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Artificial Intelligence in Product Design Education: Status, Benefits, and Challenges in the Tunisian Context

L'intelligence artificielle dans l'enseignement du design produit : état des lieux, bénéfices et enjeux en contexte tunisien

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Abstract

This study examines the gradual integration of artificial intelligence (AI) into product design workshops at the *École supérieure des sciences et technologies du design* (ESSTED) [Higher School of Design Sciences and Technologies] in Tunisia. Using a mixed-method approach combining questionnaires and non-participant observations of project presentations, the study analyzes how AI is used across the different phases of the design process. The results indicate the use of AI predominantly in project research, analysis, and structuring phases, accompanied by a more limited and often implicit use during the ideation and prototyping phases. This trend is accompanied by a decline in traditional manual practices, particularly sketching. While AI is perceived as a means of improving project efficiency and consistency, significant cognitive, ethical, and pedagogical concerns have nevertheless been reported by both students and teachers. The study's findings highlight the need for a structured pedagogical framework to facilitate the responsible and contextualized integration of AI, to strike a balance between technological innovation and the preservation of fundamental design skills.

Keywords

Artificial intelligence in design education, product design pedagogy, project-based workshop, generative AI, design process, creativity and automation, TPACK framework, higher education in Tunisia, cognitive and ethical issues of AI, experiential learning in design.

Résumé

Ce texte s'intéresse à l'étude de l'intégration progressive de l'intelligence artificielle (IA) dans l'atelier de projet en design produit à l'École supérieure des sciences et technologies du design (Tunisie). Elle applique une approche méthodologique mixte combinant des questionnaires et des

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observations non participantes des présentations de projets, permettant d'explorer l'intégration des outils de l'IA dans les différentes étapes du processus de conception. Elle affirme que ces outils sont largement utilisés dans les phases de recherche, d'analyse et de structuration des projets, et d'une fréquence moins importante dans les phases d'idéation et de prototypage. Cette transformation est accompagnée d'un déclin des pratiques manuelles traditionnelles, telles que le dessin, qui sont remplacées par d'autres méthodes plus rapides. Bien que les enseignants et les étudiants reconnaissent les avantages de l'IA, ils expriment des réserves considérables quant à ses implications cognitives, éthiques et pédagogiques. Les résultats de l'étude mettent en évidence la nécessité d'un cadre pédagogique structuré pour faciliter l'intégration responsable et contextualisée de l'intelligence artificielle (IA), en trouvant un équilibre entre l'innovation technologique et la préservation des compétences fondamentales en matière de conception.

Mots-clés

Intelligence artificielle en enseignement du design, pédagogie du design produit, atelier de projet, IA générative, processus de conception en design, créativité et automatisation, modèle TPACK, enseignement supérieur en Tunisie, enjeux cognitifs et éthiques de l'IA, apprentissage expérientiel en design.

I. Introduction

The gradual integration of artificial intelligence (AI) into design practices is profoundly transforming the process of creation, learning, and evaluation. With the development of digital tools, the discipline of product design has undergone continuous evolution, fueled by technological innovations that have broadened modes of expression and changed project dynamics. This transformation has accelerated with the emergence of generative tools, conversational agents, and algorithmic assistance systems. These systems can analyze data, propose conceptual directions, improve editorial coherence, and support technical stages such as prototyping. Such transformations, widely discussed in the international literature (Crawford, 2021; Luckin et al., 2016; Strubell et al., 2019; Verganti et al., 2020), are reshaping learning practices and creative dynamics. They redefine the role of the designer, who now operates at the intersection of intuition, technology, and critical reflection.

According to Amabile (1996), creativity depends on the interaction between intrinsic motivation, domain-specific skills, and general cognitive abilities. However, the widespread use of automated tools can undermine this balance by reducing exploratory effort and personal engagement in the ideation phases. Brown (2009) and Cross (2006) point out that design thinking is traditionally based on experimentation, sketching, materiality, and abductive reasoning, dimensions that may be weakened when students delegate part of their thinking to generative systems. However, AI can also support essential aspects of design: accelerating research, coming up with alternatives, assisting with formulation, improving the quality of renderings, and structuring the project. These contributions seem to manifest themselves differently depending on the stage of the project, with AI being used more for framing and analysis than for creative production. Thus, as Luckin et al. (2016) point out, the benefits of AI are only felt when it is integrated into a thoughtful educational framework geared toward the development of critical skills.

Despite the abundance of international research, this transformation remains under-documented in the Tunisian context. Recent institutional initiatives – such as the National Artificial Intelligence Strategy (Ministère des Technologies de la communication et de l'Économie numérique, 2022), the Scientific Days devoted to design and AI (Institut Supérieur des Arts et Métiers, 2023), and the awareness workshops conducted by the Virtual University of Tunis (Université virtuelle de Tunis, 2025) – attest to a growing awareness. However, local scientific literature remains limited and focuses more on the integration of ICT in education (Fatnassi, 2021) than on the specific use of AI in product design Project Studios. In particular, few studies analyze how AI fits into the different phases of a design project, making it difficult to assess its real impact on the educational and creative practices of Tunisian students and teachers, and fully justifying the importance of this study.

Project Studios play a central role in product design training as an experiential learning space where students apply their research, ideation, modeling, prototyping, testing, and conceptual justification skills. This space, historically based on sketching, manipulating materials, and experimentation, is now undergoing profound changes linked to digitization and the growing use of AI tools. At ESSTED, observations made during project defenses show a notable decrease in the number of sketches produced per project, an often-implicit presence of AI in the writing of deliverables, and a massive use of digital tools to structure and express the student's approach. These transformations suggest a gradual shift in creative practices towards more analytical and discursive forms and raise essential questions about the preservation of manual skills, the quality of experiential learning, and the balance between automation and creative sensitivity.

These findings echo into broader concerns raised in the literature: risks of standardization and cognitive dependence, the weakening of embodied know-how, and contextual and ethical biases in the systems used (Buolamwini & Gebru, 2018; Crawford, 2021). They also invite us to question how AI reconfigures the respective roles of student and teacher throughout the project process, from the discovery phase to the communication of results. In this regard, this study draws on Mishra & Koehler's (2006) TPACK (Technological Pedagogical and Content Knowledge) model, a theoretical framework that is particularly relevant for analyzing the relationship between technological knowledge (TK), pedagogical knowledge (PK), and content, or disciplinary knowledge (CK). TPACK provides a framework for interpreting how the use of AI, far from being merely technical, simultaneously affects pedagogical practices, creative processes, and the very nature of the discipline. This approach is all the more necessary given that recent work, such as the systematic review by Ge & Fan (2024), highlights the lack of international consensus on the skills development required to integrate AI into design, as well as on the teaching methods best suited to this integration.

In the specific context of ESSTED, the use of AI seems to be evolving more rapidly than the institutional capacity to support it. Students make extensive use of AI – sometimes implicitly – for documentary research, data analysis, idea generation, and writing deliverables. Teachers, for their part, express divergent attitudes: interest in creative possibilities along with concerns about educational and ethical risks, lack of training, and the absence of a common framework to guide the integration of these tools. This gap between actual practices and the institutional framework is particularly evident when it comes to the difficulty of supervising the use of AI at different stages of the project. This highlights the urgent need for a structured model to guide the transformation of teaching practices.

This study therefore aims to understand how students and teachers in the product design Project Studios at ESSTED integrate AI into their practices, as well as the associated opportunities and limitations, and the evolution and transformation of such usage throughout the different phases of the design process. More broadly, the aim is to provide a solid empirical basis for defining a future pedagogical framework for the responsible, critical, and contextualized integration of artificial intelligence into designer training.

II. Materials and Methods

II.1 Methodological Approach

This research is based on a mixed approach using both quantitative data collected through standardized questionnaires and qualitative data derived from field observations. This methodological choice allows for a comprehensive and nuanced analysis of the integration of artificial intelligence (AI) is being integrated into product design education by cross-referencing stated perceptions (students and teachers) with practices observed during design project defenses. This approach makes it possible to compare perceived uses with actual observed uses, particularly when these are implicit or undeclared.

This methodological positioning is in line with the definition of mixed research according to Creswell and Plano Clark (2017), for whom the complementarity and coordinated integration of quantitative and qualitative data allows for a more detailed, contextualized, and robust understanding of complex educational phenomena. This approach is particularly relevant when examining the use of emerging technologies, whether declared, implicit, observed, or under-reported. In this study, it also allows us to use a process-based interpretation of the design approach to analyze how AI has been incorporated at different stages of the product design process.

Statistical analyses were conducted using JASP software (version 0.19.3).

II.2 Population and Sampling

The study is based on two main samples: students and teachers involved in product design Project Studios at the *École Supérieure des Sciences et Technologies du Design* (ESSTED).

Students

The target student population consists of 145 students across three levels of education: Bachelor's degree (L3), Master's degree (M1), and Master's degree (M2). These students come from different branches of product design, namely packaging design, product design, and design for sustainable development.

A total of 53 students responded to the questionnaire, representing a participation rate of 36.5%. There are two main reasons for choosing this sample. First, the study focuses exclusively on the Project Studios, which are considered a central and structuring element of product design training. Second, the levels selected correspond to the most advanced stages of the curriculum, when students have a more highly developed understanding of the design process and sufficient autonomy to explore or experiment with new tools, such as artificial intelligence, particularly in the project's research, definition, and development phases.

Teachers

The teacher sample consists of 14 teachers who have supervised product design Project Studios across all specialties at the L3, M1, or M2 levels for at least one semester during the 2023 to 2025 academic years. To preserve survey objectivity, the researcher, who is a teacher at the institution, voluntarily excluded himself from the sample.

Of the 14 teachers surveyed, 11 responded to the questionnaire, for a participation rate of 78.6%. This reflects a high level of commitment from supervisors to discuss the integration of AI into the Project Studios.

II.3 Data Collection Tools

II.3.1 Questionnaires

Two questionnaires were developed specifically for the purpose of this study: one for students (Appendix A) and the other for teachers supervising the product design Project Studios (Appendix B). Although the questionnaires are reproduced in English in the appendices for publication purposes, they were originally administered in French. Questionnaire design was based on the research objectives and the main dimensions identified in the literature, including AI usage practices, the skills involved, creativity, ethical and environmental issues, and critical perceptions associated with these technologies. Particular attention was paid to covering the various product design project phases in order to analyze the use of AI throughout the design process.

The **student questionnaire**, consisting of 26 items, is structured into six thematic sections:

1. Respondent profiles and experience with AI.
2. The use of AI in the various project phases (research, ideation, prototyping, and testing).
3. The perceived impact of AI on creativity, productivity, and work quality.
4. Critical perceptions related to the risks of standardization, technological dependence, and loss of know-how.
5. Ethical and environmental concerns.
6. Expectations regarding the integration of AI into teaching and related training.

The **teacher questionnaire**, consisting of 22 items, is structured around five main areas:

1. Supervisory experience and personal use of AI.
2. Observation of student practices.
3. Perceived impact of AI on student creativity, skills, and autonomy.
4. The pedagogical risks and limitations associated with these tools.
5. Institutional barriers and training needs.

The response formats combine Likert scales, multiple-choice questions, and open-ended questions, allowing for the collection of both comparable quantitative data and contextualized qualitative information. To verify readability and clarity instruction, a pre-test was conducted with five people (three students and two teachers). Based on their feedback, a few minor adjustments were made before the final distribution of the questionnaires.

II.3.2 Direct Observations

In addition to the questionnaires, non-participant observation was conducted during 23 product design project defenses covering the three levels of training: Bachelor’s degree (L3), Master’s degree (M1), and Master’s degree (M2). These defenses took place between May 19 and June 6, 2025, as part of the final projects. The average duration of each defense was approximately 40 minutes and included exchanges and interactions between students and jury members.

The observation aimed to systematically document the actual presence of artificial intelligence use in the projects (declared or implicit), how students used these tools (types of tools, project phases involved, degree of autonomy), students' discourse on the use or justification of AI, and the juries' reactions (acceptance, indifference, avoidance, or implicit evaluation). Particular attention was paid to the communication and critique phase of the project, considered a key moment for visibility and recognition of AI-related practices.

To ensure that the analyses were consistent and systematic, a structured observation grid (see Appendix C) was designed. This included general information (level, specialty, jury composition), indicators relating to the tools used, the project phases concerned, and evidence of implicit AI use, as well as elements relating to the students' reflective stance (justification, critical distance), the juries' reactions, and the estimated impact of AI on project quality (relevance, originality, feasibility, and editorial consistency).

The qualitative data from the observation was analyzed using a descriptive and interpretative approach, based on a cross-sectional reading of the defenses. This made it possible to identify recurrences and contrasts in the practices observed and to link them to the different phases of the design process. This analysis was not based on a thematic coding process, but on the systematic use of indicators defined in the observation grid and triangulated with data from the questionnaires.

The observation was conducted in a non-participatory and discreet manner in order to limit any influence on the conduct of the defenses and the behaviours observed.

II.4 Ethical Considerations

All participants were informed of the objectives of the research, the voluntary and anonymous nature of their participation, and the confidentiality of data processing.

Observation of the defenses was authorized by the educational administration. No personal data, images, or audio/video recordings were kept.

All participants were informed of the research objectives, participation was voluntary, and data were collected anonymously in accordance with ethical standards for educational research.

II.5 Methodological Limitations

This study has several limitations that should be considered. First, it is based on data from a single institution, which limits the possibility of generalizing the results to other design education contexts. In addition, the student participation rate (36.5%) may introduce a selection bias, as respondents may be more aware of or more engaged with the use of artificial intelligence.

The absence of a control group makes it impossible to systematically compare the practices of students who use AI with those who do not. Furthermore, although the direct observation enriches the analysis by providing a situated approach to student practices, it was conducted over a limited period and reflects only a portion of the dynamics at work in the Project Studios.

Finally, the questionnaire data may be affected by a social desirability bias. There are several indications that some students may have minimized or under-reported their use of artificial intelligence for fear of academic sanctions or a negative evaluation of their practices. This reluctance to disclose information stems from an institutional context marked by the absence of explicit guidelines on AI use and helps to explain the discrepancies observed between the usage reported in the questionnaires and the implicit usage identified during the defenses.

These limitations do not invalidate the scope of the results but invite them to be interpreted from an exploratory and contextualized perspective, in line with the study objectives and the emerging nature of the practices analyzed.

III. Results

This section presents the results obtained from the joint analysis of quantitative data collected from students and teachers, as well as qualitative data from the observation of project defenses. The results are presented in a progressive manner in order to account for the uses, perceptions, and effects of artificial intelligence at different stages of the product design process. Without imposing a rigid structure, this section is organized on a process-based approach inspired by design thinking, allowing for the successive analysis of practices related to project discovery and scoping, problem definition, solution development, and communication and evaluation. This approach aims to highlight the continuities, breaks, and tensions observed in the integration of AI throughout the Project Studios.

III.1 Discover: Initial Uses and Current AI Practices

The data show that artificial intelligence now plays a significant role in the early stages of product design projects, corresponding to the discovery phase, which includes documentation, user research, and immersion in the problem. The students have relatively balanced levels of experience with AI, with 51% reporting that they have been using it for more than a year and 49% for less than a year. This distribution reflects a widespread but still evolving adoption of AI tools, revealing a process of appropriation that is still ongoing while already well established in teaching practices.

An analysis of AI use by project phase clearly shows that usage is concentrated in the research and initial analysis stages. Figure 1 shows students' level of AI use by project phase.

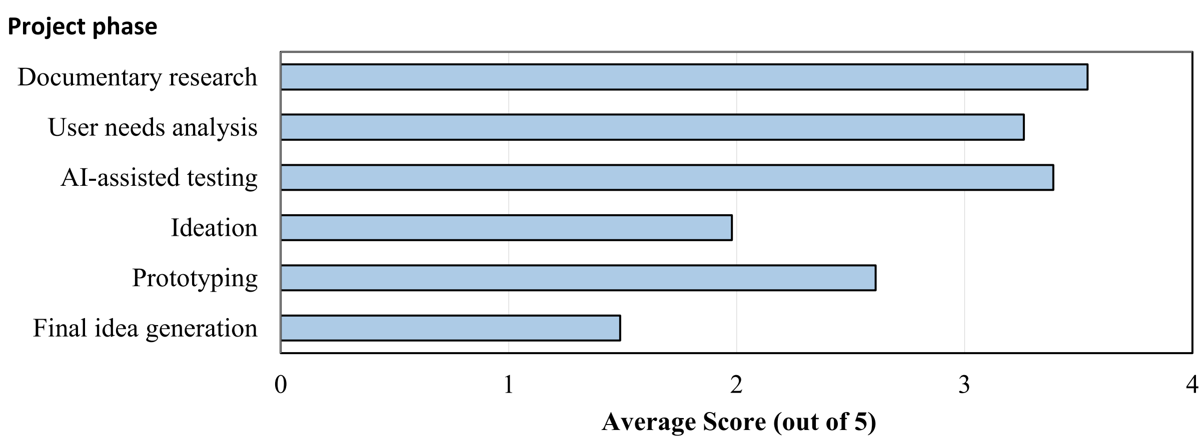


Figure 1
Students' Level of AI use by Project Phase (Items Recoded to a Common 1–5 scale for Analysis)

AI use appears to be heaviest in the documentary research phase, with an average of 3.54/5, followed by the user needs analysis (3.26/5) and preliminary testing phases (3.39/5). In these contexts, AI is mainly used as a tool for acceleration and clarification: it facilitates access to information, synthesis of complex corpora, and structuring of initial working hypotheses. The open-ended responses in the student questionnaire confirm this function, with AI frequently described as a means of “understanding the subject more quickly,” “clarifying the issue,” or “structuring user research.”

On the other hand, AI integration remains more limited in the phases traditionally considered to be at the heart of the design process. Ideation scores an average of 1.97/5, reflecting a persistent reluctance to explicitly use AI for idea generation. This reluctance seems to be linked to a still deeply rooted perception of ideation as a space for personal, gestural, and intuitive exploration, relying on the designer’s own expertise. Prototyping, meanwhile, scores an average of 2.61/5, indicating moderate use of AI, often confined to visualization or digital simulation functions rather than physical manufacturing.

This discrepancy between the heavy use of AI in the discovery phase and its more limited use in the creative and material phases suggests not an absence of ideation, but a transformation of its modalities. Ideation no longer seems to constitute a clearly identified and tooled phase, based on sketching or manual experimentation, but tends to be partially absorbed into research, analysis, and structuring activities, largely assisted by AI. In this context, creative work is carried out more through the selection, adjustment, or reformulation of existing proposals than through formal exploration. This evolution is also reflected in the decline of manual practices. Students report an average of 1.43 sketches per project, with some indicating that they do not produce any sketches at all. This decline in sketching, historically a central activity in designer training, reflects a shift towards sophisticated digital representations, often generated by AI. Manual prototyping is following the same trend: 41% of respondents say they have done little or no prototyping. Taken together, these results suggest a gradual shift from a culture of “doing” to a culture of “simulating,” where ideation becomes less tangible, less explicit, and less reflexive, while remaining diffusely present in the early stages of the project.

III.2. Define: Perceptions, Needs, and Framing of the Issue

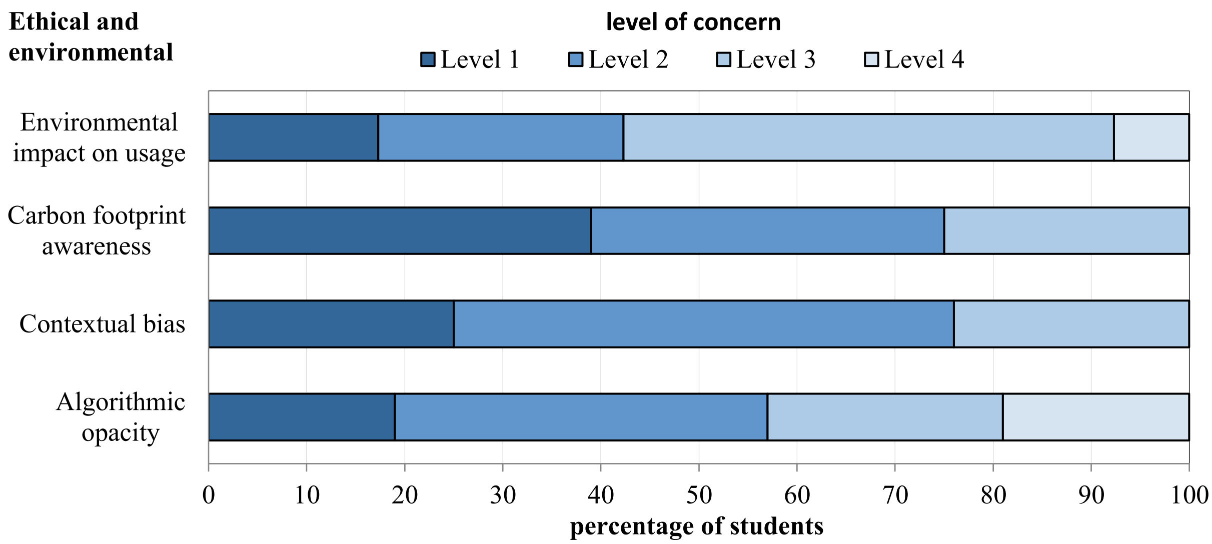
The definition phase, which corresponds to user analysis, problem formulation, and specification development, highlights a generally positive perception of artificial intelligence among students, while revealing structural concerns about its effects on the quality of reasoning and creative autonomy. The results of the questionnaire show that AI is widely perceived as a tool that facilitates project framing, particularly in analyzing and structuring data from user research. Figure 2 presents the benefits of AI as perceived by students in the product design workshop.

Figure 2
Perceived Benefits of AI by Students in the Product Design Workshop (Average Recoded Score on a 1–5 Scale)

Thus, 75% of students believe that AI stimulates their creativity, with an average score of 2.94/5. However, this positive perception must be interpreted in light of the uses observed in the previous phase: the creativity mentioned by the students seems to refer less to original formal production than to an increased ability to explore avenues, reformulate issues, or consider several scenarios based on the same body of information. AI thus appears to be a tool that promotes analytical or conceptual creativity, focused more on project framing than on the tangible generation of solutions.

This interpretation is reinforced by the results relating to the analysis of user needs. In fact, 81% of students give this dimension a score between 3 and 5, with an average of 3.26/5, making it one of the most highly valued contributions of AI. Students use AI to synthesize data from interviews or observations, clarify user profiles, and reformulate sometimes complex expectations. From this perspective, AI plays a structuring role in defining the problem and developing specifications, helping to stabilize the project framework before moving on to the development phases.

Alongside these benefits, the results highlight a number of ethical, cognitive, and environmental concerns, reflecting an emerging critical awareness among students. Figure 3 shows students' levels of concern regarding the ethical and environmental issues associated with AI.



Note. For comparability, response categories were harmonized across items. Level 1 = lowest reported level; Level 4 = highest reported level.

Figure 3
Students' Responses to Ethical and Environmental Issues Related to AI

The data show that 81% of respondents express moderate to strong concern about the opacity of algorithms (Levels 2, 3, and 4 in the harmonized figure), highlighting their difficulty in understanding the mechanisms by which AI tools produce their results. This opacity fuels a feeling of loss of control over the design process, which is particularly problematic at a stage where defining the problem depends on the designer's ability to justify and make a case for their choices.

In addition, 75% of students report encountering contextual biases, particularly proposals deemed unsuitable for the Tunisian context. This data is especially significant in the definition phase, where a detailed understanding of users and their environment is a key issue. It suggests that, despite its apparent effectiveness, AI can contribute to a normalization or decontextualization of issues if its use is not accompanied by a critical and situated perspective.

On the other hand, the environmental impact of AI remains largely underestimated by students: 39% say they are unaware of the carbon footprint associated with these technologies, and only 25% report being fully aware of it. This low level of awareness limits the integration of sustainability issues into specifications, even though these elements are fundamental criteria in contemporary design. The influence of these environmental considerations on the actual uses of AI also remains moderate, suggesting a gap between theoretical awareness and concrete translation into project practices.

A comparative analysis by academic level allows us to refine these findings. Table 1 presents the comparison of variables by academic level using the Kruskal-Wallis test.

Table 1
Comparison of Variables by Academic Level (Kruskal-Wallis Test)

Variable	χ^2	ddl	*p*-value
Length of time using AI	0.251	2	.882
Frequency of use for research	5.522	2	.063
Accuracy of user analyses	1.686	2	.430
Perception of creativity stimulated	1.723	2	.422
Facilitation of prototyping	7.683	2	**.021**
Perceived reliability of AI tests	1.476	2	.478

The results show that only one variable presents a significant difference: the facilitation of prototyping ($p = 0.021$), which is more strongly perceived by Master's 1 students. The other elements, notably perceived creativity, accuracy of user analysis, and ethical concerns, do not show significant variation between levels. This homogeneity suggests that representations of AI and its role in project definition are constructed in a cross-cutting manner, regardless of what stage a student is at in the curriculum.

Taken together, these results indicate that the project definition phase is deeply influenced by AI, not so much through direct delegation of decision-making as through a strengthening of the analytical and conceptual framework. AI helps to stabilize the problem and the specifications, while introducing tensions related to standardization, contextualization, and designer responsibility. These tensions are key to understanding the transformations observed in the project development and communication phases.

III.3 Develop: Ideation, prototyping, and how AI affects project production

The development phase, which encompasses ideation, prototyping, and testing, is a pivotal moment in the design process, where the intentions defined upstream are translated into formal and experimental proposals. The results show that, despite an overall positive perception of AI during the discovery and definition phases, its role shows more contrast in this phase and usage differs depending on the tasks involved.

An analysis of the correlations between the different variables sheds light on these dynamics. Table 2 presents the significant correlations between usage variables and perceived benefits of AI based on Spearman's test.

The results highlight a significant correlation between the use of AI for documentary research and its use in the ideation phase (ρ = .461; $p < .001$). This relationship suggests that students who integrate AI early on also tend to use it to explore or structure conceptual avenues, even if this use is not always explicitly claimed as an ideation activity in its own right.

Table 2

Significant Correlations Between Usage Variables and Perceived Benefits of AI (Spearman's Test)

Correlated variables	ρ (rho)	*p*-value	Significance
Frequency of use for search ↔ Frequency for ideation	.461	< .001	Highly significant ($p < 0.001$)
Frequency of ideation ↔ Final ideas generated by AI	.408	.002	Highly significant
User analysis accuracy ↔ Perceived creativity	.354	.009	Significant
Accuracy of user analysis ↔ Ease of prototyping	.376	.006	Significant
Length of AI use ↔ Search frequency	.339	.013	Significant
Length of use ↔ Ideation frequency	.295	.032	Moderately significant

Consistent with this observation, a significant correlation was also found between the use of AI in ideation and the generation of final ideas by AI (ρ = .408; $p = .002$). This result indicates that when AI is used at a given moment to explore solutions, it directly influences the form of the final proposals. However, this influence does not necessarily translate into a radical diversification of concepts, but rather into a process of selection, adjustment, and reformulation of proposals generated or inspired by AI, in line with the findings made in the previous phases.

Furthermore, the perceived accuracy of the user needs analysis is positively correlated with perceived creativity (ρ = .354; $p = .009$) and prototyping facilitation (ρ = .376; $p = .006$). These results suggest that AI indirectly contributes to the creative development of the project by making the analytical framework more robust. In other words, when the definition phase is perceived as more accurate and better structured thanks to AI, students feel they have a clearer framework for developing and materializing their proposals. However, this indirect contribution contrasts with the actual practices observed in ideation and prototyping. As previously indicated, the explicit use of AI in the ideation phase remains relatively low, and the manual practices associated with this phase also appear limited. This situation confirms the hypothesis of diffuse and partially dematerialized ideation, where creative work is carried out less through formal, materialized exploration than through successive iterations of already structured textual, conceptual, or visual content.

Prototyping is another point of tension in the development phase. Although some students perceive AI as a tool that facilitates this stage, the data show that its use remains largely confined to the production of visualizations or digital renderings, to the detriment of physical prototyping. The comparative analysis shows that this trend is particularly pronounced among Master's 1 students, which may be explained by a desire to reconcile academic requirements and time constraints by using fast digital tools. Nevertheless, this approach limits the possibilities for physical experimentation and direct engagement with technical constraints, which are essential in product design training.

The teachers' point of view reinforces these findings. Figure 4 summarizes teachers' adoption of AI and their expectations regarding its use in teaching.

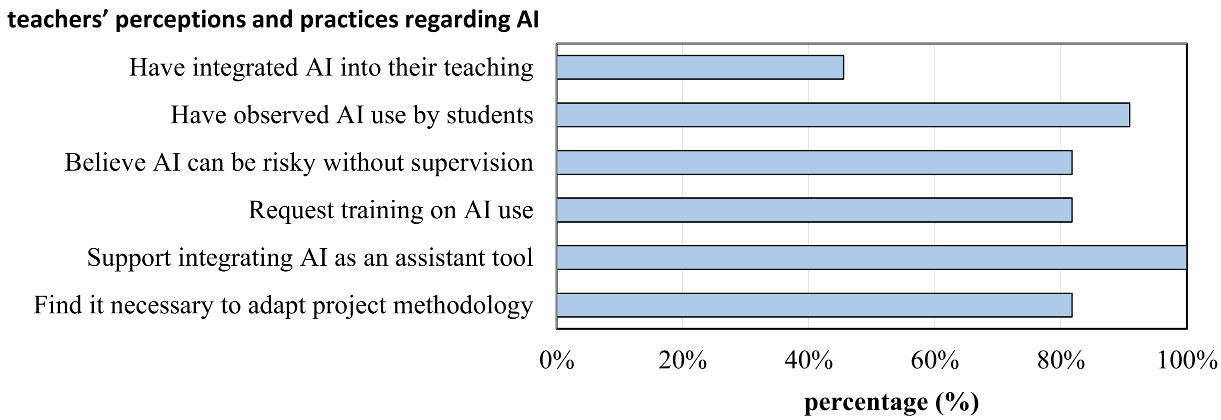


Figure 4
Teachers' Adoption and Expectations of AI

While 45.5% of the teachers say they use AI in their teaching practice, 90.9% have observed its use among students. However, 81.8% believe that AI can pose a risk to learning, in particular by promoting a form of cognitive dependence and weakening the development of fundamental skills such as critical thinking, independent creativity, and mastery of design techniques.

Teachers also identify several structural barriers to the controlled integration of AI in the development phase: the absence of an explicit educational framework, the lack of specific training, and the absence of assessment criteria that clearly integrate AI usage. These limitations help explain why AI is used more as an analytical support tool rather than as a real lever for creative and material experimentation.

Taken as a whole, the results of this phase show that AI has a real but indirect influence on project development. This influence is mainly felt upstream, in structuring the analytical and conceptual foundations, which then facilitates certain stages of development. On the other hand, the integration of AI into materialized ideation and prototyping remains limited and unclear, contributing to a transformation of creative practices rather than their disappearance. This transformation is a key element in understanding the modes of communication and criticism observed in the project delivery phase.

III.4 Deliver: Communication, Defense, and Critical Stance

The delivery phase, which corresponds to communicating and defending projects during evaluation, is a key moment when the choices made throughout the design process become visible, explainable, and subject to criticism. Observations made during 23 defenses complement the data provided in the questionnaires by shedding light on the students' actual practices and on how the use of AI is acknowledged, explained, or, conversely, concealed.

The results show a significant gap between actual AI use and its explicit recognition in the projects presented. Figure 5 compares the declared and undeclared uses of AI observed during project defenses.

Only 13% of students explicitly mention the use of AI in their project approach, even though there are many indirect indications suggesting a much wider use of these tools. These clues include stylistic consistency in written deliverables, particularly masterful syntax, the almost total absence of linguistic errors, and an argumentative structure typical of work produced with the help of generative AI tools.

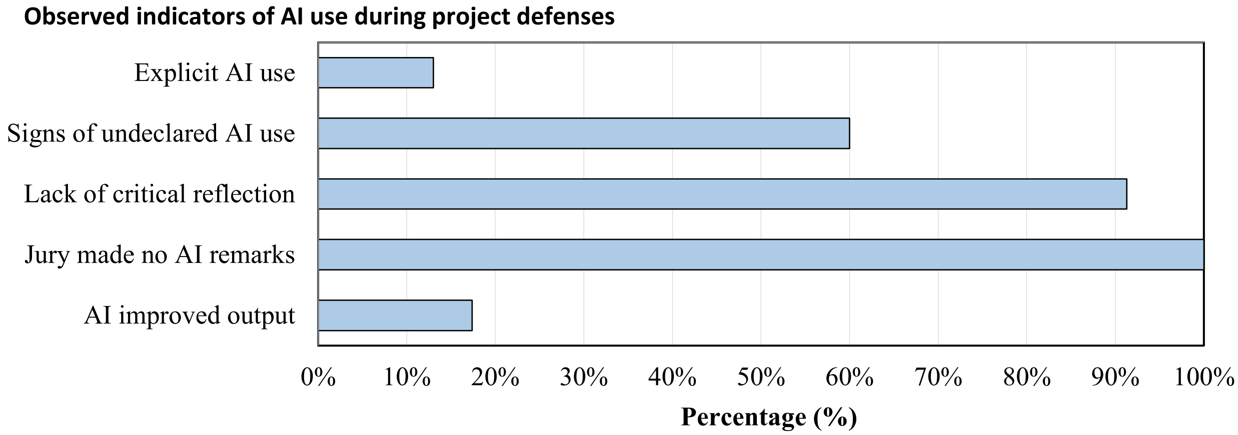


Figure 5
Declared and Undeclared use of AI Observed During Defenses

This concealment does not seem to stem from a deliberate desire to deceive, but rather from a climate of normative uncertainty surrounding the use of AI. Several factors may explain this stance: the absence of clear institutional guidelines, the existence of implicit or explicit prohibitions formulated by certain teachers, and the fear of devaluing the work presented. In this context, students seem to adopt a strategy of avoidance, preferring to use AI as an invisible tool rather than explicitly integrating it into their project discourse.

Analysis of the usage methods observed during the defense process shows that AI is mainly used in the early stages of the project, particularly for documentary research, information synthesis, user needs analysis, and the drafting of deliverables. However, no explicit use of AI was observed in the final phases of hardware prototyping or physical testing. This finding confirms the results of the previous phases, which indicate that AI has a greater influence on the conceptual and discursive structure of the project than on its concrete materialization.

Another striking result concerns the students' reflective stance towards their use of AI. In 91.3% of the defenses observed, no explicit critical reflection was formulated concerning AI's role in the project approach, or its limitations, biases, or methodological implications. When AI is mentioned, it is most often presented in an instrumental way, as a simple tool to aid writing or research, without any critical distance or reasoned justification for its integration into the design process.

This lack of reflection is reinforced by the attitude of the juries. In 100% of the defenses observed, no comments, questions, or remarks were made by jury members regarding the use of AI, even when it was explicitly mentioned by the students. This institutional silence suggests a lack of shared tools for evaluating these practices, as well as an absence of academic criteria for integrating the use of AI into the evaluation of product design projects. It also contributes to keeping AI in a grey area, neither fully authorized nor explicitly regulated.

Despite these limitations, an analysis of the projects presented shows that AI has had a positive impact in some cases. In 17.4% of the projects observed, the use of AI contributed to better structuring of the portfolio, increased clarity of the project discourse, and improved editorial quality of the deliverables. However, these contributions remain essentially discursive and conceptual and are not necessarily accompanied by an increase in the quality of the material or experimental dimensions of the project.

Taken as a whole, the results of the delivery phase reveal a strong consistency with the transformations observed in the previous phases. AI appears to be a widely integrated but rarely acknowledged tool, profoundly influencing the way projects are conceived, formulated, and presented without being explicitly discussed or evaluated. This situation highlights a central tension between the effective use of AI, its invisibility in project communication, and the absence of an educational and institutional framework that would allow it to be critically examined in its own right.

IV. Discussion

The aim of this study was to analyze the integration of artificial intelligence (AI) in the product design Project Studios at the *École Supérieure des Sciences et Technologies du Design*, by comparing the stated usage by students and teachers with the practices actually observed during the presentations. The results provide an overview of this usage and identify the benefits, limitations, and tensions generated by the introduction of AI into an educational space historically based on experimentation, sketching, and materiality.

IV.1 Differentiated Integration of AI by Project Phase

One of the main contributions of this research is to highlight the differentiated integration of AI by design process phase. The results show that AI is mainly used in the early stages of the project, particularly for documentary research and user needs analysis, while its explicit use remains more limited in the stages of materialized ideation, prototyping, and testing. This configuration confirms the trends observed internationally, notably by Verganti et al. (2020), who emphasize that AI is mainly used to enhance analytical capabilities, decision-making, and the structuring of creative processes, rather than to replace the act of design itself.

However, the low reported use of AI in ideation should not be interpreted as an absence in this phase, but rather as a transformation of its ways and means. The marked decrease in the use of manual sketching suggests that ideation is becoming more diffuse, partially integrated into research, analysis, and reformulation activities, often assisted by digital or generative tools. This shift confirms the analyses of Luckin et al. (2016), according to which AI is used more as a cognitive support tool than as an autonomous generator of creativity, influencing the way ideas are constructed, selected, and justified.

IV.2 Perceived Creativity and Materialized Creativity: A Central Tension

The results reveal a notable tension between a perception that creativity is enhanced by AI and a weakening of materialized creative practices. This tension can be illuminated by the model of creativity proposed by Amabile (1996), which emphasizes the importance of intrinsic motivation, personal commitment, and domain-specific skills. AI seems to support certain cognitive aspects of creativity, such as conceptual structuring and problem formulation, but in the absence of a critical framework, it can reduce students' exploratory and experiential investment.

The correlations observed between user needs analysis, perceived creativity, and prototyping facilitation indicate that students associate creativity with project coherence and clarity of reasoning rather than formal experimentation. This shift echoes the concerns expressed by Cross (2006), for whom manual drawing is a mode of thinking specific to design, allowing the development of an intuitive understanding of form, space, and materials. Similarly, Brown (2009) points out that rapid, iterative prototyping is central to design thinking, as a means of "thinking with your hands" and confronting ideas with material reality. The decline in these practices observed in this study therefore raises questions about the sustainability of embodied skills in product design training.

IV.3 Reconfiguration of the Designer's Role and the Skills Employed

The results show that AI does not eliminate the role of the designer, but profoundly changes its nature. Students tend to adopt an approach where the selection, adjustment, and reformulation of proposals generated or structured by AI tools replace progressive exploration through manual experimentation. This development confirms that AI reinforces certain meta-design skills while weakening gestural know-how if it is not explicitly valued within the educational framework.

In this regard, the TPACK model (Mishra & Koehler, 2006) provides a particularly relevant theoretical framework for interpreting the results. The integration of AI is not solely a matter of technological competence (TK), but transforms the relationship between content knowledge (CK) and pedagogical knowledge (PK). The results suggest that, in the absence of a structured framework, students develop technological skills that are disconnected from critical thinking about the creative, ethical, and contextual issues of design.

IV.4 AI Invisibility, Bias, and Ethical Issues

Another key finding concerns the gap between the actual use of AI and its explicit recognition during project defenses. The under-reporting observed, combined with the almost total absence of student reflection and the silence of the juries, reveals a pedagogical blind spot. This situation can be interpreted as a direct consequence of a lack of clear institutional guidelines, leading students to conceal their practices rather than discuss them critically.

The concerns expressed by students about algorithm opacity and contextual biases are in line with the analyses of Buolamwini and Gebru (2018), who demonstrated the existence of systemic biases in AI systems trained on unrepresentative data, as well as those of Crawford (2021), who highlights the ethical, political, and social issues associated with AI. In the Tunisian context, these biases are particularly significant due to the gap between local realities and the data used to train the systems.

Furthermore, the environmental impact of AI remains largely underestimated by students, despite warnings from Strubell et al. (2019) and Crawford (2021) about the carbon footprint of machine learning models. This low level of awareness limits the integration of sustainability issues into the project approach and highlights the need for a more responsible approach to AI in design education.

IV.5 Pedagogical Implications and the Need for a Structured Framework

Taken together, the results confirm the need for a thoughtful and structured integration of AI into product design education. They extend the work of Fatnassi (2021) on the integration of ICT in design workshops in Tunisia, showing that AI must be viewed not as a simple additional tool, but as an element that profoundly transforms pedagogical and creative practices.

The differences observed among academic levels, notably in Master's 1 for prototyping facilitation, suggest that certain points in the curriculum are particularly conducive to a critical and progressive appropriation of AI. These findings are in line with the conclusions of Ge and Fan (2024), who highlight the lack of international consensus on the AI skills to be developed in designers and on the appropriate teaching methods. In this perspective, the TPACK model offers an operational framework for articulating technological, disciplinary, and pedagogical skills, and for positioning AI as a tool to assist creativity, rather than as a substitute for the project approach.

In the Tunisian context, marked by cultural, institutional, and energy constraints, it seems essential that AI tools should be adapted to local realities. As highlighted by Fatnassi (2021), a contextualized integration of emerging technologies is essential to promote responsible and relevant design. Educational modules incorporating local case studies, ethical and environmental discussions, and an explanation of ways to use AI in different phases of a project could thus contribute to training designers capable of leveraging these tools in a critical, creative, and situated manner.

V. Conclusion

This study examined how artificial intelligence (AI) is integrated into product design Project Studios by comparing the stated perceptions of students and teachers with the practices actually observed during presentations. Using a mixed methodological approach combining questionnaires and field observations, it provides a rigorous and contextualized overview of this integration in the Tunisian context, which is still under-documented in the scientific literature.

The results highlight a gradual but unevenly structured adoption of AI. Students mainly use these tools in the early stages of the project, particularly for documentary research, user needs analysis, and conceptual structuring, while the materialized ideation, sketching, and physical prototyping phases remain less implicated. This pattern highlights a transformation in creative practices, where ideation, while not disappearing altogether, tends to become more diffuse and less explicitly materialized. While the perceived benefits of AI are numerous – time savings, improved project consistency, support for creativity and analytics – these are accompanied by significant concerns related to cognitive dependence, the potential weakening of critical thinking, algorithm opacity, and contextual biases.

When it comes to the teachers, the results reveal a certain ambivalence, combining interest in the potential of AI with concerns about its educational effects. There is a widely expressed need for training, clear guidelines, and evaluation criteria that explicitly recognize the use of AI. The absence of a structured institutional framework, combined with the silence observed during project defenses, helps to keep AI in a grey area, favouring implicit uses rather than critical and conscious appropriation. This situation limits the potential of AI as an educational lever and increases the risks of opportunistic or ill-considered use.

Another major finding of this research concerns the decline of fundamental manual practices, such as sketching and physical prototyping. These skills, historically at the heart of product design education, appear to have been weakened by the rise of digital and generative tools. Preserving these skills should not be seen in opposition to AI, but as an essential condition for maintaining a balanced design approach that combines analytical reasoning, material experimentation, and creative sensitivity.

As such, this study highlights the need to move beyond the instrumental integration of AI and instead incorporate its use into a structured, responsible, and contextualized educational framework. Based on the TPACK model, it emphasizes the importance of a coherent articulation between technological, content-related, and pedagogical skills, allowing AI to be positioned as a tool to assist learning, rather than a substitute for the designer's creative process. Educational approaches that explicitly integrate AI into the different phases of the project, accompanied by moments of critical reflection, ethical and environmental awareness, and the promotion of embodied practices, appear essential in order to train designers capable of using these technologies in a conscious and situated manner.

Finally, although focused on a single institution, this research makes an original contribution to the debate on the integration of AI into design education by offering an empirical perspective rooted in the Tunisian context. It opens up prospects for future work, including longitudinal studies to track the evolution of practices, or comparative research involving other institutions and cultural contexts. These extensions would provide a better understanding of the gradual development of a pedagogical culture of AI in design and enable informed support for the transformation of training programs in the face of contemporary technological challenges.

Notes

Data Availability

The data supporting the article and collected during the research described in this article are available from the author, **Moâtaz Fatnassi**, upon request.

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Appendix A – Student Questionnaire

Use of Artificial Intelligence in Product Design Project Studios

1. Student Profile

1.1 What year are you currently enrolled in?

__ L3
__ M1
__ M2

1.2 How long have you been using AI tools in your design projects?

__ Less than 6 months
__ Between 6 months and 1 year
__ More than 1 year
__ Never

2. AI and the Transformation of Pedagogical Practices

2.1 Access to Information and Analysis Phase

2.1.1 How often do you use AI tools (e.g., ChatGPT, Grok) for initial research in your projects?

__ Always (100%)
__ Often (75%)
__ Sometimes (50%)
__ Rarely (25%)
__ Never (0%)

2.1.2 How much time do you spend on average collecting information with AI compared with manual research?

__ Less than 25% of the usual time
__ Between 25% and 50%
__ Between 50% and 75%
__ More than 75%

2.1.3 To what extent does AI improve the accuracy of your analysis of user needs?
(Scale: 1 = Not at all / 5 = Enormously)

__ 1
__ 2
__ 3
__ 4
__ 5

2.2 Ideation and Creativity

2.2.1 How many times per project do you use AI idea generators (e.g., MidJourney, ChatGPT) for ideation?

__ 0 times
__ 1–2 times
__ 3–4 times
__ 5–6 times
__ More than 6 times

2.2.2 What percentage of your final ideas comes directly from AI suggestions without modification?

__ 0%
__ 1–25%
__ 26–50%
__ 51–75%
__ More than 75%

2.2.3 To what extent does AI stimulate your personal creativity?
(Scale: 1 = Not at all / 5 = Enormously)

__ 1
__ 2
__ 3
__ 4
__ 5

2.3 Modeling and Prototyping

2.3.1 What proportion of your 3D models is created or optimized using AI tools (e.g., Fusion 360, Vizcom)?

__ 0%
__ 1–25%
__ 26–50%
__ 51–75%
__ More than 75%

2.3.2 How many physical prototypes do you produce per project since you started using AI?

__ None
__ 1–2
__ 3–4
__ 5–6
__ More than 6

2.3.3 To what extent does AI facilitate prototyping compared with traditional methods?
(Scale: 1 = Not at all / 5 = Enormously)

__ 1
__ 2
__ 3
__ 4
__ 5

2.4 Testing and Validation

2.4.1 How often do you use AI tools (e.g., SimScale, ChatGPT) to test or validate your designs?

__ Always (100%)
__ Often (75%)
__ Sometimes (50%)
__ Rarely (25%)
__ Never (0%)

2.4.2 What percentage of your tests relies only on AI simulations without physical validation?

__ 0%
__ 1–25%
__ 26–50%
__ 51–75%
__ More than 75%

2.4.3 To what extent are AI test results reliable for your projects?
(Scale: 1 = Not at all / 5 = Very reliable)

__ 1
__ 2
__ 3
__ 4
__ 5

3. Critical Challenges of AI

3.1 Standardization and Cognitive Dependence

3.1.1 What percentage of your AI-generated designs seems repetitive or stereotyped to you?

__ 0%
__ 1–25%
__ 26–50%
__ 51–75%
__ More than 75%

3.1.2 To what extent do you feel dependent on AI to solve creative problems?
(Scale: 1 = Not at all / 5 = Completely)

__ 1
__ 2
__ 3
__ 4
__ 5

3.2 Loss of Traditional Skills

3.2.1 How many times per project do you make hand-drawn sketches since you started using AI?

__ 0 times
__ 1–2 times
__ 3–5 times
__ More than 5 times

3.2.2 To what extent do you think AI replaces your manual skills (drawing, prototyping)?
(Scale: 1 = Not at all / 5 = Completely)

__ 1
__ 2
__ 3
__ 4
__ 5

3.3 Bias and Ethics

3.3.1 How often do you notice AI suggestions that are not adapted to the local Tunisian context?

__ Very often
__ Often
__ Rarely
__ Never

3.3.2 To what extent does the opacity of algorithms (not knowing why a suggestion is made) concern you?
(Scale: 1 = Not at all / 4 = Very much)

__ 1
__ 2
__ 3
__ 4

4. Environmental Issues

4.1 Are you aware of the carbon footprint associated with the use of AI tools (e.g., training, data centers)?

__ Fully aware
__ Somewhat aware
__ Slightly aware
__ Not at all aware

4.2 To what extent does the environmental impact of AI influence your decision to use it? (Scale: 1 = Not at all / 4 = Very much)

__ 1
__ 2
__ 3
__ 4

5. Toward a Critical Pedagogy

5.1 How many hours of AI-related training have you completed in your curriculum?

__ 0 hours
__ 1–5 hours
__ 6–10 hours
__ More than 10 hours

5.2 To what extent do you think training on the ethics and limitations of AI would be useful? (Scale: 1 = Not at all / 5 = Very useful)

__ 1
__ 2
__ 3
__ 4
__ 5

5.3 How often do you combine traditional methods (drawing, manual prototyping) with AI in your projects?

__ Always (100%)
__ Often (75%)
__ Sometimes (50%)
__ Rarely (25%)
__ Never (0%)

6. Open Question

6.1 In your opinion, what are the main advantages and challenges of using AI in your design projects?
(Open-ended response)

Appendix B – Teacher Questionnaire

Use of Artificial Intelligence in Product Design Project Studios

1. Teaching Experience

1.1 Have you taught a product design project studio between 2023 and 2025?

__ Yes __ No

1.2 How many years have you been supervising project-based design studios?

__ Less than 2 years
__ Between 2 and 5 years
__ More than 5 years

1.3 What is your main area of specialization?
(Open-ended response)

2. Your Use of Artificial Intelligence (AI)

2.1 Have you used AI tools in your courses or project studios?

__ Yes __ No

2.2 If yes, which tools and in what context?
(Open-ended response)

2.3 For which activities have you used AI in the project studio?
(Multiple answers possible)

__ Preparation of teaching materials
__ Generation of project ideas
__ Assessment of student submissions
__ Reference and literature research
__ Simulation or prototyping
__ Other: ___________________

3. Student Use of AI

3.1 Have you observed students using AI tools in project studios?

__ Yes __ No __ Unsure

3.2 For how long do you think students have been using AI?

__ Less than 6 months
__ Between 6 months and 1 year
__ Between 1 and 2 years
__ More than 2 years
__ I do not know

3.3 At which stages of the project does AI seem to be used?
(Multiple answers possible)

__ Literature research
__ Data analysis
__ Ideation / idea generation
__ Design / modeling
__ Prototyping
__ Testing / evaluation
__ Report writing
__ Other: ___________________

3.4 How would you describe students' attitude toward AI?

__ Open and transparent
__ Cautious
__ Hidden or concealed
__ Uncertain
__ Other: ___________________

4. Effects of AI on Student Work

4.1 Have you observed changes in the way students develop their projects as a result of AI use?

__ Yes __ No __ Not yet noticeable

4.2 In your opinion, does AI influence students' creativity?

__ Positively
__ Negatively
__ Both
__ No perceived influence

4.3 In your opinion, does AI impact students' technical or manual skills?
(Open-ended response)

5. Perceived Benefits and Risks

5.1 What do you see as the main benefits of AI in the project studio?
(Open-ended response)

5.2 Do you think the use of AI may pose a risk to learning?
__ Yes __ No __ Depends on the context

5.3 If yes, what types of risks or limitations do you identify?
(Open-ended response)

5.4 Which skills may be underdeveloped in the case of excessive AI use? (Multiple answers possible)

__ Critical thinking
__ Personal creativity
__ Manual skills
__ Collaborative work
__ Other: __________________

6. Pedagogical Issues and Perspectives

6.1 What are the main barriers to integrating AI into design education? (Multiple answers possible)

__ Lack of teacher training
__ Lack of technical resources
__ Unclear pedagogical framework
__ Ethical concerns
__ Other: __________________

6.2 Would you like to receive training on the pedagogical use of AI?

__ Yes __ No __ Already trained

6.3 In your opinion, AI is likely to:

__ Replace certain human skills
__ Remain an assistive tool
__ I do not know

6.4 Do you have an example where AI has:

__ improved a student project?
__ caused a specific problem?

(Open-ended response)

6.5 Do you think project-based design methodology should be adapted to integrate AI in a thoughtful way?

__ Yes __ No __ Maybe

(If yes, how?) – Open-ended response

Appendix C – Observation Grid

Observation of AI Use During Product Design Project Presentations

1. General Information

Level of study:

__ Bachelor (Year 3) __ Master 1 __ Master 2

Specialization:

__ Product Design
__ Packaging Design
__ Design for Sustainable Development
__ Other: ___________________

Presentation date: ___________________

Approximate duration: ___________________

Jury composition (number of members): ___________

2. Presence and Visibility of AI in the Project

2.1 AI use is:

__ Explicitly declared by the student
__ Implicitly perceptible
__ Not mentioned / not observable

2.2 Observable indicators of implicit AI use: (Multiple answers possible)

__ Generated images (style, visual coherence, repetitiveness)
__ Highly structured or homogeneous texts
__ Generative mood boards or visuals
__ Highly advanced digital renderings
__ Other: ___________________

3. AI Tools Used (if identifiable)

__ Conversational agents (e.g., ChatGPT)
__ Image generators
__ Writing assistance tools
__ Simulation / prototyping tools
__ Not identifiable
__ Other: ___________________

4. Design Process Phases Concerned

AI appears to have been mainly used in:
(Multiple answers possible)

__ Literature research
__ User needs analysis

__ Concept definition
__ Ideation / idea generation
__ Prototyping / preliminary models
__ Testing and evaluation
__ Report writing and structuring

5. Observed Manual Practices

5.1 Presence of sketches or manual drawings:

__ None
__ Low
__ Moderate
__ Significant

5.2 Presence of physical prototypes or mock-ups:

__ None
__ Low
__ Moderate
__ Significant

6. Student's Reflective Stance

6.1 Does the student justify the use of AI?

__ Yes, explicitly
__ Yes, partially
__ No

6.2 Does the student demonstrate critical distance toward AI?

__ Yes
__ Partially
__ No

6.3 AI is presented as:

__ An assistive tool
__ A central tool in the project
__ A secondary tool
__ Not mentioned

7. Jury Reactions

7.1 Does the jury explicitly mention AI use?

__ Yes
__ No

7.2 If yes, the jury's reaction is:

__ Positive
__ Neutral

__ Critical
__ Ambivalent

7.3 Does AI use influence the project evaluation?

__ Yes, positively
__ Yes, negatively
__ No perceptible influence

8. Estimated Impact of AI on the Project

Overall assessment (1 = very low / 5 = very high):

- Concept relevance __ 1 __ 2 __ 3 __ 4 __ 5
- Originality __ 1 __ 2 __ 3 __ 4 __ 5
- Feasibility __ 1 __ 2 __ 3 __ 4 __ 5
- Editorial coherence __ 1 __ 2 __ 3 __ 4 __ 5

9. Qualitative Comments

Additional observations (student discourse, inconsistencies, salient points, tensions observed between AI use and manual practices, etc.).

(Open-ended response)