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RESEARCH ARTICLE

The Role of Artificial Intelligence and Digital Technologies in Developing Infographic Competence of Future Teachers: Theoretical Foundations and Integration Methodology

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Abstract

This article examines the problem of developing infographic competence in future primary school teachers within the framework of modern digital pedagogy. Infographic competence is defined as a four-component cyclic structure: cognitive-epistemological, practical-technological, methodological-pedagogical, and creative-reflective. The specific pedagogical role of artificial intelligence tools (Canva Magic Design, Piktochart AI, Gamma.app, ChatGPT) is identified for each component. The theoretical foundation of the study consists of the DigCompEdu framework, the TPACK model, and R. Mayer's multimedia learning theory. The article proposes a three-stage competence development pathway and provides practical recommendations for integration into higher education curricula. The research directly aligns with the "Digital Uzbekistan – 2030" strategy and state decisions on reforming pedagogical education in the Republic of Uzbekistan.

KEYWORDS

Infographic competence, artificial intelligence, generative AI, digital technologies, DigCompEdu, TPACK, multimedia learning, competence model, primary education, pre-service teacher.

INTRODUCTION

Modern education faces fundamentally new professional demands: a future teacher must not only possess subject-matter knowledge but also acquire the competence to present complex pedagogical information in visual formats accessible to students' perception. However, international observations reveal a sharp problem: in a survey of 322 student teachers at Austrian universities, half reported that their programs did not adequately develop digital competence [1]. The Spanish experience confirms this conclusion: traditional courses not based on active methodologies fail to develop teacher digital competence to the expected level [2].

The problem runs deeper: in pedagogical education, infographics often remain at the level of "visual aids" and are not taught as a competence. As a result, graduating teachers encounter diverse visual content creation tools in practice and are unable to use them for pedagogical purposes — which directly affects the quality of learning for primary school students [3, 4].

In response to this problem, this article raises the following central question: through what specific mechanisms can artificial intelligence and digital technologies participate in forming future teachers' infographic competence? The scientific novelty of the research is manifested in two directions: (1) infographic competence is defined for the first time as a four-component cyclic model, and a corresponding generative AI tool is assigned to each component; (2) DigCompEdu, TPACK, and multimedia learning theories are applied as a unified methodological basis to the national educational context.

LITERATURE REVIEW AND PROBLEM STATE

1.1. Digital Competence: International Frameworks

The European Commission's DigCompEdu framework (Redecker, 2017) describes teacher digital competence through 22 skills across six domains; the most critical being digital content creation and adaptation [1]. Extensive analyses of this framework show that traditional teacher education programs cover only the surface layer of DigCompEdu requirements, and visual content creation skills are not developed systematically [2, 5].

The TPACK model (Mishra & Koehler, 2006) emphasizes that teacher competence forms at the intersection of three types of knowledge: Content, Pedagogy, and Technology [6]. Infographic competence is an ideal example for this model: a teacher creating an infographic simultaneously selects subject content didactically, transforms it into a visual structure, and consciously manages the technological tool for this purpose.

1.2. Cognitive Foundations: Mayer and Sweller

R. Mayer's (2009; 2020) multimedia learning theory serves as the primary theoretical pillar of infographic pedagogy. According to the theory, humans process information through two separate channels — visual and verbal; synchronously activating these channels significantly increases comprehension and retention [7]. Based on Mayer's "coherence principle," excess visual elements in a lesson increase cognitive load — this defines the key methodological constraint of pedagogical infographic design.

J. Sweller's (1988) cognitive load theory complements this model: organizing information into a graphic structure reduces "extraneous cognitive load" for the limited "working memory" capacity of the mind, directing students' mental energy toward understanding [8]. For primary school students — at a stage when abstract thinking is still developing — the practical synthesis of these two theories holds particular didactic significance [3, 4].

1.3. Infographics in Education: Empirical Findings

Ozdamli and Ozdal (2018), conducting a 52-hour training session with 43 primary school teachers based on the ADDIE model, achieved two important results: specialized infographic design training statistically significantly increased participants' self-efficacy; students in lessons using infographics mastered content faster and more deeply [3]. The particular significance of this finding is that teachers' infographic competence was proven to directly affect the quality of student learning.

Fadzil (2015), in a qualitative study with 40 pre-service science teachers in Malaysia, identified three key effects of the infographic creation process: increased digital literacy, development of multimodality skills, and strengthened ability to didactically select learning content [11]. Fridman (2018), in a study with four student teachers in Canada, demonstrated that infographics serve as a "project-based learning" tool that simultaneously develops 21st century competencies and global competencies [13].

THE FOUR-COMPONENT CYCLIC MODEL OF INFOGRAPHIC COMPETENCE

Based on the synthesis of the scientific foundations above and analysis of international experience, a four-component cyclic model of infographic competence is proposed. The key distinctive feature of the model is that components operate not sequentially but cyclically and interactively: reflective experience deepens cognitive knowledge, and new cognitive knowledge generates technological need.

Component	Theoretical Basis	Development Pathway	Generative AI Tool
Cognitive-Epistemological	Mayer (2009): dual coding; Sweller (1988): cognitive load	Theoretical mastery of visual grammar, infographic types, cognitive principles	ChatGPT — interactive contextualization of theoretical concepts
Practical-Technological	DigCompEdu: digital content creation domain	Step-by-step progression from template to adapted	Canva Magic Design, Piktochart AI — sketch generation; Gamma.app

Component	Theoretical Basis	Development Pathway	Generative AI Tool
	(Redecker, 2017)	design to fully independent creation	— presentation visualization
Methodological-Pedagogical	TPACK model: T × P × C intersection (Mishra & Koehler, 2006)	Selecting and adapting infographics to lesson plans, accounting for student age	Adobe Firefly — pedagogically targeted visual content; Infogram AI — data diagrams
Creative-Reflective	Fridman (2018): multimodal reflection; DigCompEdu: professional development	Rubric-based self-assessment and peer analysis; each cycle reveals new cognitive needs	AI feedback systems (ChatGPT rubric review) — accelerates the reflection cycle

Table 1. Four components of infographic competence, theoretical foundations, and generative AI tools

Infographic Competence Model: Component and AI Tool Interrelationships

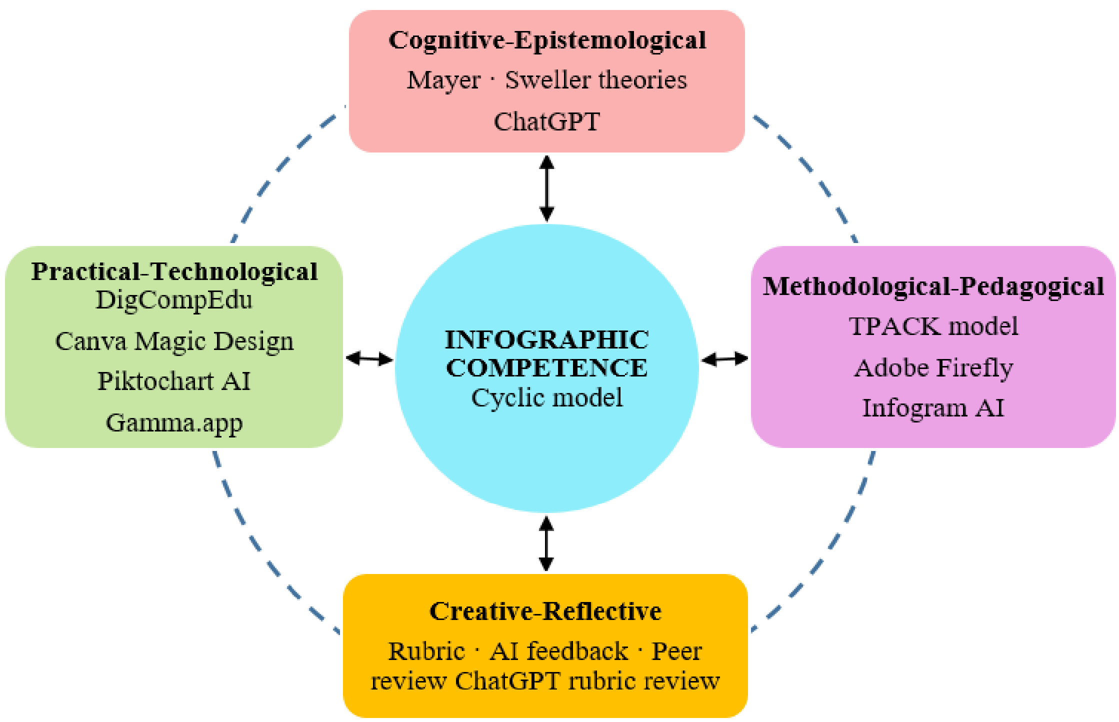

Figure 1. Cyclic Model of Infographic Competence

2.1. Specific Pedagogical Mechanism of AI for Each Component

Cognitive-Epistemological Component. ChatGPT at this stage functions as an interactive explanation system replacing the traditional textbook: when a student requests an example to understand Mayer's "signaling principle," AI explains it linking directly to the student's specialization — primary education. This personalization provides a level of cognitive contextualization not possible in traditional lectures [7, 9].

Practical-Technological Component. Canva Magic Design generates a visual sketch from the student's text input within seconds. This mechanism is pedagogically significant: the student bypasses the technical barrier of "creating from scratch" and directly enters the process of "improving from a sketch" — making didactic decisions. Piktochart AI specializes in data visualization, and Gamma.app in structuring lesson presentation visualization [4, 10].

Methodological-Pedagogical Component. Through Adobe Firefly, the teacher generates original images suited to the topic — ensuring that visual content is used without legal issues and fully adapted to pedagogical purposes. Infogram AI automatically transforms statistical and tabular data into diagrams, freeing the teacher from data collection and directing attention to presentation design [3, 6].

Creative-Reflective Component. Using ChatGPT as a "rubric reviewer" is a new methodological approach that enhances the reflection cycle: the student has AI evaluate their infographic against rubric criteria, analyzes the feedback received, and revises accordingly. This process systematizes the "iterative learning" phenomenon observed by Fridman (2018) [13].

THREE-STAGE INTEGRATION PATHWAY

For applying the model in pedagogical education practice, a three-stage progressive pathway is proposed. This pathway is based on the logical sequence of the ADDIE model (Analysis → Design → Development) and the principle of active methodologies proven by Romero-García et al. (2020) [2, 3].

Stage	Task	AI Tool	Component Developed
I — Observation & Analysis	Analyze existing infographics based on Mayer's principles; assess cognitive load levels	ChatGPT — explains principles; Canva template library	Cognitive-Epistemological
II — Creation & Testing	Create a lesson infographic using Canva AI/Piktochart AI; test with classmates	Canva Magic Design, Piktochart AI, Gamma.app, Adobe Firefly	Practical-Technological + Methodological-Pedagogical
III — Reflection & Refinement	Revise based on AI rubric review + peer feedback; complete digital portfolio	ChatGPT rubric assessment; Infogram AI data visualization	Creative-Reflective → cycle restarts

Table 2. Three-stage integration pathway for developing infographic competence

DISCUSSION

The proposed model does not contradict a range of international studies — it aligns with them — but differs in important respects.

First, our model adds a fourth tendency to the three leading trends — interactive infographics, mobile learning, and data literacy — identified by Bhat and Alyahya's (2023) comprehensive literature review: generative AI lowers the entry barrier to infographic creation and shifts the student's attention from technical execution to pedagogical design [10]. This shift provides a qualitatively new level of competence.

Second, Karshibaev (2025) noted that integrating pedagogical technologies with infographics allows students to simultaneously develop "digital, visual, and metacognitive competencies" [4]. Our cyclic model systematically explains this phenomenon: the circular connection of four components ensures the parallel development of multiple competence levels within a single activity.

Third, Alekseyeva (2023) noted the problem of "clip thinking" in digital learning environments, presenting visual structures as a means of developing the capacity to perceive holistic information [12]. This observation justifies why a primary school teacher's infographic competence is not a professional option but a didactic necessity.

At the same time, limitations must be honestly acknowledged. The level of pedagogical effectiveness of AI tools depends on the quality of their data and the teacher's methodological literacy. The gap between digital competence and expected standards identified by Beták (2025) is not an argument against AI integration but a signal for the necessity of systematic methodological preparation for it [5].

CONCLUSION AND PRACTICAL RECOMMENDATIONS

The study concludes with the following findings:

Infographic competence is a multi-component cyclic professional structure, and developing it in combination with artificial intelligence tools is fully theoretically grounded by DigCompEdu, TPACK, and multimedia learning theories. The assignment of a specific generative AI tool (ChatGPT, Canva Magic Design, Piktochart AI, Gamma.app, Adobe Firefly, Infogram AI) to each component ensures the model's practical applicability.

International empirical studies (Ozdamli & Ozdal, 2018; Fadzil, 2015; Fridman, 2018; Romero-García et al., 2020) have demonstrated that infographic and digital competencies do not form on their own within traditional courses — a specialized, project-based active methodology is required.

The transformational role of generative AI is that it shifts the student from "technical executor" to "pedagogical designer": sketch generation eliminates the initial technical barrier and directs cognitive energy toward didactic decision-making.

Two practical recommendations regarding the curriculum:

Integration into Higher Education Curricula: It is recommended that an "Infographic Competence and Generative AI" module of at least 30 hours be allocated within the "Information Technologies" or "Digital Pedagogy" course. The module should be organized on a project basis — each student creates an infographic portfolio intended for a real lesson — and evaluated through a digital portfolio system. This approach aligns with the "personalized learning plan" principle justified by Beták (2025) [5].

Development of a National Competence Framework: Based on Domain 6 of DigCompEdu ("Developing Students' Digital Competence"), national assessment criteria for infographic competence ("Infographic Competence Levels: A1–C2") should be developed for Uzbekistan and integrated into the pedagogical education certification system. This step would be a practical contribution to fulfilling the education-related tasks of the "Digital Uzbekistan – 2030" strategy.

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