Research Article

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Ethical human-AI collaboration in design education – past, present, and future

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Abstract: Design education has historically evolved from craft-based master-apprentice models to human-centred and interdisciplinary approaches. Generative AI represents a further shift that fundamentally changes creative processes and requires design education to adapt it's curricula and graduate competencies. This paper examines how human-AI collaboration is currently integrated into design education through a qualitative study combining interviews with design educators and observations of undergraduate student projects. The findings indicate that AI tools are increasingly accepted as part of contemporary design practice but primarily positioned as supports for ideation and early prototyping rather than as a replacement for creative judgement. Building on both historical perspectives and empirical findings, the paper outlines short-, mid-, and long-term implications for design education. It suggests that AI may progressively transform the traditional master-apprentice model and reinforces the value of distinctly human contributions. As AI-generated design becomes more widespread and homogenous, design education and professional practice may increasingly differentiate between AI- and human-made design, potentially splitting curricula and markets.

Keywords: generative AI; design education; AI in higher education; human-AI collaboration; ethical competency; AI literacy

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1 Introduction

Humans and computers have been in a collaborative relationship for decades in nearly all domains, including design.[1,2] Design has long been understood as a reflective and problem-oriented practice that balances creativity, technical skill, and critical judgement.[3] Throughout history, design students have been trained to solve problems through iterative processes and collaborative reflection.[4] These foundational principles have shaped how designers think, act, and communicate.[5]

Design students increasingly use AI for creative tasks, idea generation, and brainstorming,[6] which raises questions surrounding authorship, bias, intellectual property, and ethical awareness. AI technologies must be handled cautiously to enhance rather than undermine human capabilities. It is crucial to get students to use AI actively as a supportive tool rather than passively relying on it.[7] Critical thinking is therefore becoming more important since AI output must be assessed regarding validity, relevance, and ethical implications.[8]

This paper explores human-AI collaboration in design education by outlining the historical development of design education, analysing the current integration of AI through interviews with design experts and student observations, and developing future prognoses based on both past and present practices. The following research questions guide the study:

1. What is the tradition of design education in the light of human-AI co-creation?
2. How do design educators currently navigate the AI-driven changes?
3. What is the future of design education in the context of human-AI collaboration?

2 Historical foundations of design education

Design education is grounded in theoretical conceptions of design that frame it as both creative and analytical practice. "Design is a disciplined inquiry engaged in for the purpose

of creating some new thing of practical utility. It involves exploring an ill-defined situation, finding – as well as solving–a problem(s), and specifying ways to effect change".[3] Design further "requires a balance of reason and intuition, an impetus to act, and an ability to reflect on actions taken".[3]

This definition highlights design as a goal-oriented and intentional practice that integrates analytical reasoning, creativity and reflection. Within design education, however, design is not only understood as the production of objects or solutions, but also as an iterative learning process in which students develop ways of thinking and reflecting as designers.

2.1 Processes of traditional design education

Before the institutionalisation of design education, knowledge was transmitted informally in workshops from master to apprentice.[9,10] It was focused on craftsmanship, material skills, established models, and learning through making.[9,11] In this setting, design and production were tightly integrated. Learning relied largely on observation, repetition and direct guidance from a master rather than a formal curriculum.[12]

With the rise of academies, design education moved into formal institutions. In the late 18th and early 19th century, the École des Beaux Arts in France shaped design to become increasingly separate from making and valued representation over production.[13] Drawing formed the foundation and was used as a shared visual language to build competencies, generate ideas, and communicate with peers, clients and craftsmen. This period introduced the design studio as a central pedagogical model. Studios were organised by students themselves but supervised by masters.[13]

In the late 19th to early 20th century, European schools like Bauhaus revolutionised design teaching by blending craft, theory, art, and technology.[10] It reconnected design with broader social, technological and behavioural knowledge, which traditional design education often lacked.[10]

In the mid-20th century, the Design Methods Movement emerged as a result of post-war optimism and made design more scientific through system thinking and user research.[14]

In the late 20th century, the term human-centred design was coined, and design education began to expand beyond executive tasks to emphasise multidisciplinary skills and perspectives. This shift included a stronger focus on explicit understanding of users, tasks and environments, user-centred evaluation and iterative design processes that involve all stakeholders.[15]

Nowadays, design education is expected to support interdisciplinary collaboration and digital tools, expanding the scope of design competencies.[16]

These historical developments not only shaped design processes but also laid the foundation for the core competencies that continue to define design education today.

2.2 Design competencies

Research on design education repeatedly points to a set of central competencies, most notably creativity, critical thinking and reflection, communication and collaboration, and contextual and ethical awareness.[17,18]

2.2.1 Creativity

An emphasis is placed on developing artistic sensibility, creativity and the ability to produce innovative and aesthetically compelling work. This includes training in the core elements of design, such as form, colour, proportion, and composition, alongside the development of spatial thinking and conceptual exploration through executive tasks such as sketching, modelling, and iteration.[19]

Margaret Boden identifies three forms of creativity that help explain both human and computational creative processes.[20] Combinational creativity involves making new associations between familiar ideas, such as analogies or artistic collages. Exploratory creativity happens within a defined conceptual space, such as a style of music or scientific theory, where generative rules shape what can be produced. Transformational creativity goes a step further by altering the structure of the conceptual space itself, and therefore produces entirely new kinds of ideas.[20]

Beyond individual-centric models of creativity, creativity can also be conceptualised as a distributed and sociotechnical process. From this perspective, creative outcomes emerge through interactions between individuals, tools and cultural contexts rather than from a single creative agent.[21] In human-computer collaboration, creativity is therefore not attributed exclusively to either the human or the computer, but comes from their dynamic, where the computer system acts as a mediator that shapes idea exploration and reflection within the design process.[22]

In design education, these forms of creativity are taught through structured design processes that integrate classic creative-thinking stages with analytical, generative, and evaluative phases.[23] Educators provide foundational knowledge before guiding students through idea generation, often incorporating pauses to support reflection and idea development.[23] Group-based work and stage-focused exercises

distribute cognitive effort, help students practise creativity at specific moments of the design process, and support the development of both novelty and critical judgement within a supportive learning environment.[23]

2.2.2 Critical thinking and reflection

Additional essential competencies include critical thinking and reflective practice, allowing designers to understand complex problem contexts, evaluate design proposals, and make informed decisions.[17] Reflection encourages designers not only to assess outcomes but also to examine their own processes.

William Huitt defined critical thinking as "the disciplined mental activity of evaluating arguments or propositions and making judgments that can guide the development of beliefs and taking action".[24]

Raising awareness of cognitive biases and recognising their influence on decision-making and judgment can help to reduce their impact. Targeted interventions, such as instructions to avoid prejudice and reflective exercises, help mitigate these biases but also encourage students to question assumptions and adopt a more objective perspective.[25,26]

Although critical thinking and critical reflection are distinct, they are deeply interconnected and mutually reinforcing skills. Critical thinking involves objectively analysing and evaluating arguments, evidence, and information. Critical reflection or reflective thinking centres on introspection about experiences, beliefs, actions, and their influence on each other during or after completing a task.[27,28]

Reflective techniques have proven highly effective and include reflective writing and summaries in the form of journals, diaries, or self-evaluation forms, as well as perspective taking, where students take the view of stakeholders and participate in reflective interviews.[29] Reflective writing assignments give students a possibility for critical analysis.[30]

Such systematic and evidence-based forms of reflection are particularly important in design education.[31] Within Schön's framework of reflective practice, these methods primarily support "reflection-on-action" by encouraging students to critically examine their design decisions, while also informing "reflection-in-action" by sharpening awareness during the design process.[4]

2.2.3 Communication and collaboration

Equally important are communication and collaboration skills, which enable designers to consider human, social and ethical implications, balance individual and societal needs, and mediate between diverse stakeholders.[17]

Communication in design collaboration is challenged by differences in how participants interpret and convey information.[32] Four main problem areas include choosing suitable media to transmit information, ensuring that messages keep their intended meaning and are understood and acted upon, and coordinating communication across many people and teams.[32]

Research on design team communication shows that informal conversations and formal meetings serve different but complementary roles.[33] Dialogues allow quick exchange and help team members build a shared understanding, especially early in a project or for detailed issues. Meetings are more structured and therefore useful for coordinating stakeholders and making decisions. They help teams manage complexity and avoid misunderstanding.[33]

In design education, students develop communication skills through studio critiques, group discussions, and teamwork on projects. One-on-one critiques and group reviews allow students to present their work, receive feedback, and refine their ideas.[5] Through repeated participation, students also internalise disciplinary norms of "speaking like a designer", including the clear coordination of verbal explanations with visual material and the persuasive justification of design decisions.[34] These activities not only help students explain their design choices and take feedback constructively but also teach them to navigate emotionally charged situations, balance ownership of their work with collaborative input, and work effectively with peers toward shared goals.[5]

2.2.4 Contextual, ethical and cultural awareness

Design decisions are always situated within social, cultural, economic, and political contexts, and designers must be able to recognise how these contexts shape both problems and proposed solutions.[35]

Many design programs embed contextual, ethical, and cultural awareness as a continuous element across the curriculum and introduce ethics early in the first or second year.[36] Ethical questions, case studies, and discussion prompts are integrated into core studios and technical courses to encourage students to consider social consequences, cultural values, and power relations as part of everyday design reasoning.[36]

One approach to teaching ethical design is through sensitive design situations, which prepare students to engage with complex, real-world problems.[37] These situations are structured to encourage critical reflection by exposing

vulnerabilities, considering diverse stakeholder needs and expectations, and allowing open-ended exploration of multiple solutions.[37] Students actively prototype their designs, making decisions and justifying their choices, which helps challenge assumptions and deepen ethical understanding.[37]

Critics argue that as modern design is becoming increasingly complex, a curricular expansion beyond formal and aesthetic concerns is needed to include applied psychology, systems thinking, and an understanding of human behaviour.[10]

Taken together, these competencies reflect a long-grounded understanding of design as a reflective, collaborative, and context-sensitive practice, forming the foundation of contemporary design education and the discussion around human–AI collaboration.

3 Human-AI Co-creation in contemporary design education

Radical technological changes in computer speed, size, and intelligence lead to deeper human-computer collaboration.[1] Early automated systems promised to revolutionise industries by reducing manual labour and increasing precision.

Sheridan and Parasuraman presented social, political and ethical dimensions of human-automation interaction.[1] They highlighted how failures in automation often raise questions on liability, with responsibility frequently assigned to human operators despite multiple contributing factors. Early automation also suffered from mismatches between human intentions and machine logic, which underlines the need for scepticism in heavily automated systems.[1]

These early debates on automation ethics established core concerns, such as over-reliance, loss of control and responsibility, that resurface with even greater urgency in contemporary AI systems. In design education, these issues are particularly salient, as students increasingly use AI as a co-creative partner.

3.1 Technical capabilities and current applications of AI

While early computer systems primarily supported efficiency and control, generative AI represents a qualitative shift by actively participating in creative processes. Generative AI enables the production of multimodal content, including text, images, audio, videos, and three-dimensional models. As these tools are applied in diverse domains, they introduce both possibilities and risks to education.[38] This is particularly relevant in design studies, where creativity and critical evaluation of visual, textual, and conceptual elements play a central role.

Human-AI co-creation refers to collaborative processes in which humans and AI systems jointly generate creative outputs.[39] AI systems demonstrate strong abilities in handling repetitive and predictable tasks, managing complexity and multitasking. In contrast, humans contribute flexibility, creativity, and strong capabilities in understanding knowledge and strategic thinking.[39]

In design practice and education, AI tools enhance efficiency by automating routine tasks and expanding creative possibilities during ideation and early prototyping. This enables design students to experiment and iterate on different ideas.[40] Empirical studies indicate that such tools are less commonly used in later stages, such as detailed refinement and final prototyping.[41]

However, AI is not just about improving productivity but also helps designers to a deeper level of innovation.[41] With design processes fundamentally changing, design education is putting more emphasis on human-AI collaboration. AI tools should be used not as substitutes for creativity but as partners in iterative, co-creative processes.[39]

Latest surveys show that AI already surpasses humans in many narrow tasks.[42] The field of artificial general intelligence (AGI) describes machine learning that can think and reason like a human. Unlike narrow AI, which is designed for specific tasks, AGI can understand, learn, and perform a wide range of intellectual activities. It has the potential to solve problems, make decisions, and even grasp emotions and social interactions, much like a human being.[43] However, current systems still lack these core traits. Expert predictions vary widely from a few years to several decades before AGI emerges.[42]

3.2 Limitations of AI

Ethical concerns in human-AI co-creativity centre on trust, transparency, and bias.[44] Many of these concerns stem from the black-box nature of AI systems. Transparency regarding AI capabilities, limitations, and data handling is crucial to prevent unintended data disclosure and to ensure informed tool use.[45]

Further challenges highlight the need for advanced critical thinking skills in design education.[44] Copyright represents a major concern, as AI-generated content may involve copyright infringements when protected works are used for model training.[46] At the same time, ownership rights are still unclear for AI-generated output. While some allocate the initial copyright to the AI software company, OpenAI assigns all rights to the user.[47]

Another limitation is the reproduction of gender-, ethnicity-, and culture-based stereotypes in AI-generated content. Because generative AI models are trained on historically biased datasets, they tend to reinforce dominant norms and exclude underrepresented identities.[48–50] In visual design, this can manifest in stereotypical, sexualised, or unrealistic representations, as well as inaccuracies and distortions in AI images.[51,52]

Research further indicates disciplinary differences in AI literacy. Design students often demonstrate moderate overall competence but show notable gaps in legal, ethical, and technical understanding, highlighting the need for targeted educational interventions.[53,54] In this context, explainable AI approaches are particularly relevant, as they support students in critically examining how AI-generated outputs are produced and evaluated.[55]

Over-reliance on AI tools poses risks for students' cognitive development. Studies suggest that uncritical acceptance of AI-generated output can weaken critical thinking, problem-solving, and independent ideation, while frequent reliance on dialogue systems may reduce information retention and increase dependency.[40,56,57]

Finally, generative AI has a significant environmental impact because of the vast amounts of energy and water that are consumed for GPU production, data centres, and model training.[58]

3.3 Emerging competencies for designers in human-AI collaboration

To address these challenges associated with human-AI co-creation, the integration of AI-related competencies into design curricula has become essential. Previous research has identified potential modules where AI-related content can be meaningfully incorporated. This should include teaching students to analyse AI-generated content critically, be aware of its ethical implications, understand the limitations of AI tools, and apply quality control.[59]

AI literacy, regarding understanding data origins and influence, represents a foundational competence for designers working with AI.[60] Students must develop a basic understanding of how generative AI models are trained, including the limitations of large-scale datasets. Awareness of data volume, diversity, and quality is crucial for evaluating AI-generated output and mitigating bias.

Emerging competencies can thus be grouped into three areas: technical understanding of AI systems, ethical and legal awareness, and reflective-critical judgement.

Understanding how students and educators currently navigate design practices and AI use is therefore critical and further emphasises the need for design education to move beyond tool-oriented instruction and toward a more reflective and critical engagement with human-AI collaboration.

Given how AI is changing both education and design practice and the numerous ethical concerns it brings, this study asks: How does design education need to adapt?

4 Empirical study: current human-AI collaboration in design education

4.1 Methodology

Our research is centred around the undergraduate study program in communication design at a University of Applied Sciences.

Four semi-structured interviews were conducted with design educators teaching in the communication design programme. One participant was a full-time professor, while three also worked part-time in the design industry. The four interviewees were selected because they each supervised selectable projects included in the observational study. Their disciplinary background, from photography, visual storytelling, design strategy, and brand and corporate design, was intentionally diverse to depict multiple perspectives across design practice.

The interviews lasted between 30 min and 60 min, and were conducted during the same semester as the observed student projects.

The interviews explored educators' perspectives on AI in design education, including their expectations regarding students' use of AI tools, perceived impacts on creativity and critical thinking, and strategies for encouraging or regulating AI use in the design process. Participants were asked to reflect on trends they see in human-AI collaboration, the competencies they consider essential for future designers, and whether they had adapted their teaching methods.

To complement the interview data, an observational study was conducted across five semester projects involving fourth- and sixth-semester students. Students were offered a range of project topics, some explicitly incorporating AI technology, while others did not.

Observations focused on how students integrated AI tools into their workflows, the types of tasks for which AI was used, and how students evaluated AI-generated outputs. Each project was observed during one to three sessions, with between five and fourteen students per session. Data was documented through a field notes capturing tool usage, design decisions, and moments of reflection or critique related to AI-generated content.

Interview data were transcribed and analysed using qualitative thematic analysis. Recurring themes related to AI use, creativity, ethics, and collaboration were identified and iteratively refined. Observational notes were analysed in parallel and used to contextualise the interview findings.

As a qualitative study conducted within a single institution and discipline, the findings are not intended to be statistically generalisable. Instead, the study aims to provide in-depth insights into current practices and perceptions of human-AI collaboration in design education.

4.2 Perceptions on AI by design educators and students

Across all interviews, educators stated that AI tools are not intended to replace creativity but to support design processes. AI was described as a tool for assisting conceptual thinking, structuring workflows, and supporting ideation rather than producing final design outcomes.

The way AI is being used varies across disciplines. In strategy and branding, AI was primarily applied for concept development and positioning. In visual storytelling and image production, AI tools were more commonly used for aesthetic inspiration.

One educator working in design strategy described using AI to explore oppositional thinking and to reframe strategic challenges. In their teaching practice, AI was used to reinterpret existing ideas, uncover contradictions and generate alternative perspectives. At the same time, the educator emphasised that students should critically reflect on their own use of AI and remain aware of their agency in the design process.

An educator with a background in photography highlighted that AI-generated images disrupt established visual and photographic conventions. They pointed out that, unlike photography, AI-generated images lack a clear connection to a referent to the real world, as it is impossible to trace how much of the generated image originates from specific sources. An example was given in which AI produced coloured photographs attributed to a photographer who had never worked in colour. This raised concerns about historical accuracy and the reliability of AI-generated visual material. The educator emphasised the importance of contextual knowledge and verification when working with AI-generated images.

Similarly, another educator described using AI to inspire visual concepts and clarify conceptual structures, but stressed that students should remain the primary authors of their work. Across interviews, educators agreed that AI should support the design process rather than determine creative outcomes.

Scepticism was also expressed by one educator who questioned the necessity of introducing AI tools too early in design education. They emphasised that core creative skills should be developed before integrating AI into the curriculum.

Observations showed that students engaged with AI tools in a variety of contexts. Generally, AI was integrated as a creative collaborator and “idea enhancer”. It proved to be valuable in overcoming creative blocks and generating initial concepts. ChatGPT was frequently used for text generation and refinement, supporting tasks such as writing exposés, preparing presentations, and composing emails. Additionally, AI tools were used for translation and grammar correction. For research and fact-checking, students relied on tools like Perplexity and ChatGPT to explore topics and gather background information. In the area of visual creation, applications such as Midjourney, DALL-E, and Meshy AI were used for image generation and 3D modelling. ChatGPT also served as a resource for coding and programming assistance. One student noted, however, that without a solid technical background, AI-generated code was often difficult to interpret.

At the same time, students expressed concerns about becoming overly reliant on AI and questioned the depth and originality of AI-generated output. Some students voiced concerns about AI replacing creative professions. Students generally showed awareness of ethical concerns and a critical stance towards AI-generated results. Several expressed a desire to further develop competencies such as better prompting and understanding ethical implications.

While many students prefer to work fully digitally, a renewed interest in analogue practices was also evident.

4.3 Developments in design classes

None of the educators reported having formal rules restricting the use of AI in their module. Instead, AI use was informally permitted, and students were free to decide whether and how to integrate AI tools into their projects. One educator noted that although AI was not explicitly mentioned in assignment guidelines, they anticipated students would use it for layout suggestions, structuring presentations, or ideation.

Educators identified several competencies as important, including the ability to critically assess AI-generated output, a basic understanding of how AI models are trained, and awareness of biases in training data. Technical awareness for understanding how prompts influence results and where the limits of generative tools lie was also mentioned.

All interviewees expressed a pragmatic openness to integrating AI further into design education, but maintained

a strong emphasis on having contextual knowledge that is necessary for properly interpreting and assessing AI output. They anticipated that AI use would likely become unavoidable in professional contexts and that design education would need to reflect these developments.

One educator said there is always a level of dependence on current technologies. They see AI as a tool to lay out ideas in their head and to close gaps in the creative process.

Another educator highlighted that future design education should combine critical reflection with a basic technical understanding of AI's functionality, even in fields like photography, where coding isn't essential. They said they see their role less as a technical expert and more as a guide for exploratory learning, where students experiment and reflect together. In their opinion, students often handle the tools more confidently, but can benefit from structured and critical discussions on AI usage.

One educator with a focus on corporate design acknowledged the pressure from industry to use AI to increase efficiency in their design process. They emphasised the need for students to develop their own brands and styles that differentiate them from generic AI output, but also to use AI tools to their advantage.

Interviewees also anticipated changes in teaching formats. They saw value in introducing a variety of AI applications in the classroom to help students understand the potential and constraints, but also stated that they were still experimenting and had not yet formalised new teaching strategies.

Overall, educators described an ongoing process of adjustment, characterised by uncertainty but also openness toward integrating AI into design education in a reflective and responsible manner.

4.4 Discussion of findings

The findings indicate that critical and reflective thinking remain central to how educators frame AI in design education, aligning with established design pedagogy emphasising reflection-on-action and reflection-in-action.[4,26,28] Educators consistently positioned AI as a supportive tool rather than a replacement for human creativity, supporting ideation, workflow structuring, and conceptual exploration rather than determining final outcomes. This echoes the broader conceptualisation of creativity as a distributed and sociotechnical process, where AI mediates but does not replace human agency.[21,22]

Human-AI co-creation was a recurring theme, with AI primarily acting as an "idea enhancer" or assistant. This mirrors patterns reported in literature, where generative AI tools are most often employed during early phases of design, supporting combinational creativity by recombining existing ideas.[20,41] While AI occasionally contributed to variation within predefined conceptual spaces, transformational creativity and fundamental conceptual shifts remained the domain of human designers.[20,22]

The study also highlights the relevance of core design competencies, grounded in traditional design education. Studio critiques, group discussions, and collaborative projects support communication and collaboration skills, allowing students to justify design choices and integrate peer feedback.[5] Observations revealed that students applied these competencies in their interaction with AI. They evaluated output and integrated AI-generated content selectively.

Ethical considerations were consistently present in teaching practices and student reflections. Awareness of bias, stereotyping, and cultural representation was particularly evident in the use of visual generation tools. Educators highlighted the importance of having contextual and domain background knowledge,[35] indicating that ethical engagement with AI is closely tied to disciplinary expertise rather than purely technical understanding. These findings show how ethical concerns surrounding AI are already embedded in design education, even when not formalised through explicit curricular structures.

The findings indicate a hybrid approach to design practice, in which digital AI tools coexist with analogue and hands-on methods. This reflects the continued value of traditional design competencies such as observational skills and material understanding, which are fundamental in studio-based learning.[3,9,12] Students' selective adoption of AI suggests a balanced approach where AI increases efficiency but individual creativity and critical reflection are preserved.

Finally, both educators and students expressed awareness of increasing industry expectations regarding AI proficiency. This creates a tension between the need to develop technical fluency with AI tools and the desire to maintain individual design identity. Rather than framing this as a contradiction, the findings suggest that design education helps students to find a balance by using AI strategically while keeping a critical distance from generic outputs.

The study confirms that AI in design education should be approached as a co-creative partner that enhances but does not replace human agency. Integrating AI requires a balanced development of creativity, reflection, communication, and ethical awareness.

5 Future predictions on AI in design education

Based on the historical development of design education, the identified core competencies, and the empirical findings of this study, possible future scenarios of AI in design education are outlined. Developments in the field of AI are difficult to predict, as demonstrated by the rapid and largely unforeseen rise of large language models. The following scenarios should therefore not be understood as deterministic forecasts, but rather as plausible and informed assumptions. This outlook is structured in short-term (5–10 years), mid-term (10–25 years), and long-term (25–50 years). Given the pace of current technological change, however, some of these developments may occur more rapidly than anticipated.

5.1 Short-term developments (5–10 years)

In the short-term, generative AI is likely to become a standard design tool, comparable to image-editing software. As these AI tools become increasingly accessible, they will lower entry barriers to design practices, which will reinforce the notion that "everybody can design". Tasks such as illustration, layout, and visual storytelling may be practised by individuals without formal design education. While this can be seen as a form of creative democratisation, it may lead to an aesthetic homogenisation, as AI-generated output often follows similar stylistic conventions.

This coexistence of AI-driven automation and rising AI competency requirements for professional designers is not unique to design but is characteristic of many creative fields. It signals a broader transformation of professional identities, in which creative expertise is less defined by technical skills and more by the ability to contextualise and evaluate AI-supported processes. At the same time, this shift is closely tied to ongoing concerns about changing job profiles and long-term employment perspectives within creative industries.

Simultaneously, AI technology will become more deeply embedded in existing tools and workflows, making their use less visible and more routine. This integration may further normalise AI-supported design practices and reduce the distinction between human and machine contributions.

As AI systems handle executive tasks, design education may place less emphasis on manual skills and more on conceptualisation, reflection, and reasoning. The designers' role may shift towards choreographing AI-supported design processes. Central activities might include defining goals, selecting tools, guiding iterations, and evaluating results.

Design curricula are expected to make ethical AI literacy an explicit learning outcome. This includes bias awareness, authorship, and data literacy, while also emphasising tool proficiency and prompt engineering. Assessment format may shift accordingly to place less weight on final artefacts and more on process documentation, decision-making, and students' ability to justify their design choices.

In professional contexts, designers are likely to act as communicators between clients and AI systems, mediating between human needs, ethical considerations, and technical capabilities. Communication, contextual awareness, and critical evaluation, which are already core design competencies, will gain further importance.

5.2 Mid-term developments (10–25 years)

In the mid-term, as models become larger and even more complex, the energy, water, and material demands of AI infrastructure are likely to increase substantially. This will amplify environmental pressures and might lead to sustainability becoming a central concern for AI usage in design education and in general.

With AI technology embedded in design tools and workflows, design education may respond by more explicitly differentiating between combinational, exploratory, and transformational creativity. At this point, AI systems support combinational and exploratory processes. Transformational creativity may remain a human design competency.

At the same time, traditional pedagogical models, such as the master-apprentice, may be challenged. As students learn from and with AI systems that provide continuous feedback and examples, the role of the educator may shift further towards a mediator for critical discourse and ethical reflection. This development may raise fundamental questions about the necessity and purpose of formal design education.

This might also result in design being increasingly framed as a form of artistic and cultural practice, rather than solely as a problem-solving discipline. As functional and aesthetic solutions become easier to generate through AI, human designers may focus more strongly on expressive forms of design. The human touch may gain symbolic importance as AI-generated design becomes more uniform.

5.3 Long-term developments (25–50 years)

In the long-term, generative AI may reach functionality levels at which they can perform not only combinational and exploratory tasks but also transformational creative

processes, approaching capabilities associated with AGI. Such developments would challenge current assumptions about the limits of machine creativity. In this scenario, genuinely collaborative human-AI teams may emerge, in which humans and AI agents work together in design processes.

As a potential counter-development, the cultural and economic value of human-made design may increase. A market saturated with homogeneous AI-design, design explicitly produced without AI may become a marker of authenticity and distinction. This could lead to a divide of design markets and practices, distinguishing between low-entry AI-supported design and design that is intentionally human-made.

Design education may reflect this division by offering differentiated paths. One curriculum may continue to prepare students for efficient collaboration with advanced AI systems, and another may emphasise craftsmanship, materiality, and hands-on making. This shift could result in fewer practising designers and a corresponding decrease in resources and capacity for design education.

Overall, these scenarios suggest that AI will not replace design education but reconfigure its focus. Rather than relying on traditional models such as the master-apprenticeship structures, design education may shift toward new forms of human-AI collaboration. The value attributed to design practice itself might also change. Consequently, the future of design education appears to be less about whether or not AI is used and more about how human designers will meaningfully contribute. Educational institutions will therefore continue to play a crucial role in developing students' ability to use their core competencies, such as creativity, reflection, communication and ethical judgement in diverse contexts. Even as tools and workflows evolve, these competencies are likely to remain central to design education and professional practice.

6 Conclusions

This study was set out to trace historical developments of design education, identify core design competencies, and examine human-AI co-creation. By combining interviews with design educators and observations of student projects, the study provides insight into how AI is already integrated into everyday design practices and pedagogical decisions.

Addressing the first research question on the traditional roots of design education, the analysis shows that contemporary discussions of human-AI co-creation are firmly grounded in established traditions of design education. Master-apprentice and studio-based learning, critique, reflection, and learning through making frame design as a reflective practice, with AI extending rather than replacing these foundations.

In response to the second research question regarding how design educators navigate AI-driven changes, the findings show that educators demonstrate a largely pragmatic and reflective manner. Instead of enforcing strict rules, educators integrate AI as a supportive tool for ideation, structuring, and exploration. This approach reflects long-standing pedagogical values and highlights the role of educators as guides.

Finally, the third research question on the future of design education was addressed through short-, mid-, and long-term predictions based on the empirical findings and existing research. These predictions suggest that AI will increasingly support routine and combinational creative tasks, while design education places greater emphasis on conceptual thinking, reflection, communication, and contextual awareness. Despite technological change, the findings indicate that core design competencies remain grounded in human decision-making.

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References

1. Sheridan, T. B.; Parasuraman, R. Human-Automation Interaction. *Rev. Hum. Factors Ergon.* **2005**, *1* (1), 89—129.
2. John, S. P. The Integration of Information Technology in Higher Education: A Study of Faculty's Attitude Towards IT Adoption in the Teaching Process. *Contad. Adm.* **2015**, *60*, 230—252.
3. Rowland, G. Designing and Instructional Design. *Educ. Technol. Res. Dev.* **1993**, *41* (1), 79—91.
4. Schön, D. A. *The Reflective Practitioner: How Professionals Think in Action*; Taylor & Francis: London, 1986.
5. Goldschmidt, G.; Hochman, H.; Dafni, I. The Design Studio "Crit": Teacher — Student Communication. *AI Edam* **2010**, *24* (3), 285—302.
6. Schmidt, L.; Piazza, A.; Wiedenhöft, C. "Augmented Brainstorming with AI"—Research Approach for Identifying Design Criteria for Improved Collaborative Idea Generation Between Humans and AI. In *HHAI 2023: Augmenting Human Intellect*; IOS Press, 2023; pp. 410—412.
7. Wu, Y. Integrating Generative AI in Education: How ChatGPT Brings Challenges for Future Learning and Teaching. *J. Adv. Educ. Res.* **2023**, *2* (4), 6—10.
8. Walter, Y. Embracing the Future of Artificial Intelligence in the Classroom: The Relevance of AI Literacy, Prompt Engineering, and Critical Thinking in Modern Education. *Int. J. Educ. Technol. High. Educ.* **2024**, *21*, 15.
9. Sennett, R. *The Craftsman*; Yale University Press, 2008.
10. Meyer, M. W.; Norman, D. Changing Design Education for the 21st Century. *She Ji* **2020**, *6* (1), 13—49.
11. Pye, D. W. *The Nature and Art of Workmanship*; The Herbert Press: Cambridge, Vol. *47*, 1968.
12. Dormer, P. *The Art of the Maker*; Thames and Hudson, 1994. https://books.google.de/books?id=iZ9pQgAACAAJ.
13. Garric, J. P. The French Beaux-Arts. In *The Companions to the History of Architecture*; Bressani, M., Contandriopoulos, C., Eds., Vol. *3*, 2017; pp. 1—15.
14. Langrish, J. Z. The Design Methods Movement from Optimism to Darwinism. In *Future Focused Thinking — DRS International Conference 2016*, 2016.
15. Giacomin, J. What is Human Centred Design? *Des. J.* **2014**, *17* (4), 606—623.
16. Sclater, M.; Lally, V. Interdisciplinarity and Technology-Enhanced Learning: Reflections from Art and Design and Educational Perspectives. *Res. Comp. Int. Educ.* **2018**, *13* (1), 46—69.
17. Weil, D.; Mayfield, M. Tomorrow's Critical Design Competencies: Building a Course System for 21st Century Designers. *She Ji* **2020**, *6* (2), 157—169.
18. Sudhindra, S. T.; He, Y.; Blessing, L.; Khan, S. A. Stories of Design Education: An Analysis of Practices and Competencies. *Proc. Des. Soc.* **2022**, *2*, 2403—2412.
19. Zhu, L.; Lu, J. Development of Artistic and Creative Activities for Design Students. *Harmon. J. Arts Res. Educ.* **2023**, *23* (1), 121—131.
20. Boden, M. A. Computer Models of Creativity. *AI Mag.* **2009**, *30* (3), 23—34.
21. Sawyer, R. K.; DeZutter, S. Distributed Creativity: How Collective Creations Emerge from Collaboration. *Psychol. Aesthet. Creat. Arts* **2009**, *3* (2), 81—92.
22. Lubart, T. How Can Computers be Partners in the Creative Process: Classification and Commentary on the Special Issue. *Int. J. Hum. Comput. Stud.* **2005**, *63* (4—5), 365—369.
23. Wong, Y. L.; Siu, K. W. M. A Model of Creative Design Process for Fostering Creativity of Students in Design Education. *Int. J. Technol. Des. Educ.* **2012**, *22* (4), 437—450.
24. Huitt, W. Critical Thinking: An Overview. *Educ. Psychol. Interact.* **1998**, *3* (6), 34—50.
25. Macpherson, R.; Stanovich, K. E. Cognitive Ability, Thinking Dispositions, and Instructional Set as Predictors of Critical Thinking. *Learn. Individ. Differ.* **2007**, *17* (2), 115—127.
26. Aston, K. J. 'Why is this Hard, to Have Critical Thinking?' Exploring the Factors Affecting Critical Thinking with International Higher Education Students. *Act. Learn. High. Educ.* **2023**, *29* (3), 14697874231168341.
27. Indrašienė, V.; Jegelevičienė, V.; Merfeldaitė, O.; Penkauskienė, D.; Pivorienė, J.; Railienė, A.; Sadauskas, J. Critical Reflection in Students' Critical Thinking Teaching and Learning Experiences. *Sustainability* **2023**, *15* (18), 13500.
28. Ghanizadeh, A. The Interplay Between Reflective Thinking, Critical Thinking, Self-Monitoring, and Academic Achievement in Higher Education. *High. Educ.* **2017**, *74*, 101—114.
29. Smith, E. Teaching Critical Reflection. *Teach. High. Educ.* **2011**, *16* (2), 211—223.
30. Bayles, T. M. A Reflective Writing Assignment to Engage Etudents in Critical Thinking. In *2013 ASEE Annual Conference & Exposition*, 2013; pp. 23—96.
31. Agouridas, V.; Race, P. Enhancing Knowledge Management in Design Education Through Systematic Reflection Practice. *Concurr. Eng.* **2007**, *15* (1), 63—76.
32. Chiu, M. L. An Organizational View of Design Communication in Design Collaboration. *Des. Stud.* **2002**, *23* (2), 187—210.
33. Den Otter, A.; Emmitt, S. Design Team Communication and Design Task Complexity: The Preference for Dialogues. *Arch. Eng. Des. Manag.* **2008**, *4* (2), 121—129.
34. Dannels, D.; Gaffney, A. H.; Martin, K. N. Beyond Content, Deeper than Delivery: What Critique Feedback Reveals About Communication Expectations in Design Education. *IJ-SoTL* **2008**, *2* (2), 12.
35. Nieusma, D. Alternative Design Scholarship: Working Toward Appropriate Design. *Des. Issues* **2004**, *20* (3), 13—24.
36. Çelik, F. A Holistic Approach to Creating Ethical Sensitivity and Awareness in Landscape Design Education. *J. Archit. Sci. Appl.* **2024**, *9* (1), 634—651.
37. Islind, A. S.; Willermark, S. M. J. Becoming a Designer: The Value of Sensitive Design Situations for Teaching and Learning Ethical Design and Design Theory. *Scand. J. Inf. Syst.* **2022**, *34* (1), 1.
38. Chiu, T. K. Future Research Recommendations for Transforming Higher Education with Generative AI. *Comput. Educ. Artif. Intell.* **2024**, *6*, 100197.
39. Wu, Z.; Ji, D.; Yu, K.; Zeng, X.; Wu, D.; Shidujaman, M. AI Creativity and the Human-AI Co-Creation Model. In *Human-Computer Interaction. Theory, Methods and Tools: Thematic Area, HCI 2021, Held as Part of the 23rd HCI International Conference, HCII 2021, Virtual Event, July 24—29, 2021, Proceedings, Part I 23*; Springer, 2021; pp. 171—190.

40. Lin, Y.; Liu, H. The Impact of Artificial Intelligence Generated Content Driven Graphic Design Tools on Creative Thinking of Designers. In *International Conference on Human-Computer Interaction*; Springer, 2024; pp. 258—272.
41. Nugroho, B. S.; Annasit, A.; Hamid, F. A.; Setiyono, A. Application of AI in the Creative Process: Case Study in the Design Industry. *J. Soc. Entrep. Creat. Tech.* **2025**, *2* (1), 24—35.
42. Feng, T.; Jin, C.; Liu, J.; Zhu, K.; Tu, H.; Cheng, Z.; Lin, G; You, J. How far are we from Agi. *CoRR* **2024**.
43. Latif, E.; Mai, G.; Nyaaba, M.; Wu, X.; Liu, N.; Lu, G.; Li, S; Liu, T; Zhai, X. Artificial General Intelligence (AGI) for Education. arXiv preprint arXiv:230412479 **2023**, *1*, 1—34.
44. Al-kfairy, M.; Mustafa, D.; Kshetri, N.; Insiew, M.; Alfandi, O. Ethical Challenges and Solutions of Generative AI: An Interdisciplinary Perspective. *Informatics* **2024**, *11*, 58.
45. Ruane, E.; Birhane, A.; Ventresque, A. Conversational AI: Social and Ethical Considerations. *AICS* **2019**, *2563*, 104—115.
46. Matulionyte, R. Generative AI and Copyright: Exception, Compensation or Both? In *Intellectual Property Forum: Journal of the Intellectual and Industrial Property Society of Australia and New Zealand. 134. Intellectual and Industrial Property Society of Australia and New Zealand …*, 2023; pp. 33—40.
47. Zirpoli, C. T. *Generative Artificial Intelligence and Copyright Law*. Copyright, Fair Use, Scholarly Communication, etc, 2023.
48. Ferrara, E. Fairness and Bias in Artificial Intelligence: A Brief Survey of Sources, Impacts, and Mitigation Strategies. *Sci.* **2023**, *6* (1), 3.
49. Sun, L.; Wei, M.; Sun, Y.; Suh, Y. J.; Shen, L.; Yang, S. Smiling Women Pitching Down: Auditing Representational and Presentational Gender Biases in Image-Generative AI. *J. Comput.-Mediat. Commun.* **2024**, *29* (1), zmad045.
50. García-Ull, F. J.; Melero-Lázaro, M. Gender Stereotypes in AI-Generated Images. *Prof. Inf.* **2023**, *32* (5).
51. Kuck, K. Generative Artificial Intelligence: A Double-Edged Sword. In *2023 World Engineering Education Forum-Global Engineering Deans Council (WEEF-GEDC)*; IEEE, 2023; pp. 1—10.
52. York, E. J.; Brumberger, E.; Harris, L. V. A. Prompting Bias: Assessing Representation and Accuracy in AI-Generated Images. In *Proceedings of the 42nd ACM International Conference on Design of Communication*, 2024; pp. 106—115.
53. Hornberger, M.; Bewersdorff, A.; Nerdel, C. What Do University Students Know About Artificial Intelligence? Development and Validation of an AI Literacy Test. *Comput. Educ. Artif. Intell.* **2023**, *5*, 100165.
54. Schauer, S.; Simbeck, K.; Pinkwart, N. AI Literacy and Attitudes Towards AI in Design Education: A Comparative Study of Communication and Architectural Design Students. *CSEDU* **2025**, *1*, 464—471.
55. Khosravi, H.; Shum, S. B.; Chen, G.; Conati, C.; Tsai, Y. S.; Kay, J.; Knight, S.; Martinez-Maldonado, R.; Sadiq, S.; Gašević, D. Explainable Artificial Intelligence in Education. *Comput. Educ. Artif. Intell.* **2022**, *3*, 100074.
56. Zou, X.; Su, P.; Li, L.; Fu, P. AI-Generated Content Tools and Students' Critical Thinking: Insights from a Chinese University. *IFLA J.* **2024**, *50* (2), 228—241.
57. Zhai, C.; Wibowo, S.; Li, L. D. The Effects of Over-Reliance on AI Dialogue Systems on Students' Cognitive Abilities: A Systematic Review. *Smart Learn. Environ.* **2024**, *11* (1), 28.
58. Hosseini, M.; Gao, P.; Vivas-Valencia, C. A Social-Environmental Impact Perspective of Generative Artificial Intelligence. *Environ. Sci. Ecotechnology* **2025**, *23*, 100520.
59. Schauer, S.; Simbeck, K. AI Literacy for Cultural and Design Studies. *CSEDU* **2024**, *2*, 39—50.
60. Frank, M.; Walker, J.; Attard, J.; Tygel, A. Data Literacy-What is it and How Can We Make it Happen? *J. Community Inf.* **2016**, *12* (3); https://doi.org/10.15353/joci.v12i3.3274.