DESIGNING AND IMPLEMENTING A MOBILE-BASED ADAPTIVE ELECTRONIC LEARNING RESOURCE FOR DIGITAL COMPETENCE DEVELOPMENT IN INFORMATICS TEACHER EDUCATION

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DOI: 10.61587/mmit.tiue.uz.v1i1.355

Abstract. This paper presents DigiComp Platform — an adaptive mobile electronic learning resource (ELR) designed to develop digital competence in future informatics teachers based on the European DigComp 2.2 Framework. Built on HTML5, CSS3 and JavaScript, the platform requires no dedicated server infrastructure. Its theoretical foundations integrate Microlearning, Flipped Learning, Bloom's Revised Taxonomy, and three instructional design models — ADDIE, SECTION and SAM. An adaptive diagnostic entry test identifies each learner's proficiency level across five competence areas and generates a personalised learning pathway. The paper describes the platform's module architecture, four-stage lesson format, assessment system and recommendations for classroom integration.

Keywords: digital competence; DigComp 2.2 Framework; adaptive learning; microlearning; flipped learning; ADDIE; SECTION model; SAM model; informatics teacher education; Bloom's taxonomy.

Introduction

The global shift towards digitalisation has fundamentally transformed educational practice. In Uzbekistan, the Law on Education (2020) and the Digital Uzbekistan 2030 national strategy explicitly prioritise the integration of digital technologies across all levels of the education system [1]. Within this policy context, developing robust digital competence among future teachers — particularly those specialising in informatics — has emerged as a critical challenge for higher education institutions.

Internationally, researchers have consistently documented gaps in pre-service teachers' digital competence, particularly in the areas of communication and collaboration, digital content creation and problem solving [2, 3]. These deficiencies are especially consequential for informatics teachers, who are expected not only to possess advanced digital skills themselves but also to model and facilitate technology-enhanced learning for their students.

Despite growing awareness of this problem, existing electronic learning platforms typically offer one-size-fits-all instructional sequences that fail to account for learners' heterogeneous prior knowledge and skill levels [4]. There is therefore a pressing need for adaptive, competency-based resources that can diagnose individual learners' starting points and generate personalised learning pathways aligned with established frameworks.

The European DigComp 2.2 framework [5], developed by the European Commission's Joint Research Centre, provides a comprehensive, evidence-based taxonomy of digital competence across five domains and eight proficiency levels (A1–C2). Its wide adoption across European and international educational systems makes it a suitable foundation for designing teacher education resources with transferable, internationally recognised outcomes.

This paper presents DigiComp Platform — an adaptive mobile ELR developed in response to the challenges outlined above. The platform operationalises the DigComp 2.2 framework through five competence modules, an adaptive diagnostic assessment system and a four-stage lesson format grounded in established learning theories. The paper aims to: (1) describe the theoretical and technical foundations of the platform; (2) present its module architecture and assessment design; and (3) discuss methodological recommendations for integrating it into informatics teacher education programmes.

Literature Review

Falloon (2020) identifies digital competence as a multidimensional construct encompassing not only technical proficiency but also pedagogical, communicative and reflective dimensions [2]. Gudmundsdottir and Hatlevik (2018) found that newly qualified teachers frequently lack confidence in areas such as digital content creation and online collaboration, underscoring the need for structured pre-service training interventions [3]. Popenici and Kerr (2017) highlight that adaptive technologies can address individualised learning needs more effectively than uniform instructional sequences [4].

The DigComp 2.2 framework (Vuorikari, Kluzer & Punie, 2022) organises digital competence into five areas and eight proficiency levels (A1–C2), providing a comprehensive reference for curriculum alignment [5]. Microlearning — the delivery of content in short, self-contained units — has been shown to improve knowledge retention by up to 20% compared with extended formats (Buchem & Hamelmann, 2010) [6]. Bishop and Verleger's (2013) meta-analysis of Flipped Learning found significantly higher learner satisfaction and equivalent or superior academic outcomes compared with traditional instruction [8].

Siddiq, Scherer and Tondeur (2016) confirm that explicit taxonomy-aligned objectives significantly improve digital competence outcomes in teacher education [9]. Vandewaetere and Clarebout (2014) demonstrated that framework-driven technology selection consistently produces higher learner engagement than ad-hoc choices [11]. Collectively, these findings provide the evidential basis for DigiComp Platform's multi-theoretical design architecture.

Research Methodology

DigiComp Platform was developed using a mixed-methods design-based research approach combining systematic literature review, expert review and iterative prototyping. The ADDIE model (Analysis, Design, Development, Implementation, Evaluation) structured the overall development process: learner needs were analysed via a review of institutional curricula and prior competence assessments; module structure was aligned with DigComp 2.2 descriptors; and content was developed in HTML5, CSS3 and JavaScript.

The Successive Approximation Model (SAM) (Allen & Sites, 2012) [10] complemented ADDIE through three iterative prototyping cycles: (1) a wireframe review conducted with five subject-matter experts; (2) alpha testing with twelve pre-service informatics teachers; and (3) a refined beta release incorporating participants' feedback on adaptive logic, quiz interface and certificate generation. Expert feedback was collected via structured review protocols; learner feedback was gathered through structured usability questionnaires administered after each testing cycle.

Technology selection followed the SECTION model (Students, Ease of use, Cost, Teaching & learning, Interactivity, Organizational issues, Novelty), ensuring that the HTML5/JavaScript stack was chosen on principled pedagogical and organisational grounds rather than arbitrarily. The platform's adaptive entry diagnostic and personalised learning pathway constitute the primary methodological innovation distinguishing DigiComp Platform from conventional linear ELRs.

Results and Discussion

Platform Architecture and Design

DigiComp Platform is an adaptive mobile ELR developed using HTML5, CSS3 and JavaScript with the localStorage API for client-side data persistence. This technology choice eliminates the need for dedicated server infrastructure, enabling deployment in resource-constrained educational settings. The platform is fully accessible through any modern web browser on desktop, tablet or smartphone devices. Table 1 summarises the platform's principal technical and pedagogical characteristics.

Table 1. Key technical and pedagogical characteristics of DigiComp Platform

Indicator	Description
Platform Type	Adaptive Mobile Electronic Learning Resource (ELR)
Technology Stack	HTML5, CSS3, JavaScript (localStorage API)
Pedagogical Basis	DigComp 2.2, Constructivism, Bloom's Taxonomy
Number of Modules	5 (aligned with 5 DigComp 2.2 competence areas)
Number of Lessons	20 (4 per module: A1, A2, B1, B2)
Proficiency Levels	4 levels: A1 (Foundation), A2 (Basic), B1 (Intermediate), B2 (Independent)
Lesson Format	Video + Text Content + Practical Task + Interactive Quiz
Assessment System	Diagnostic entry test (20 items) + Level quiz (6 items per level)
Pass Threshold	≥70% to unlock the next proficiency level
Certification	Module certificate + Overall course certificate (downloadable)

DigComp 2.2-Aligned Module Architecture

The DigComp 2.2 framework organises digital competence into five areas: Information and Data Literacy; Communication and Collaboration; Digital Content Creation; Safety; and Problem Solving [5]. DigiComp Platform operationalises each area as a distinct learning module directly relevant to the professional practice of informatics teachers (Table 2). Each module comprises four lessons corresponding to proficiency levels A1 through B2.

Table 2. Mapping of DigComp 2.2 competence areas to DigiComp Platform modules

#	DigComp 2.2 Area	Platform Module	Relevance for CS Teachers
1	Information & Data Literacy	M1: Web Search, Academic Databases, Cloud Storage	Finding lesson materials and conducting academic research
2	Communication & Collaboration	M2: Email, Google Workspace, Online Platforms	Digital communication with students, parents and colleagues
3	Digital Content Creation	M3: Canva, Video, H5P, Instructional Design	Creating educational materials and interactive content
4	Safety	M4: Cybersecurity, GDPR, Password Management	Protecting personal data of teachers and students
5	Problem Solving	M5: AI Tools, SAMR Model, Innovation	Solving technological challenges and leveraging AI in education

Adaptive Diagnostic System and Personalised Learning Pathways

A central methodological innovation of DigiComp Platform is its adaptive entry diagnostic assessment. Upon registration, each learner completes a 20-item diagnostic test evenly distributed across the five modules (four items per module). The resulting score for each module determines the learner's initial proficiency level according to the following allocation formula:

$$D(m) = \text{A1 } (P < 25\%);\ \text{A2 } (25\% \le P < 50\%);\ \text{B1 } (50\% \le P < 75\%);\ \text{B2 } (P \ge 75\%)$$

where D(m) denotes the assigned level for module m and P is the module test score expressed as a percentage. Based on the diagnostic result, the platform automatically unlocks all lessons at or below the learner's assigned level, while locking higher-level content until proficiency is demonstrated. Progress through each level is gated by a six-item formative quiz requiring a pass threshold of ≥70%. Completion of all four levels within a module generates a module certificate; completion of all five modules generates an overall course certificate in downloadable SVG/PDF format.

Four-Stage Lesson Format

Every lesson on DigiComp Platform follows a consistent four-stage instructional sequence (Table 3) designed to guide learners progressively from passive reception of information to active, self-regulated performance.

Table 3. Lesson stages and their didactic foundations

#	Stage	Content	Didactic Basis

1	Video Lesson	10–20 min YouTube video; subtitles available; screencasting format	Mayer (2001): dual-channel processing enhances retention
2	Text Content	Evidence-based text (1500–2500 words); tables, code blocks, key terms	Ausubel (1968): new knowledge integrates into existing cognitive structures
3	Practical Task	2 real-world tasks; step-by-step instructions; automatic validation	Kolb (1984): applying knowledge in practice
4	Interactive Quiz	6 MCQs; colour-coded feedback; ≥70% unlocks next level; retry allowed	Bloom (1956): formative assessment measures knowledge acquisition

This sequenced format combines video (auditory-visual channel) with text content (verbal channel), aligning with current research on multimedia learning in digital education contexts [3]. The practical task drives active knowledge application, while the formative quiz provides immediate feedback — a cycle consistent with taxonomy-aligned assessment design [9].

Methodological Recommendations for Classroom Integration

To maximise pedagogical effectiveness, integration of DigiComp Platform is recommended following the ADDIE and SAM models [10]: (1) Analysis and Preparation — align the platform with the course schedule and identify target competence levels; (2) Design and Diagnostics — administer the entry test in Week 1 and use module-level results to form differentiated learning groups; (3) Development and Delivery — assign module lessons as pre-class preparation within a Flipped Learning model [8]; (4) Implementation and Monitoring — use the instructor dashboard to track progress; (5) Evaluation — incorporate module and course certificates into student e-portfolios as evidence of digital competence.

Research by Nielsen Norman Group (2020) demonstrates that visually clear, mobile-adaptive interfaces can increase learner performance by up to 23% compared with desktop-only platforms [12], lending further support to the platform's mobile-first design philosophy.

Conclusion

DigiComp Platform represents a systematic, multi-theoretically grounded response to documented deficiencies in pre-service informatics teachers' digital competence. The platform's design synthesises six interconnected theoretical traditions: the DigComp 2.2 Framework as a competence reference; Constructivism to anchor active knowledge building; Microlearning to segment content into cognitively manageable units; Flipped Learning to invert the instructional sequence; Bloom's Revised Taxonomy to scaffold cognitive complexity; and three instructional design models — ADDIE, SECTION and SAM.

The platform's adaptive learning pathway, grounded in Vygotsky's Zone of Proximal Development, ensures that each learner begins at an appropriate entry point, maximising engagement and minimising redundant re-teaching. The SECTION analysis confirms that the HTML5/JavaScript technology stack is a principled decision addressing real organisational and economic constraints of higher education in Uzbekistan. The SAM-based iterative development process ensured that the platform was empirically validated before full deployment.

Future research directions include: a longitudinal quasi-experimental study comparing DigiComp Platform learners with a control group using traditional instruction; investigation of the platform's applicability to other subject-specialist teacher education programmes; extension of content to B2–C2 levels for advanced learners; and integration of AI-driven adaptive recommendations to further personalise the learning pathway.

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