

Modelling information-communicative competence for AI-era designers

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Abstract. The rapid diffusion of generative artificial intelligence (AI) in design practice is transforming the professional competencies required of designers, yet the theoretical foundations guiding educational responses remain underdeveloped. A recent scoping review found that 73.7% of studies on generative AI in design education are entirely atheoretical, while domain-specific competency constructs for the AI era remain scarce. This conceptual paper proposes an integrative theoretical framework that (1) operationalises information-communicative competence (ICC) as a four-component construct for designers in the context of AI-driven professional transformation; (2) adapts the TPACK model to account for AI tools and studio pedagogy; and (3) identifies gaps when mapping national design competency standards to ICC. The study employs a conceptual analysis approach combining theory synthesis with framework adaptation. Terminological differentiation situates ICC among adjacent constructs (digital competence, ICT competence, information literacy, media competence). The framework is developed through systematic integration of TPACK, studio pedagogy theory, and competency-based education. ICC is operationalised as a four-component model comprising information-analytical, communicative, technological, and reflective components, each incorporating AI-specific descriptors. An adapted TPACK model reconceptualises Technological Knowledge to encompass prompt engineering, AI tool selection, and critical evaluation of AI outputs. A gap analysis of the Ukrainian B2 Design standard against ICC reveals systematic omissions in AI-related competencies across all four components. The integrative framework synthesises these three pillars into a coherent theoretical foundation for curriculum transformation. The proposed framework addresses the dominant atheoretical trend in generative AI design education research by providing a domain-specific theoretical architecture that can guide curriculum redesign. Its three-pillar structure – what knowledge is needed (TPACK), how it is acquired (studio pedagogy), and what standards require (competency mapping) – offers a replicable model for other professional fields undergoing AI transformation.


Keywords: information-communicative competence, TPACK, design education, artificial intelligence, studio pedagogy, competency framework, generative AI


1. Introduction

The professional practice of design is undergoing a fundamental transformation driven by generative artificial intelligence (AI). Tools such as Midjourney, DALL-E, Stable Diffusion, and Adobe Firefly have compressed ideation cycles from hours to minutes, enabling designers to generate, evaluate, and curate dozens of visual alternatives through natural language prompts rather than manual production alone [21, 56]. This shift – described as a transition from “maker” to “curator” [39] – does not merely add new tools to the designer’s repertoire; it fundamentally alters the nature of information seeking, communication, technological engagement, and reflective practice that constitute professional design activity.

However, educational responses to this transformation remain predominantly atheoretical. A scoping review of 156 studies on generative AI in design higher education [39] found that 73.7% employed no theoretical framework whatsoever, while the dominant framework among the remaining

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26.3% – the Technological Pedagogical Content Knowledge (TPACK) model [36] – appeared in only 3.8% of the corpus. This theoretical deficit is consequential: without conceptual foundations, individual studies remain isolated empirical observations that cannot accumulate into coherent pedagogical guidance for curriculum designers, accreditation bodies, or educational policymakers.

The problem is compounded by the lack of a domain-specific competency construct that captures what designers need to know and do in the AI era. Existing frameworks address adjacent but insufficient territory: digital competence (DigComp 2.2; [57]) provides a universal citizen-level model without professional specificity; ICT competence [15] emphasises technological operation without communicative or reflective dimensions; information literacy [5] foregrounds information evaluation without technological or visual communication dimensions. None of these constructs was designed for the distinctive demands of design practice – visual communication, studio-based learning, project-based iteration, or the emerging requirement to collaborate with generative AI systems through prompt engineering.

Parallel analysis of national standards reveals structural readiness but AI-specific gaps. An examination of the Ukrainian B2 Design bachelor’s standard against the European Qualifications Framework [38] demonstrated that existing competency descriptors provide foundational elements for each dimension of professional digital practice, yet systematically omit AI-related capabilities: critical evaluation of AI-generated content, prompt engineering, ethical reasoning about algorithmic outputs, and reflective practice regarding human-AI collaboration in design.

This paper addresses these converging gaps by proposing an integrative theoretical framework that operationalises *information-communicative competence* (ICC) for designers in the AI era. ICC is defined as an integrative personal quality characterising a designer’s capacity and readiness for effective searching, analysis, and use of professionally significant information; digital communication and visual presentation; mastery of digital design tools, including AI; and critical reflection on one’s activity in the digital environment, as well as continuous professional development.

The framework is organised around three research questions:

- RQ1:** How can ICC be operationalised for designers in the context of AI-driven professional transformation?
- RQ2:** How should the TPACK framework be adapted to account for AI tools and studio pedagogy in design education?
- RQ3:** What gaps exist when mapping national design competency standards to ICC, and how can an integrative framework address them?

The paper contributes to the field in three ways. First, it provides a theoretically grounded four-component ICC model with AI-specific descriptors and proficiency levels (RQ1). Second, it offers a domain-specific TPACK adaptation that reconceptualises Technological Knowledge for the generative AI era (RQ2). Third, it synthesises TPACK, studio pedagogy, and competency-based education into an integrative framework that can guide empirical research and curriculum reform (RQ3).

The remainder of the paper is organised as follows: section 2 describes the conceptual methodology; section 3 differentiates ICC from adjacent constructs; section 4 presents the four-component ICC model; section 5 adapts TPACK for AI-era design; section 6 maps B2 Design competencies to ICC; section 7 presents the integrative framework; section 8 discusses implications; and section 9 concludes with future research directions.

2. Methodology

This study is a conceptual paper following the *theory synthesis* and *framework adaptation* approaches identified by Jaakkola [24]. Theory synthesis integrates existing theoretical perspectives to produce a novel conceptual framework, while framework adaptation modifies an established model (here,

TPACK) for a new domain. The methodological design draws on established guidelines for integrative reviews [55] and document analysis [7].

The research proceeded in four phases. Phase 1 (terminological analysis) employed systematic comparison of five constructs – information literacy, ICT competence, digital competence, media competence, and ICC – across four analytical dimensions: dominant focus, governing framework, limitations for design, and AI coverage. The comparison drew on primary framework documents (ACRL Framework, e-CF 3.0, DigComp 2.2, DigCompEdu) and the Ukrainian pedagogical literature on competency-based education.

Phase 2 (ICC model construction) synthesised the terminological analysis with design profession characteristics identified through the scoping review [39] and comparative standards analysis [38] to define four ICC components and three proficiency levels. Component identification followed thematic analysis principles [8], with initial codes derived from competency descriptors in national standards and framework documents.

Phase 3 (TPACK adaptation) reinterpreted the three knowledge domains of TPACK [36] through the lens of AI-era design practice, drawing on the scoping review’s findings regarding theoretical framework usage and studio pedagogy’s transformation under generative AI [2, 17, 39].

Phase 4 (integrative synthesis) combined the ICC model, adapted TPACK, and studio pedagogy into a unified theoretical framework, validated against the gap analysis of national standards [38].

3. ICC among adjacent constructs: terminological differentiation

Effective operationalisation of ICC requires systematic differentiation from related constructs that populate the same semantic field in educational research. Five constructs warrant examination: information literacy, ICT competence, digital competence, media competence, and ICC.

Information literacy originated in library and information science. The American Library Association [4] defined information-literate individuals as those who can “recognise when information is needed and have the ability to locate, evaluate, and use effectively the needed information”. The ACRL Framework [5] expanded this to “a set of integrated abilities encompassing the reflective discovery of information, an understanding of how information is produced and valued, and the use of information in creating new knowledge”. For design practice, information literacy has domain-specific value – designers must evaluate visual references, analyse trends, and work with portfolio platforms [58] – but the construct omits communicative dimensions (visual presentation, collaboration) and the technological dimension (mastery of design and AI tools), limiting its applicability.

ICT competence foregrounds the technological component: the ability to use hardware, software, and network technologies for practical tasks. The European e-Competence Framework defines ICT competence as “the demonstrated ability to apply knowledge, skills, and attitudes for achieving observable results” in ICT [15]. Its strength lies in concreteness; its limitation is an overemphasis on technology at the expense of information-analytical and reflective dimensions. In design education, ICT competence describes only one aspect – mastery of software tools – without capturing critical evaluation of AI outputs, ethical dimensions, or professional identity reflection [25].

Digital competence is the broadest construct, institutionalised through the European DigComp framework. DigComp 2.2 [57] defines digital competence as “the confident, critical, and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society”, spanning five areas: (1) information and data literacy; (2) communication and collaboration; (3) digital content creation; (4) safety; (5) problem solving. Crucially, the 2022 update first included AI interaction skills, recognising the need for critical engagement with AI-generated content. DigCompEdu [46] extends this to educators. Digital competence is conceptually closest to ICC but remains universal rather than profession-specific – it describes general citizen capabilities without accounting for the distinctive demands of design practice: visual communication, studio-based learning, prompt engineering for image generation, and aesthetic evaluation of AI outputs.

Media competence focuses on the ability to critically receive, analyse, evaluate, and create media

messages. It extends beyond the purely technological to encompass critical thinking about media content, understanding of influence mechanisms, and the ability to distinguish reliable from manipulative information. For designers – who are simultaneously consumers and producers of media content – media competence holds particular relevance. However, it does not fully cover the technological dimension of design activity (specialised design tools) or the reflective dimension (self-assessment of professional development, AI ethics).

Information-communicative competence (ICC) is proposed as an integrative construct that synthesises the informational, communicational, technological, and reflective dimensions of professional activity. Unlike ICT competence, ICC is not limited to instrumental technology use; it encompasses the full cycle of information-communication activity – from search and analysis through transformation and communication to critical reflection. Unlike digital competence (DigComp), ICC can be operationalised for a specific professional domain, enabling the incorporation of discipline-specific content. Table 1 systematises the comparison.

Table 1

Comparative analysis of constructs adjacent to ICC.

Construct	Dominant focus	Key framework	Limitation for design	AI coverage
Information literacy	Search, evaluation, use of information	ACRL Framework	Omits technological and communicative dimensions	Partial
ICT competence	Technological use of ICT	e-CF 3.0	Over-emphasis on technology	Partial
Digital competence	Integrative digital technology use	DigComp 2.2	Universal character; not profession-specific	Yes (since 2022)
Media competence	Critical media reception and creation	Media education	Omits technological dimension of design	Partial
ICC (designer)	Integrative: info-analytical, communicative, technological, reflective	Proposed model	Profession-specific	Systematic

As table 1 demonstrates, each adjacent construct addresses a particular dimension of human-information interaction, yet none covers all dimensions necessary for characterising the information-communication activity of designers. Information literacy remains within search and evaluation; ICT competence concentrates on the technological component; digital competence is too general; media competence does not capture the design tooling dimension. ICC, as an integrative construct that synthesises all four dimensions, is the most appropriate concept for describing a designer’s holistic readiness for professional activity in the AI-era digital environment.

4. The four-component ICC model

The structure of ICC for designers comprises four interrelated components: information-analytical, communicative, technological, and reflective. Each component carries specific content shaped by the distinctive characteristics of design practice in the generative AI era. Before presenting the components, we note four profession-specific characteristics that motivate this particular structure.

First, design is a *visually communicative activity*. Designers create visual messages that must be comprehensible to target audiences, meet aesthetic and functional requirements, and account for cultural context. This means the communicative component of a designer’s ICC differs substantially from that of other professions, encompassing not only verbal and textual but also visual communication, project presentation, and the ability to formulate and defend design concepts [32, 38].

Second, design practice is *instrumentally dense*. A contemporary designer uses a broad spectrum of digital tools from graphic editors and UX/UI platforms to 3D modelling software, generative AI systems, and automation tools, including prompt engineering. The technological component of ICC correspondingly encompasses not merely basic software use but adaptive tool selection, AI integration into the project workflow, and prompt engineering as a new dimension of technological competence.

Third, design activity is *project-based and iterative*. The design process is built on cycles of research, concept, prototype, testing, and iteration, requiring constant reflection, self-assessment, and activity correction. Küçükersen et al. [29] demonstrate that the design learning cycle extends beyond Kolb's [28] classical model to include reflective sense-making as an integral element of each phase.

Fourth, design has undergone a radical *AI transformation*. The paradigm shift from “designer-maker” to “designer-curator” [39] alters the nature of information-communication activity: rather than directly producing visual output, the designer increasingly formulates tasks for AI (prompt engineering), evaluates generated alternatives, curates results, and integrates them into a coherent project.

4.1. Information-analytical component

The information-analytical component encompasses a designer's capacity for effective searching, evaluation, systematisation, and use of professionally significant information. Its content includes: searching and analysing visual references, design trends, case studies, and best practices using specialised platforms (Behance, Dribbble, Pinterest, Dezeen); critically evaluating the quality and reliability of information sources, including AI-generated content [39]; analysing target audiences, user needs, and usage contexts; structuring collected information to form design briefs and concepts; working with large volumes of visual information to identify patterns and connections across heterogeneous data; and understanding how recommendation algorithms and search systems influence information retrieval results.

This component extends beyond classical information literacy by incorporating design-specific skills: visual source analysis, portfolio platform navigation, and – critically – evaluation of AI-generated visual content. As the volume of AI-generated imagery grows exponentially [39], the ability to distinguish authentic design from generated artefacts becomes increasingly important.

4.2. Communicative component

The communicative component characterises a designer's capacity for effective professional communication in the digital environment. It encompasses: visual communication – creating comprehensible, aesthetically accomplished, and functional visual messages for diverse audiences; project presentation – persuasively conveying design concepts to clients, teams, and expert panels using digital tools; digital collaboration – effective distributed teamwork using collaborative platforms; professional networking – building and maintaining professional contacts, participating in professional communities, developing online portfolios; and multimodal communication – integrating text, image, video, animation, and interactive elements.

A distinctive feature is the inclusion of *communication with AI systems* – the ability to formulate clear, effective prompts (prompt engineering) that yield desired results from generative AI tools [16, 39]. This represents a qualitatively new form of human-machine interaction in which the quality of the “dialogue” directly determines the output quality.

4.3. Technological component

The technological component covers a designer's capacity to use digital design tools effectively, including both traditional software and AI tools. It includes: mastery of graphic design tools (Adobe Creative Suite, Affinity, CorelDRAW); UX/UI design and prototyping tools (Figma, Sketch); 3D modeling and visualisation (Blender, 3ds Max); generative AI tools (Midjourney, DALL-E, Stable

Diffusion, Adobe Firefly); prompt engineering – formulating effective textual and visual queries for AI systems; adaptive tool selection – choosing the optimal instrument (traditional or AI-based) depending on task, context, and constraints; AI integration – combining AI-generated elements with authored work into coherent design products; and foundational understanding of how AI algorithms (GANs, diffusion models, transformers) work at a level sufficient for effective interaction.

This component differs substantially from general ICT competence by including design-specific tools and – as a fundamentally new element – generative AI skills. Prompt engineering as a new dimension of technological competence is becoming an integral part of the designer’s professional toolkit [16, 39].

4.4. Reflective component

The reflective component characterises a designer’s capacity for critical analysis, self-assessment, and self-regulation of information-communication activity. It encompasses: self-assessment of ICC development – the ability to adequately evaluate one’s own level of information-analytical, communicative, and technological skills and identify development zones; critical evaluation of AI-generated results – the ability to detect artifacts, biases, stereotypes, and ethical problems in AI-generated content; AI ethics in design – awareness of copyright, intellectual property, design authenticity, and transparency in AI tool use; critical stance toward algorithmic biases – understanding that AI models reproduce training data biases (gender, cultural, racial) and the ability to compensate for these in design decisions; continuous professional development planning; and professional identity reflection – understanding one’s role as a designer amid AI transformation, defining the balance between authored and AI-assisted creation.

The reflective component is *system-forming* within the ICC structure because it ensures consciousness and self-regulation of information-communication activity [14, 48]. Without it, the other components remain a collection of discrete skills rather than an integrated competence. It enables the transition from mechanical tool use to conscious, ethically responsible, and adaptive professional practice.

4.5. ICC in the context of the AI transformation of design

The proposed four-component model reflects the current state of the design profession, which is undergoing a deep transformation driven by generative AI. Analysis of 156 studies [39] documented the formation of a new paradigm – the transition from “designer-maker” to “designer-curator” – that directly affects the content of each ICC component.

In the maker paradigm, the technological component was limited to mastery of graphic editors and design tools. In the curator paradigm, it expands to include prompt engineering, critical evaluation and curation of AI-generated content, and the integration of AI tools into the project workflow. The information-analytical component is similarly transformed: designers must not only search for information but also evaluate the reliability and quality of AI-generated visual materials, requiring new analytical competencies. The communicative component gains a qualitatively new dimension – communication with AI systems, where prompt quality directly determines output quality [16]. The reflective component becomes particularly important because the AI transformation raises ethical challenges identified in the scoping review [39]: copyright issues regarding AI-generated content, algorithmic biases (gender, cultural, and racial stereotypes in training data), problems of design authenticity, and academic integrity.

We further note the relationship between the proposed ICC model and the DigComp 2.2 framework [57]. DigComp’s five dimensions partially overlap with ICC components: (1) information and data literacy corresponds to the information-analytical component, but ICC adds design-specific content; (2) communication and collaboration corresponds to the communicative component, but ICC extends it with visual communication and prompt engineering; (3) digital content creation corresponds to the technological component, but ICC specifies design tools and generative AI; (4) safety is

partially reflected in the reflective component (ethics, copyright, data protection); and (5) problem solving is a cross-cutting dimension realised through all four ICC components. Thus, ICC does not contradict DigComp but contextualises it for the design profession with AI-era extensions.

4.6. Structural model

Figure 1 visualises the interrelationship among ICC components. All four components are connected by bidirectional links, reflecting their mutual dependence. The information-analytical component provides the foundation for informed technology use and effective communication. The communicative component supports the reflective component through feedback mechanisms from colleagues, clients, and audiences. The technological component realises information-analytical and communicative intentions through specific tools. The reflective component, as the system-forming element, ensures conscious self-regulation of the entire information-communication activity.

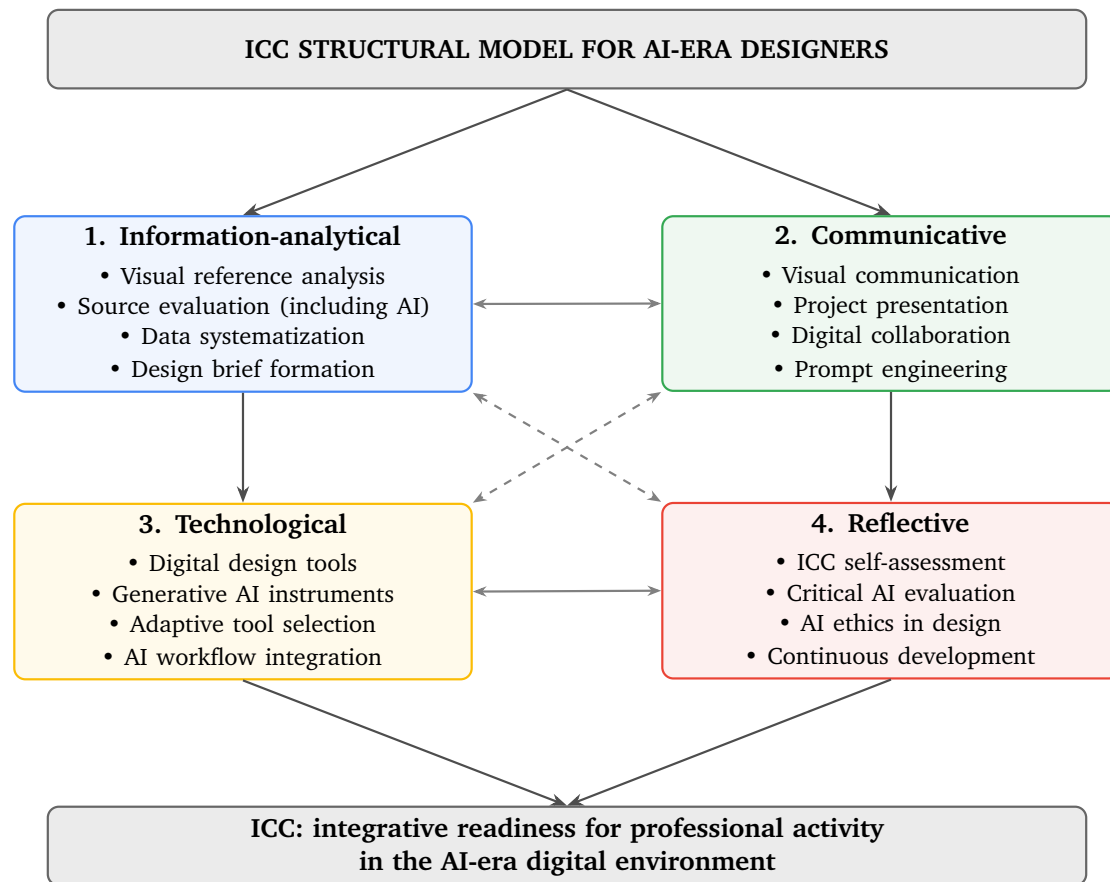


Figure 1: Structural model of information-communicative competence for AI-era designers. Solid bidirectional arrows indicate direct mutual dependence; dashed arrows indicate cross-component reinforcement.

4.7. Proficiency levels

For practical application of the ICC model in educational contexts, three proficiency levels are defined drawing on descriptors from DigComp 2.2 [57] and constructive alignment principles [6]. Table 2 presents the level descriptors for each component.

5. Adapting TPACK for AI-era design education

The Technological Pedagogical Content Knowledge (TPACK) model, proposed by Mishra and Koehler [36], building on Shulman's [50] pedagogical content knowledge concept, describes the interaction

Table 2
ICC proficiency levels for AI-era designers.

Component	Beginner	Proficient	Advanced
Information-analytical	Template-based search; does not distinguish source quality	Purposeful search; evaluates information quality; works with multiple source types	Systematic field analysis; critically evaluates AI-generated content; forms research-based design briefs
Communicative	Uses basic communication tools; visual presentation undeveloped	Communicates effectively with team; creates quality presentations; uses collaborative platforms	Masterful visual communication; effective prompt engineering; coordinates distributed teams
Technological	Uses 1–2 tools at basic level; does not work with AI	Confidently uses core tools; employs basic AI instruments	Fluently integrates traditional and AI tools; adaptive tool selection; advanced prompt engineering
Reflective	Does not self-assess; unaware of AI ethical aspects	Evaluates own activity results; understands basic AI ethical issues	Systematic reflection; plans self-development; critically analyses AI ethics; articulates position on AI in design

of three foundational knowledge domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). At their intersections emerge integrated knowledge forms: TCK, TPK, PCK, and the central construct – TPACK – that synthesises all three. Research demonstrates that developing TPACK in future professionals requires not merely technology familiarisation but systematic pedagogical support [3, 43], and that integrated models of technology acceptance and TPACK inform continuous technology use among educators [1].

Despite its wide adoption, TPACK remains remarkably underused in design education research. Our scoping review [39] found that among 156 studies of generative AI in design education, only 3.8% employed TPACK – despite it being the single most common framework in the corpus. This underrepresentation signals a need for domain-specific adaptation rather than mere application.

In the context of AI-era design education, we propose that each TPACK domain acquire specific content:

1. **Content Knowledge (CK)** encompasses the design domain: colour theory, composition, typography, art and design history, ergonomics, and materials science. This is the core of professional preparation that defines *what* a designer must know. CK remains anchored in design’s disciplinary traditions [11, 30] and is not fundamentally altered by AI – though the breadth of visual traditions a designer must reference expands as AI tools draw on vast training datasets.
2. **Pedagogical Knowledge (PK)** includes studio-based teaching methods: master classes, critique sessions (crits), project-based learning, and reflective practice following Schön [48]. This defines *how* design learning occurs. Studio pedagogy is the “signature pedagogy” of design professions [51], characterised by learning through doing, public critique, iterative cycles, and professional identity formation [2, 26]. Generative AI transforms studio pedagogy in several directions: the student’s role shifts from maker to curator [39]; iterative processes accelerate dramatically; and critique acquires new dimensions as students must justify not only design decisions but tool choices, prompting strategies, and selection criteria among generated alternatives [27, 44].
3. **Technological Knowledge (TK)** is the domain requiring the most radical reconceptualisation. TK can no longer be limited to mastering specific software. It now includes: (1) the capacity to evaluate and select the optimal tool (traditional or AI-based) for a given design task; (2) prompt

engineering skills – formulating textual queries for generative models that produce desired outcomes [16]; (3) critical evaluation of AI-generated results against aesthetic, ethical, and functional requirements; and (4) understanding of generative model principles at a level sufficient for effective interaction. The pragmatist philosophy of Dewey, adapted for the AI context [41], provides philosophical grounding for this TK expansion: technological knowledge is formed through active interaction with tools in the process of solving authentic project tasks.

Figure 2 visualises the adapted TPACK model for AI-era design education.

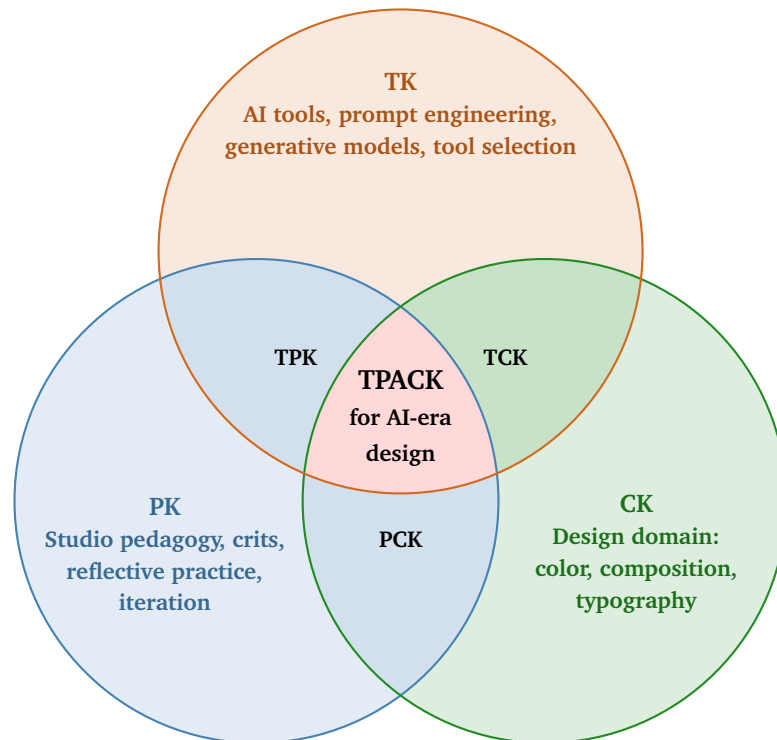


Figure 2: Adapted TPACK model for AI-era design education. TK is reconceptualised to encompass AI tools and prompt engineering; PK incorporates studio pedagogy transformed by generative AI; CK remains grounded in design disciplinary knowledge.

The key insight of the adapted model lies in the integrated knowledge forms at the intersections.

TCK (Technological Content Knowledge) describes how AI tools relate to the design domain. In traditional design education, TCK involved understanding which software best serves specific design tasks (e.g., Illustrator for vector graphics, Blender for 3D). In the AI era, TCK expands to encompass how prompt engineering intersects with composition principles when generating visual alternatives, how generative models handle different aesthetic styles, and how AI-generated outputs relate to design theory concepts such as visual hierarchy, colour harmony, or typographic conventions.

TPK (Technological Pedagogical Knowledge) concerns how AI tools transform teaching methods. This is where the studio pedagogy pillar intersects with TPACK most directly. TPK in AI-era design addresses: how to structure critique sessions when students use AI-generated elements; how to assess work that combines human creativity with AI assistance; and how to design project briefs that develop authentic AI literacy rather than mere tool operation. The shift from demonstration-based to curation-based studio practice [17, 44] exemplifies TPK in action.

PCK (Pedagogical Content Knowledge) retains its classical meaning – understanding how design content is best taught through studio methods [47, 48] – but gains new urgency as educators must help students distinguish between competencies that AI can augment and foundational skills (drawing, spatial reasoning, material understanding) that require embodied practice [49].

The central *TPACK* construct integrates all three, representing a teacher’s ability to make pedagogically sound decisions about when and how to integrate AI tools into design studio instruction while

maintaining disciplinary rigour. A design educator with fully developed TPACK can, for example, design a project where students use Midjourney for rapid ideation (TK) within a brief addressing typographic hierarchy (CK), structured as a critique-driven iterative process (PK), where the assessment criteria reward critical evaluation of AI outputs against design principles (TPACK integration).

This reconceptualisation acknowledges that generative AI transforms not just the tools but the relationships between knowing, teaching, and making. Fleischmann [17] documented the paradigm shift in studio pedagogy during the pandemic, and the AI transformation extends this shift further – from physical-to-digital to human-to-hybrid creation. Mouza and Karchmer-Klein [37] emphasised the necessity of systematically assessing TPACK in professional preparation, confirming the relevance of this integrated approach. Recent work on the intelligent-TPACK (I-TPACK) framework [52] and mapping of theoretical frameworks for AI-era digital literacy [54] further validates the direction of TPACK adaptation for AI contexts.

6. Mapping B2 Design competencies to ICC: gap analysis

The competency-based approach, which became normative for the European Higher Education Area following the Bologna Process, defines learning outcomes through categories of knowledge, skills, and competencies [10]. The Ukrainian higher education standard for speciality 022 Design at the bachelor's level (the B2 Design standard) defines two competency categories: general competencies (GC) and professional competencies (PC) [35]. Analysis conducted in our prior work [38] revealed structural alignment between the B2 Design standard and the European Qualifications Framework across the dimensions of knowledge, skills, and autonomy, yet with significant gaps in competencies related to critical reflection, interdisciplinary collaboration, sustainable design, and – most critically for this paper – digital and AI skills.

Pitsikalis et al. [45] developed recommendations for updating EQF learning outcomes to accommodate immersive technologies, underscoring the need to adapt competency frameworks to emerging technologies. Similarly, an analysis of pre-service teachers' digital competence based on DigCompEdu [13] revealed that student teachers require significant strengthening of professional digital skills – a finding that resonates with the design education context.

B2 Design standard competencies can be directly mapped onto the four-component ICC structure, revealing both existing foundations and AI-specific gaps. Table 3 presents this mapping.

Table 3

Mapping B2 Design standard competencies to ICC components with AI gaps identified.

ICC component	B2 Design competencies	AI-specific gap
Information-analytical	GC2: ability to search and analyse information from various sources	No mention of AI-generated content as a source; no provision for critical evaluation of AI outputs
Communicative	GC6: ability to communicate; PC5: ability for visual presentation	Does not account for digital communication platforms and AI tools for presentation
Technological	PC8: ability to apply computer technologies; PC12: ability to use modern software	No mention of AI tools, prompt engineering, or generative design
Reflective	GC1: ability for critical thinking; GC10: ability for self-education	Does not provide for reflection on ethical aspects of AI use in design

Table 3 demonstrates that the B2 Design standard contains foundational prerequisites for ICC formation but does not account for the AI dimension, which is critical under contemporary conditions. Each ICC component has a partial foothold in existing B2 Design competency descriptors, yet the AI-specific extensions required by current professional practice are systematically absent. GC2 (information search and analysis) provides a basis for the information-analytical component, yet

says nothing about evaluating AI-generated content. PC8 and PC12 (computer technologies and modern software) ground the technological component, yet do not mention generative AI or prompt engineering. GC1 (critical thinking) anchors the reflective component, yet omits ethical reasoning about AI-generated outputs.

This systematic gap pattern – foundational capacity present, AI-specific extension absent – suggests that curriculum transformation does not require a wholesale rebuild but rather a targeted augmentation of existing competency structures with AI-relevant content. This finding is consistent with the “adaptive integration” approach advocated in our prior analysis of Ukrainian design education and European integration [38].

Notably, this pattern is not unique to Ukraine. The European Qualifications Framework itself does not yet include AI-specific competency descriptors, suggesting similar gaps likely exist across European design education standards. The digital competence frameworks (DigComp 2.2 and DigCompEdu) have begun addressing AI [46, 57], but national professional standards have not yet followed suit. Osadcha, Krashenninnik and Osadchyi [42] analysed international educational practices for digital skill formation, confirming that cross-national knowledge transfer is essential for modernising domestic design programs. The B2-ICC gap analysis thus serves a dual purpose: it identifies concrete transformation targets for the Ukrainian context and illustrates a methodology replicable for other national standards within the EQF-aligned system.

7. Integrative theoretical framework

Having established the four-component ICC model (section 4), the adapted TPACK model (section 5), and the B2 Design gap analysis (section 6), we now synthesise these three theoretical perspectives into an integrative framework for researching and developing ICC in design education (figure 3).

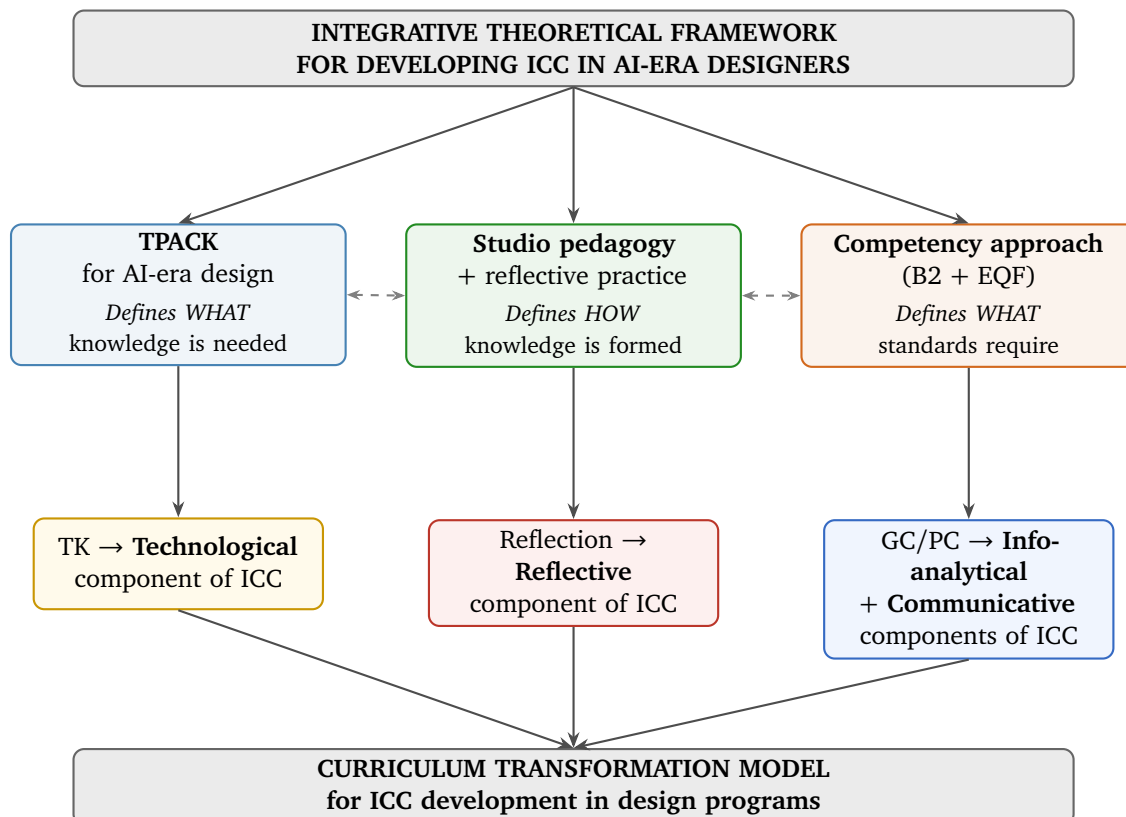


Figure 3: Integrative theoretical framework for developing ICC in AI-era designers: synthesis of TPACK, studio pedagogy, and the competency approach. Each pillar addresses a distinct question and maps to specific ICC components.

The integrative framework operates through the following logic:

1. *TPACK defines the knowledge structure* necessary for effective integration of AI tools into design education. The Technological Knowledge component is directly linked to the technological component of ICC, while integrated knowledge forms (TPK, TCK, TPACK) determine how AI technologies should be woven into the pedagogical process and disciplinary content.
2. *Studio pedagogy provides the methodological foundation* for ICC formation through activity. Schön's [48] reflective practice theory grounds the reflective component of ICC, while the studio format (projects, critiques, iterations) creates an authentic context for developing all four components. The design learning cycle [29] extends beyond Kolb's [28] classical experiential model by incorporating reflective sense-making as an inseparable element of each phase. Digital reflective practice in studio courses [19, 20] demonstrates how technology-mediated reflection enhances creativity and deeper engagement with the design process.
3. *The competency approach and the B2 Design standard* define normative requirements for learning outcomes and ensure that proposed changes conform to formal higher education frameworks. The B2 Design gap analysis (table 3) identifies specific directions for transformation: each gap represents a concrete point where AI-related ICC content should augment existing competency descriptors.

This framework is not a mechanical combination of three theories. It presupposes their interaction: TPACK informs the knowledge structure that needs to be formed; studio pedagogy determines how this knowledge is developed in the design context; the competency approach ensures alignment with formal requirements and validates outcomes. It is precisely this triangulation of theoretical perspectives that distinguishes the proposed approach from previous research, where, as the scoping review demonstrated [39], the overwhelming majority (73.7%) remained atheoretical.

8. Discussion

8.1. Theoretical contributions

The proposed framework makes three principal contributions to the field. First, it responds to the dominant atheoretical trend in generative AI design education research [39] by providing a domain-specific theoretical architecture. While recent conceptual papers have proposed frameworks for specific niches – graphic design, advertising education [23], fashion design ideation through TPACK [31], or dialogic pedagogy for AI integration [59] – the ICC framework offered here is distinctive in addressing the profession-wide competency structure rather than a single pedagogical intervention.

Second, the four-component ICC model extends and contextualises existing competency frameworks. It shares DNA with DigComp 2.2 [57] and AI literacy models [9, 33, 40] but differs in two crucial respects: (a) it is operationalised for a specific professional domain rather than universal citizenship, enabling design-specific content (visual communication, aesthetic evaluation, studio-based iteration); and (b) it explicitly incorporates a reflective component as system-forming, recognising that in creative professions, the ability to reflect on one's relationship with AI tools is not ancillary but constitutive of competence. Zhang et al.'s [60] recent four-component design competence framework for the generative AI era – comprising aesthetic, thinking, practice, and resilience competencies – offers a complementary perspective from the product design domain. Our ICC model converges with theirs on the importance of domain-specific operationalisation, but diverges in foregrounding the information-communicative dimension and in explicitly modelling AI ethics within the reflective component.

Third, the TPACK adaptation addresses the framework's underuse in design education (3.8% of studies). By reconceptualising TK to encompass prompt engineering, AI tool selection, and the critical

evaluation of AI outputs – rather than mere software proficiency – the adapted model provides a more adequate representation of the knowledge needed by design educators and students alike. This adaptation aligns with emerging I-TPACK approaches [52, 54] but grounds them specifically in studio pedagogy and design disciplinary knowledge, addressing a gap that generic TPACK adaptations cannot fill.

8.2. Relation to prior literature

The framework builds on and extends several lines of prior work across four convergent streams:

1. *AI integration frameworks for design education.* Fleischmann’s [18] call for introducing generative AI into design curricula provides practical motivation but lacks the theoretical scaffolding offered here. Iranmanesh and Lotfabadi’s [22] critical analysis of text-to-image AI in architectural pedagogy identifies similar tensions between creative exploration and loss of foundational skills – tensions that the ICC model addresses through its balanced component structure. Ismail et al. [23] proposed a four-phase conceptual framework for integrating generative AI in graphic design education, drawing on constructivism and the Technology Acceptance Model. Their framework operates at the course level, whereas ICC addresses the competency structure that should underpin such courses. Tellez’s [53] phenomenological reflection on generative AI in design education explicitly invokes TPACK and reflective practice as theoretical lenses, confirming the relevance of the pillars we synthesise.
2. *AI literacy and competency models.* The growing literature on AI literacy [9, 33, 40] provides validated constructs and measurement instruments that partially overlap with ICC. Long and Magerko [33] defined AI literacy through competencies including recognising, understanding, and evaluating AI. Carolus et al.’s [9] MAILS instrument operationalizes AI literacy facets – use and apply, understand, detect, and ethics – that map onto our information-analytical and reflective components. However, these models address general AI literacy rather than domain-specificity. The ICC model extends them by embedding AI competencies within the distinctive context of design practice, adding visual communication, studio-based assessment, and aesthetic evaluation as dimensions absent from general AI literacy frameworks.
3. *Studio pedagogy transformation.* The studio pedagogy pillar is supported by recent empirical work on AI-human collaboration in design studios [27, 44] and by evolving understanding of how digital tools interact with studio critique practices [17]. Hwang and Wu’s [21] analysis of graphic design education’s transition to “contents creator” in the text-to-image era mirrors the maker-to-curator paradigm shift central to our framework. Mewburn’s [34] reconsideration of reflective practice in studio pedagogy provides important nuance: reflection in design is not merely metacognitive but embodied and situated, which our reflective component acknowledges through its emphasis on professional identity and the designer-AI relationship.
4. *Dialogic and constructivist approaches.* Wegerif and Casebourne [59] proposed a “double dialogic pedagogy” for AI integration in education, positioning AI as a partner in expanding dialogue space. While their framework operates at a higher level of abstraction, it complements the ICC model by providing philosophical grounding for the communicative component’s inclusion of human-AI dialogue through prompt engineering. Davis and Dubberly’s [12] rethinking of design education further validates the need for frameworks that address the paradigmatic shift from artefact production to system stewardship.

8.3. Practical implications

For curriculum designers, the framework offers a structured approach to AI integration: the B2-to-ICC mapping (table 3) identifies specific competency gaps that need to be addressed; the proficiency

levels (table 2) provide assessment benchmarks; and the three-pillar structure ensures that changes address knowledge structure (TPACK), learning methods (studio pedagogy), and formal requirements (standards) simultaneously. This three-dimensional approach prevents the common pitfall of adding AI tools to courses without reconsidering pedagogy or learning outcomes [12].

For accreditation bodies, the framework suggests that design education standards should be updated to include: explicit AI-related competency descriptors in each ICC dimension; prompt engineering as a recognised professional skill; ethical reasoning about AI-generated design as a learning outcome; and reflective practice regarding human-AI collaboration.

For researchers, the framework provides testable propositions: that ICC develops through all four components rather than through technological skills alone; that studio pedagogy is the most effective context for integrated ICC formation; and that the reflective component mediates the relationship between technological skill acquisition and professional competence development.

8.4. Limitations

This study has several limitations that should guide future work. First, as a conceptual paper, the framework has not been empirically validated. While it draws on empirical evidence from two prior studies [38, 39], the ICC model's component structure, proficiency levels, and integrative logic require empirical testing through instrument development and field studies.

Second, the gap analysis is based on a single national standard (Ukrainian B2 Design). While the European Qualifications Framework alignment [38] provides partial generalizability, cross-national comparison would strengthen the framework's applicability. Design education standards vary significantly across countries in their specificity and technology orientation.

Third, the framework addresses the bachelor's level and may require adaptation for graduate-level design education, where research competencies and advanced AI capabilities (e.g., fine-tuning models and developing custom tools) become relevant.

Fourth, the rapid pace of AI tool development means that specific tool mentions (Midjourney, DALL-E, etc.) may become outdated. The framework is designed to be tool-agnostic at the structural level – its components and proficiency levels describe capabilities rather than specific technologies – but the examples will inevitably require updating.

9. Conclusion

This paper proposed an integrative theoretical framework for developing information-communicative competence (ICC) in AI-era designers, addressing the dominant atheoretical trend in generative AI design education research.

Regarding RQ1, ICC was operationalised as a four-component model comprising information-analytical, communicative, technological, and reflective components, each incorporating AI-specific descriptors. The reflective component was identified as system-forming, ensuring conscious self-regulation of the entire information-communication activity. Three proficiency levels (beginner, proficient, and advanced) were defined for each component.

Regarding RQ2, the TPACK framework was adapted for AI-era design education by reconceptualising the Technological Knowledge domain to encompass prompt engineering, AI tool selection, and the critical evaluation of AI outputs. The adapted model integrates studio pedagogy as the signature pedagogical approach of design, with the studio format providing an authentic context for developing all four ICC components.

Regarding RQ3, a gap analysis of the Ukrainian B2 Design standard against ICC revealed a systematic pattern: foundational competency prerequisites exist for each ICC component, but AI-specific extensions are absent. This finding supports an “adaptive augmentation” strategy rather than wholesale curriculum replacement.

The integrative framework synthesises TPACK (what knowledge is needed), studio pedagogy (how it is acquired), and the competency approach (what standards require) into a coherent theoretical

foundation. Each pillar addresses a distinct question, and their interactions ensure comprehensive coverage. Future research should pursue three priorities: (1) instrument development and empirical validation of the ICC model's component structure and proficiency levels; (2) cross-national comparative analysis of design education standards against ICC; and (3) intervention studies testing the framework's effectiveness in guiding curriculum transformation across different design specialisations.

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