learning Environments.

Abstract: The integration of Learning Management Systems (LMS) and e-learning platforms into teacher education represents a fundamental structural shift in how professional competencies are formed, documented, and systematically assessed over time. This paper examines the functional architecture of LMS-based instructional environments and their specific role in developing professional teaching competencies and research-oriented activity among pre-service educators at the higher education level. Drawing on recent and peer-reviewed literature in educational technology, digital pedagogy, and teacher preparation programs, the paper proposes a four-component conceptual framework-comprising task design, feedback infrastructure, portfolio integration, and learning analytics-as the central organizing logic for technology-supported competence formation in contemporary teacher training contexts. The analysis reveals that measurable competency gains are most consistent and sustainable when LMS environments are deliberately configured to support authentic task production, iterative and formative feedback cycles, and evidence-based self-reflection, rather than functioning merely as passive content delivery systems. Furthermore, the paper highlights how research-oriented dispositions among pre-service teachers can be meaningfully cultivated through structured digital inquiry tasks embedded within LMS workflows. The proposed framework offers concrete and scalable practical guidance for higher education institutions seeking to modernize teacher education curricula through purposefully designed and pedagogically coherent digital learning environments.

1 INTRODUCTION

Learning Management Systems and e-learning platforms have moved from supplementary tools to primary instructional infrastructure in higher education worldwide. In teacher education specifically, the question is no longer whether digital platforms should be used, but how they should be configured to produce measurable professional outcomes. Pre-service educators who graduate without structured LMS experience face a documented readiness gap: they understand technology conceptually but lack the operational competence to deploy digital environments for pedagogically justified purposes [1].

Professional competence in the contemporary sense encompasses more than subject knowledge. It includes the capacity to design learning sequences aligned with outcomes, select and configure digital assessment instruments, orchestrate learner interaction in virtual spaces, interpret evidence of student progress, and iteratively improve instructional decisions based on data. Each of these capabilities can be cultivated within a well-designed LMS environment - but only when the platform is treated as a pedagogical infrastructure rather than a content repository [2].

The gap in current practice is that many teacher education programs use LMS platforms primarily for document distribution and grade recording. This usage pattern does not develop the competencies required for evidence-informed teaching. Research consistently shows that competence development requires repeated cycles of authentic production, feedback, and revision - processes that LMS environments can support but rarely instantiate by default [3].

This paper addresses the following question: what organizational and functional principles should govern LMS-integrated instructional environments to reliably develop professional competencies and research-oriented activity in pre-service teachers? The paper proceeds by reviewing the relevant literature on LMS functionality and competence development, proposing a four-component framework, and discussing practical implications for curriculum design and platform configuration.

2 LMS PLATFORMS AS PEDAGOGICAL INFRASTRUCTURE

2.1 Functional Architecture

A Learning Management System provides a unified digital environment for course delivery, task management, communication, assessment, and data collection. Contemporary platforms - including Moodle, Canvas, Blackboard, and Google Classroom - share a common functional architecture: content presentation layers, submission and grading modules, communication tools (forums, messaging, and video conferencing integrations), and data logging subsystems that record user interactions with sufficient granularity for learning analytics [4]. Google Classroom is included here as a widely used platform sharing this general architecture, although it is typically regarded as a simplified learning-management platform rather than a full-featured LMS such as Moodle, Canvas, or Blackboard, and its more limited rubric, analytics, and portfolio functionality should be taken into account when applying the framework proposed in this paper.

For teacher education purposes, the relevant distinction is between platforms used as passive repositories and platforms configured as active learning environments. In the passive configuration, students download readings, submit assignments, and receive grades. In the active configuration, the platform mediates iterative cycles of task production, peer review, instructor feedback, artifact revision, and reflective documentation. The latter configuration requires deliberate instructional design: assignment structures must specify criteria explicitly, feedback workflows must require responses, and portfolio components must link performance artifacts to reflective commentary [5].

The technical organization of the LMS-integrated module and its evidence flow are illustrated in Figure 1. The diagram shows how competency artifacts and inquiry deliverables are submitted through structured templates, scored by teacher educators using rubric dimensions, aggregated by the analytics service into progress views and feedback prompts, and exported in anonymized form for statistical analysis of competency change.

2.2 LMS in the Context of Teacher Competence Frameworks

Several national and international frameworks define the digital competencies expected of practicing teachers. The European DigComp 2.2 framework and its education-specific adaptation DigCompEdu identify six competency areas relevant to LMS use: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence [6]. These areas map directly onto LMS functional components: professional engagement through collaborative spaces and shared repositories; digital resources through curated content modules; teaching and learning through structured task sequences and interactive activities; assessment through rubric-scored assignments and formative feedback tools; and empowering learners through differentiated pathways and self-monitoring dashboards. The sixth area, facilitating learners' digital competence, maps onto the LMS's role in modelling and scaffolding students' own digital skills through the structured tasks, feedback tools, and portfolio activities described below.

The alignment between competence frameworks and LMS functionality suggests that a well-configured LMS can serve as both the learning environment and the assessment context for professional competence development. When pre-service teachers produce lesson plans, assessment instruments, and reflective portfolios within the LMS, the platform simultaneously delivers the learning experience and captures the evidence for competency evaluation [7].

3 PROPOSED FRAMEWORK: FOUR COMPONENTS OF LMS-SUPPORTED COMPETENCE FORMATION

Based on the literature review, this paper proposes a four-component framework for organizing LMS-integrated instructional environments in teacher education. The components are: Authentic Task Architecture, Structured Feedback Infrastructure, Electronic Portfolio Integration and Formative Analytics. These four components were selected because, taken together, they cover the complete instructional cycle identified in the literature review above: task design (what pre-service teachers produce), feedback (how performance is interpreted and improved), documentation (how evidence of competence accumulates over time), and data infrastructure (how progress is monitored and used for revision). Other candidate components considered during the review, such as peer-collaboration tools or gamification features, were treated as design choices within these four components rather than as separate structural elements. The iterative relationship among these components is illustrated in Figure 2, which depicts the Design-Enact-Evidence-Revise cycle that operationalizes competence formation across the term. Within an LMS, each stage of the cycle corresponds to a concrete set of platform activities. "Design" corresponds to the instructor configuring authentic tasks, rubrics, and portfolio templates in the course space. "Enact" corresponds to pre-service teachers completing these tasks and submitting artifacts through the LMS. "Evidence" corresponds to the accumulation of rubric scores, feedback records, portfolio entries, and interaction analytics generated automatically as students work. "Revise" corresponds to instructors and program teams using this accumulated evidence to adjust task design, feedback protocols, and course configuration for the next cycle, closing the loop back to "Design."

3.1 Authentic Task Architecture

Competence develops through doing, not observing. The first component of the framework requires that LMS assignments be designed as authentic professional productions rather than declarative exercises. Authentic tasks in teacher education include designing digital lesson plans with specified learning outcomes and technology rationale, constructing formative assessment instruments with explicit criteria and scoring guides, planning differentiated instruction sequences for diverse learner profiles, and conducting structured peer review of professional artifacts using evaluative rubrics [8].

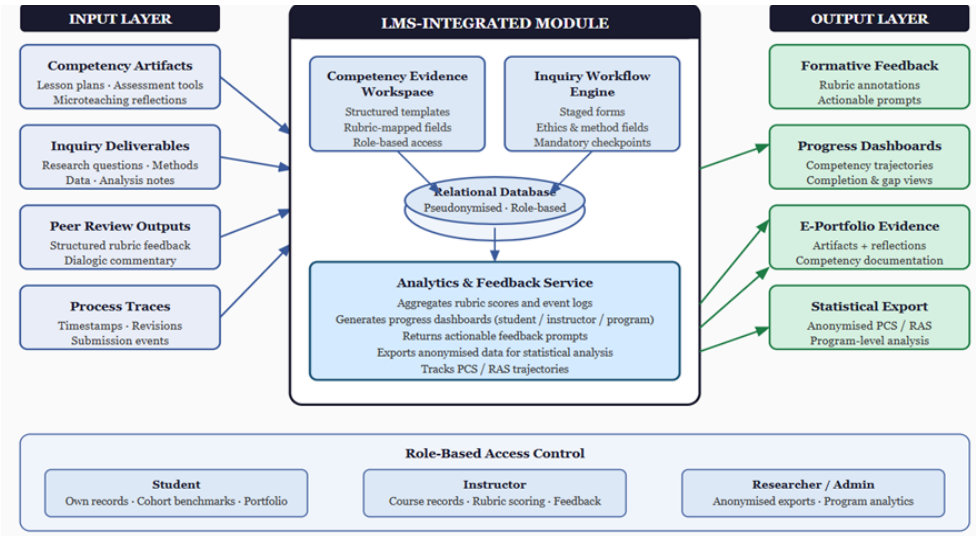

Figure 1: Architecture of the LMS-Integrated competence and research support module.

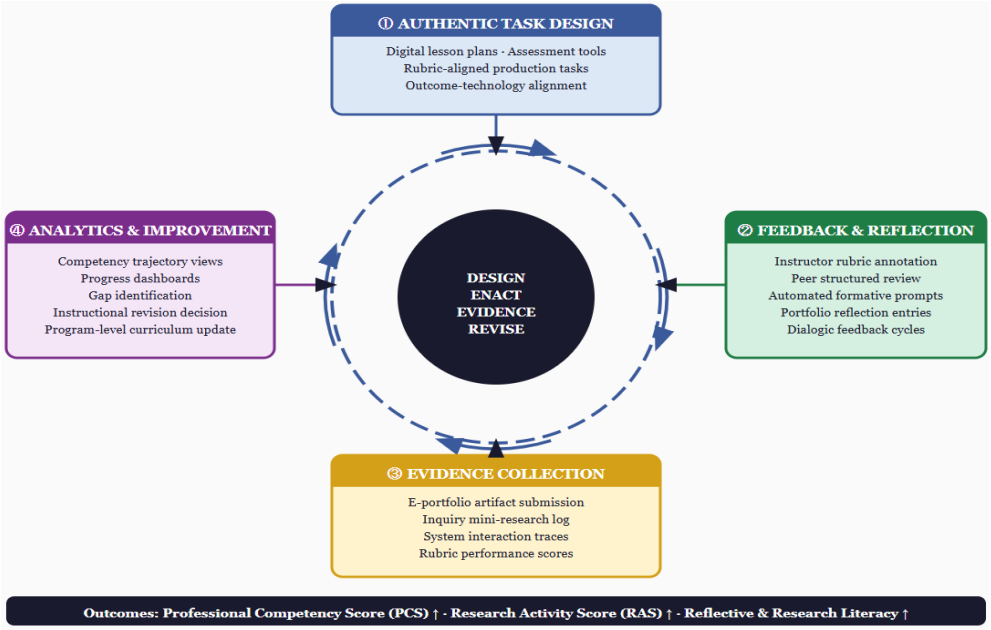

Figure 2: Competency development cycle in LMS-Integrated teacher education.

The key design principle is alignment: each task must be linked to a specific competency indicator, assessed with criteria that reflect professional standards, and positioned within a sequence that builds complexity progressively across the term. LMS assignment settings should enforce structured submission formats - for example, requiring separate fields for lesson objective, technology selection rationale, assessment plan, and anticipated adaptations - so that competency-relevant evidence is captured systematically.

Authentic task design also requires that assignments connect to teaching practice contexts. Where possible, tasks should be designed so that products created within the LMS can be used or tested in actual or simulated classroom settings, creating a productive loop between digital production and professional enactment [9].

3.2 Structured Feedback Infrastructure

Feedback is the primary mechanism through which competence develops in iterative cycles. The second component requires that LMS environments be configured to deliver structured, actionable, and dialogic feedback rather than summative grades alone. Three feedback modalities are particularly relevant in teacher education contexts.

Instructor feedback using rubric annotation tools allows evaluators to comment on specific competency dimensions rather than providing global impressions. When rubric dimensions correspond to professional competency indicators, annotated feedback becomes a direct instructional intervention targeted at competence gaps. LMS platforms with inline annotation, audio feedback, and criterion-specific comment fields support this modality effectively [3].

Peer feedback through structured review protocols extends the feedback capacity of the environment and simultaneously develops evaluative competence in the reviewer. When peer review assignments require reviewers to apply the same rubric used in instructor assessment, the activity builds assessment literacy alongside the competencies targeted in the original task. Research indicates that evaluating others' professional work activates metacognitive processes that strengthen reflective practice [10].

Automated formative feedback through adaptive quiz modules and submission checklists provides immediate response to lower-stakes learning activities. While automated feedback cannot replace professional judgment on complex performance tasks, it supports competence development by maintaining engagement between instructor feedback cycles and providing immediate confirmation or

correction on knowledge-level learning relevant to professional decision-making [4].

3.3 Electronic Portfolio Integration

The electronic portfolio is the competence documentation infrastructure of the framework. An e-portfolio within the LMS serves three simultaneous functions: it is a learning tool, an assessment tool, and a professional development tool. As a learning tool, portfolio maintenance requires pre-service teachers to select artifacts, write reflective commentary, and articulate connections between learning experiences and competency development. As an assessment tool, it provides evidence for competency-level judgments that cannot be captured by single-point assignments. As a professional development tool, it begins the documentation practice that many educational systems require throughout the career [6].

Effective portfolio integration requires explicit structural design. Portfolio entries should follow a consistent format linking artifact description, competency indicator addressed, evidence of learning, and improvement plan. For example, a single portfolio entry might be structured as four short fields: (1) Artifact - a link to the submitted lesson plan or assessment instrument; (2) Competency indicator - the specific DigCompEdu or program competency the artifact demonstrates; (3) Evidence of learning - a short reflective statement explaining what the artifact shows about the student's developing practice; and (4) Improvement plan - a brief note on what the student intends to change in the next iteration. This four-field template can be implemented directly as a structured LMS submission form. Supervisors should provide scheduled feedback on portfolio entries - not only on the artifacts contained within them - so that reflection quality itself is assessed and supported. The LMS should be configured so that portfolio development is a continuous, module-spanning activity rather than a summative submission at the end of the term [5].

Research on reflective portfolio designs indicates that structured portfolio work combined with dialogic feedback strengthens learners' capacity to interpret feedback, make epistemic shifts in learning goals, and develop sustainable reflective habits [7]. These capabilities are directly connected to evidence-informed teaching practice and research engagement.

3.4 Formative Analytics

The fourth component addresses the data infrastructure that makes the other three components observable and improvable. Contemporary LMS platforms generate granular interaction data: access timestamps, submission timing, time-on-task estimates, revision frequencies, feedback view events, forum participation patterns, and grade trajectories. When these data are organized into actionable dashboards, they support three types of formative decision-making.

At the student level, progress dashboards allow pre-service teachers to monitor their own engagement patterns, identify gaps in feedback uptake, and compare their trajectories against course expectations. This self-monitoring function develops metacognitive and self-regulatory competencies that are directly relevant to professional autonomy in the classroom.

At the instructor level, cohort-level analytics allow teacher educators to identify students at risk of disengagement before summative assessment points, adjust task pacing or feedback frequency based on submission patterns, and evaluate whether specific assignment designs are generating the intended engagement.

At the program level, aggregated competency trajectories across cohorts provide evidence for curriculum evaluation and revision. When rubric-scored data are extracted and analyzed systematically, programs can identify which instructional components produce the strongest competency gains and which require redesign [10].

4 RESEARCH COMPETENCE WITHIN LMS ENVIRONMENTS

Research-oriented activity is increasingly recognized as a core outcome of initial teacher preparation rather than an advanced specialization. Pre-service teachers who develop research competence during initial training are better positioned to engage in evidence-based practice, contribute to school improvement processes, and maintain professional learning throughout the career [8].

LMS environments support research competence development through three mechanisms. First, structured inquiry workflows can be embedded as assignment sequences within the LMS: problem identification and literature review, research question formulation, instrument design, data collection planning, analysis and interpretation, and academic reporting. When these stages are scaffolded as separate submissions with specific feedback at each stage, the inquiry process becomes a series of

manageable, assessable steps rather than an overwhelming terminal project.

Second, integration with academic databases and digital library resources through LMS link repositories gives pre-service teachers direct access to peer-reviewed literature within the course environment. When literature engagement is built into assignment requirements - for example, requiring annotated bibliography submissions or evidence-based lesson plan justifications - students develop research information literacy as part of professional task production.

Third, the LMS portfolio provides a natural home for mini-research documentation. When pre-service teachers are required to connect their supervised inquiry projects to portfolio entries that link research findings to instructional decisions, research activity becomes integrated with professional practice rather than treated as a separate academic exercise [9].

5 IMPLEMENTATION CONSIDERATIONS

5.1 Instructor Readiness and Modelling

The effectiveness of LMS-integrated competence development depends substantially on how teacher educators use the platform themselves. Research consistently shows that preservice teachers benefit most when teacher educators demonstrate authentic technology use and align tasks with real instructional decisions [2]. This implies that implementing the proposed framework requires attention to instructor professional development alongside platform configuration: teacher educators need supported time to redesign assignments, calibrate rubrics, develop feedback protocols, and interpret analytics.

Accessibility and Equity

LMS-based instruction introduces accessibility requirements that must be addressed proactively. Students with limited device access, unstable internet connectivity, or disabilities requiring platform accommodations represent a significant proportion of pre-service teacher populations in many regional and national contexts. Framework implementation should include provisions for offline access where feasible, mobile-responsive design, accessibility testing for screen readers and alternative navigation, and explicit accommodation protocols that do not penalize students for connectivity barriers [1].

5.2 Academic Integrity and Data Ethics

LMS environments collect substantial personal and behavioral data, creating obligations for ethical data governance. Access controls should operate on a role-based model with minimum necessary data principles: students access their own records and aggregated cohort benchmarks; instructors access records of students enrolled in their courses; administrators access anonymized program-level aggregates. Data retention policies should be defined prior to implementation, and students should receive clear information about what data are collected, how they are used, and under what conditions they may be shared [4].

Academic integrity in LMS environments requires policy alignment between platform settings and institutional expectations. Submission originality checking, time-limited assessment configurations, and proctoring integrations each carry pedagogical trade-offs that should be resolved at the program level rather than left to individual instructor discretion.

6 CONCLUSIONS

This paper has proposed a four-component framework - authentic task architecture, structured feedback infrastructure, electronic portfolio integration, and formative analytics - as the organizing logic for LMS-integrated competence development in teacher education. The framework is grounded in the convergence of evidence on task authenticity, feedback dialogicity, portfolio-based reflection, and data-informed instruction.

The central argument is that LMS platforms develop professional competencies reliably only when they are configured as active pedagogical infrastructures rather than passive content repositories. Configuration requires deliberate alignment between competency frameworks, assignment designs, assessment criteria, feedback workflows, and analytics dashboards. When these elements are coherently connected, the LMS environment becomes capable of supporting iterative competence formation, research-oriented activity, and reflective professional development simultaneously.

For higher education institutions seeking to modernize teacher education curricula, the framework offers a practical basis for LMS redesign that does not require new platforms - only purposeful reconfiguration of existing ones. Future work should examine implementation fidelity across diverse

institutional contexts, explore the differential effects of individual framework components, and develop validated instruments for assessing the quality of LMS configuration as a predictor of competency outcomes.

ACKNOWLEDGMENTS

The authors thank the participating universities for providing the institutional conditions necessary for this work. We are grateful to colleagues who assisted with framework review and provided methodological feedback during preparation.

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