



THEORETICAL AND METHODOLOGICAL FOUNDATIONS FOR THE DEVELOPMENT OF DESIGN COMPETENCE AMONG FUTURE PRESCHOOL EDUCATORS IN A DIGITAL EDUCATIONAL ENVIRONMENT

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Abstract

Background. The digital transformation of education requires preschool teacher education to move beyond the instrumental use of technology towards the ability to purposefully design learning experiences for young children. Design competence, understood as the capacity to analyse learning needs, model, prototype, implement and evaluate developmentally appropriate learning environments and resources, remains insufficiently conceptualised in early childhood teacher education. **Aim.** This article substantiates the theoretical and methodological foundations for developing design competence among future preschool educators in a digital educational environment. **Methods.** The study applies a conceptual-methodological approach based on thematic analysis of the theoretical literature and on the integration of the TPACK, DigCompEdu, backward design and constructive alignment frameworks. **Results.** A working definition of design competence is proposed, together with a five-component structure (conceptual-pedagogical, digital-technological, creative-design, reflective-evaluative and ethical-value), a three-level scale of development, and a four-stage methodological model of training (orientation, modelling, practice-based implementation, reflection). Pedagogical conditions and an assessment approach are specified. **Conclusion.** The proposed model provides a coherent basis for curriculum design and for future empirical validation through mixed-methods research.

Keywords: design competence; preschool teacher education; digital educational environment; TPACK; digital competence; reflective practice; methodological model

1. Introduction

Digital technologies are reshaping the content, tools and organisation of teacher education worldwide. International frameworks such as the European Framework for the Digital Competence of Educators (DigCompEdu) and the UNESCO ICT Competency Framework for Teachers define digital competence as a broad professional capacity that includes planning, pedagogy, assessment and professional engagement, not merely technical skill [1], [2]. For early childhood education this shift is particularly sensitive, because the use of technology with young children must be developmentally appropriate, play-based and safe.

Research shows that the use of digital technology in preschool settings depends strongly on educators' beliefs, knowledge and confidence [3]. Studies of guided interaction demonstrate that the quality of adult mediation, rather than the device itself, determines the learning value of children's digital activity [4]. At the same time, educators' dispositions towards digital devices in play-based pedagogy are often ambivalent [5]. These findings suggest that future

preschool educators need to be prepared not only to use ready-made applications, but to select, adapt and create learning activities and environments consciously.

This capacity can be described as design competence. Laurillard conceptualised teaching as a design science, in which teachers continually improve learning designs using evidence and digital tools [6]. In the technology-integration literature, the TPACK framework explains the interplay of technological, pedagogical and content knowledge [7], and the design of educational technology by teachers themselves has been shown to be an effective way of developing it [8]. However, syntheses of pre-service teacher education indicate that programmes often treat technology as a separate course and offer limited authentic design experience [9]. Moreover, teacher technology change is influenced by both first-order barriers (access, time) and second-order barriers (beliefs, pedagogical thinking) [10].

The research gap is therefore twofold: (a) the concept of design competence of future preschool educators lacks a clear structure and developmental levels; (b) there is no coherent methodological model that links theory, digital environment, practicum and assessment. **The aim** of this article is to substantiate the theoretical and methodological foundations for the development of design competence among future preschool educators in a digital educational environment. The research questions are: (1) What is the content and structure of design competence in this context? (2) Which theoretical approaches underpin its development? (3) What methodological model and pedagogical conditions ensure its development?

2. Methods

2.1. Research design

The study is conceptual-methodological in nature. It follows the logic of design-oriented and mixed-methods research, in which a theoretical model is first constructed and then prepared for empirical validation [11]. The present article reports the first phase, model construction.

2.2. Analytical procedure

The theoretical literature on teacher design competence, digital competence, early childhood technology use and teacher education was analysed using thematic analysis, which involves familiarisation with the sources, coding, theme generation, theme review and definition [12]. The identified themes were used to derive components of design competence and the principles of the training model.

2.3. Theoretical frameworks

Three groups of frameworks structured the analysis: (a) competence frameworks (TPACK [7], [8] and DigCompEdu [1]), which supplied the knowledge and digital dimensions; (b) curriculum design frameworks, namely backward design [13] and constructive alignment [14], which supplied the logic of aligning outcomes, activities and assessment; and (c) learning theories (sociocultural, experiential, reflective-practice and multimedia learning theories), which supplied the psychological and didactic foundations.

2.4. Model construction criteria

The model was developed according to four criteria: theoretical coherence, relevance to early childhood education, operationalisability in a digital learning environment (a learning management system, collaborative boards, authoring and prototyping tools), and assessability through observable indicators.

3. Results

3.1. Working definition

Design competence of a future preschool educator is defined as an integrative professional quality that enables the student to analyse the developmental needs of children and the learning context, to model and prototype play-based learning activities, resources and environments using digital and non-digital means, to implement them with pedagogical sensitivity, and to evaluate and improve them reflectively, in accordance with ethical and safety requirements.

3.2. Structure of design competence

The analysis resulted in five interrelated components.

1. **Conceptual-pedagogical component:** knowledge of child development, early learning standards, play-based pedagogy and the principles of learning design; corresponds to pedagogical and content knowledge in TPACK [7].
2. **Digital-technological component:** the ability to select, use and critically evaluate digital tools, to create digital resources, and to protect children's data and wellbeing; corresponds to the technological dimensions of TPACK and to DigCompEdu areas of digital resources and teaching and learning [1], [7].
3. **Creative-design component:** skills of needs analysis, idea generation, storyboarding, prototyping and adaptation of resources for diverse children, including inclusive adaptation.
4. **Reflective-evaluative component:** the ability to analyse one's own design decisions, to collect feedback from children, mentors and peers, and to iterate.
5. **Ethical-value component:** responsibility for the child's rights, safety, privacy and balanced screen use; professional motivation and a positive attitude towards innovation.

3.3. Theoretical foundations

Four theoretical approaches were identified as the foundation for development.

- **Sociocultural approach.** Learning is mediated by tools and social interaction, and develops in the zone of proximal development [15]. In teacher education this supports collaborative design in teams, mentoring and scaffolded tasks, and it also underlies the educator's mediation of children's digital activity.
- **Reflective practice.** Professional expertise develops through reflection-in-action and reflection-on-action [16], which justifies the iterative design cycle and design journals.
- **Experiential learning.** Competence develops through a cycle of concrete experience, reflective observation, abstract conceptualisation and active experimentation [17], which supports practicum-based design projects.
- **Cognitive theory of multimedia learning.** Principles such as coherence, signalling and modality guide the design of effective digital materials and prevent cognitive overload [18]. For preschool children these principles require adaptation towards concrete, multisensory and play-based formats.

3.4. Levels of development

A three-level scale was proposed for diagnostics and for planning the learning trajectory.

Level	Characteristics	Typical indicators
Basic (reproductive)	Uses ready-made digital resources and templates; limited justification of choices	Selects an existing application for a given topic; describes its purpose
Intermediate (adaptive)	Adapts and combines resources to the group's needs; links activities to learning outcomes	Modifies a digital activity for different developmental levels; justifies choices using standards
Advanced (creative-productive)	Independently designs original activities and environments; evaluates and improves them systematically	Creates and tests a prototype; revises it using evidence from practice; shares it with peers

3.5. Four-stage methodological model

The model integrates backward design [13] and constructive alignment [14] with the design cycle.

Stage 1. Orientation and analysis. Students study the standards, children's needs and the digital environment, and analyse exemplar learning designs. Outcomes and criteria are defined first, and assessment evidence and activities are planned afterwards [13].

Stage 2. Modelling and prototyping. In teams, students create storyboards, activity scenarios and digital prototypes (interactive stories, simple games, augmented-reality cards, digital portfolios for children). Teacher educators provide scaffolding and models.

Stage 3. Implementation in practice. Prototypes are tested in simulated settings and during practicum in kindergartens under mentor supervision, with attention to child safety and ethical requirements.

Stage 4. Reflection and refinement. Students analyse results using observation notes, feedback and design journals, revise the prototype and present a design portfolio.

3.6. Pedagogical conditions

Five conditions were identified as necessary: (1) a digital educational environment that supports collaboration, resource sharing and feedback; (2) integration of design tasks across subject courses instead of an isolated technology course [9]; (3) authentic practicum partnerships with kindergartens; (4) professional development of teacher educators, who themselves model design and technology use; and (5) collaborative curriculum design as a learning format, since collaboration has been shown to support teacher learning in design [19].

3.7. Assessment

Assessment is aligned with the intended outcomes [14] and uses an analytic rubric covering the five components and three levels, supplemented by portfolio evaluation, peer review and mentor observation during practicum. Formative assessment is applied at each stage to guide improvement.

4. Discussion

The proposed model responds to the criticism that technology preparation in teacher education is often fragmented and weakly connected to practice [9]. By placing design as the integrative activity, it connects knowledge (TPACK), digital competence (DigCompEdu) and

professional reflection in one cycle. This is consistent with the evidence that engaging teachers as designers of technology-enhanced learning promotes the integration of technological, pedagogical and content knowledge [8], and with the view of teaching as a design science [6].

The model also addresses the second-order barriers identified in the literature, namely beliefs and pedagogical reasoning [10], through reflective tasks and mentored practice. Its ethical-value component responds to concerns about developmentally appropriate technology use in the early years and to the finding that adult mediation determines the quality of children's digital experiences [3], [4], [5].

Several limitations should be noted. First, the model is theoretically derived and has not yet been empirically tested. Second, the proposed levels and indicators require validation of the rubric (content validity, inter-rater reliability) in the Uzbek higher education context. Third, the availability of digital infrastructure in kindergartens and universities may vary, and the model must be adapted to local conditions.

Future research should include a mixed-methods study [11] with a quasi-experimental pre-test/post-test design, comparing experimental and control groups of students, supported by rubric scores, portfolio analysis, questionnaires on digital competence and interviews or focus groups with students and mentors.

5. Conclusion

The article substantiated the content and structure of design competence of future preschool educators, identified its theoretical foundations (sociocultural, reflective, experiential and multimedia learning approaches), and proposed a four-stage methodological model with pedagogical conditions and an assessment approach in a digital educational environment. The model can serve as a basis for updating teacher education programmes and for subsequent empirical validation of its effectiveness.

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