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Design in dialogue: AI as an aid of imagination for future scenarios

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Abstract: Generative AI tools foreshadow fundamental changes in the dynamics of creative work. Albeit controlling the output is still challenging, the rapid conceptual development and visualization can be particularly helpful in the exploratory phase, facilitating approaches such as design fiction. The contribution aims at providing an overview of how AI can fit in various steps, demonstrating in particular how the AI-enabled visualization from text and sketches allows imagining and iterating quickly on future scenarios. Starting from a benchmarking of over sixty AI tools according to the Design Thinking process, the efficacy of a human-AI collaboration has been experimented through workshops with over hundred and fifty students. These activities have demonstrated the efficacy of following a well-defined dialogue protocol of Human Intelligence "framing" Artificial Intelligence, which serves as an AI skill-building tool, as well as a creative icebreaker, leading to vivid representations of speculative scenarios as foundation for the forward-thinking design process.

Keywords: design fiction; AI tools; prompting; design education

1. Introduction

The development of generative AI anticipates a significant transformation in design practices and consumer culture, as AI can change the design process, its products and consumer perceptions. Some studies show that products developed with the help of AI are generally more attractive to customers (Zhang, Bai and Ma, 2022), while others argue for the irreplaceable value of human craftsmanship (Granulo, Fuchs and Puntoni, 2021). Recognizing these divergent points of view, the article starts from the assumption that designers need to develop a conscious position and skills for the adequate use of AI throughout the Design Thinking process.

In particular, various studies in different fields have shown that AI can be a useful icebreaker in the initial phases of the design process, from mechanical engineering (Liao, Hansen and

Chai, 2020) to innovation management (Garbuio and Lin, 2021; Verganti, Vendraminelli and Iansiti, 2020). Can AI be applied to enhance long-term visionary thinking? Would it be possible to quickly develop and visualize future scenarios and concepts based on text and sketch prompts through generative AI tools? This contribution aims to understand how AI can act as a creative companion for Design Fiction assignments and stimulate ideating in problematic environments.

To analyze the cooperation between designer and AI, the authors created protocols that help this collaboration with a special focus on Design Fiction and its ability to present artefacts for potential future scenarios through rich storyboards (Dur, 2021).

The paper starts by outlining AI and designer collaboration across different design stages, considering its advantages and drawbacks. Design-related AI tools were evaluated and organized in a visual map, both by output type and by the phases of Design Thinking. AI makes interesting combinations from its vast training database, that can be useful for early conceptual development. Therefore, focusing on Design Fiction, after an introduction about its role and challenges, the article presents 3 experiments carried out to test generative AI-enabled ideation involving 165 students in two classes, both MSc and BSc level, with individual and group work respectively. The experiments were conducted using step-by-step protocols, which evolved over the three workshops according to the observations gathered. At the end of the article, a discussion and conclusion are presented on the results and reflections of these workshops and research.

2. AI roles in Design

Rapid advances in the intelligence of machines present opportunities for AI systems to become trusted teammates alongside designers (Figoli, Rampino and Mattioli, 2022). Multiple studies demonstrate that AI may be particularly effective in the early stages of the design process, improving the generation of innovative ideas by overcoming cognitive limitations such as restricted cognitive load and cognitive biases (Garbuio and Lin, 2021). Moreover, generative AI tools can help to face the abstraction of the design problem, for example, Autodesk DreamSketch produces multiple 3D sketches based on a designer’s initial problem definition (Saadi and Yang, 2023). AI systems become a valuable tool for increasing designer creativity and facilitating access to greater variety and inspiration (Figoli, Mattioli and Rampino, 2022). There are already examples of AI-based creativity support tools being successfully integrated into the ideation process of fashion design, that have capabilities of fashion attribute detection, style clustering and trend forecasting (Jeon et al., 2021).

AI can be beneficial not only in the initial phases of the design process but also in enhancing user experience, thereby fostering technology-driven innovation at both the system and service levels (Yildirim et al. 2022). Because AI's capabilities are already rather broad at the moment, some researchers are investigating how much AI can be autonomous in the design process, ranging from designers having complete control to AI tools functioning autono-

mously (Altavilla and Blanco, 2020). Specific AI-enabled design challenges have been highlighted as uncertainty around AI capabilities and the complexity of AI output that can lead to further design errors (Yang et al., 2020).

3. AI tools for Design

The following step offers an overview and a critical reflection on the current state of Generative AI tools for designers, which will form the basis for the exercises described in section 5. The categorization of the tools is inspired by the five-stage Design Thinking model by Stanford University d.school and slightly adapted to our tools findings: Empathise & Define, Ideate, Prototype & Implement, and Validate. This Goal-Derived Category takes into account the extent to which the AI tool has the necessary properties to satisfy the goals of various Design Thinking stages, such as the design research assistance for “Empathise & Define”; the design ideation tools creation and brainstorming assistance for “Ideate”; the prototyping capabilities for “Prototype & Implement”; the evaluation tools creation and usability test assistance for “Validate”. The possible outputs are also considered in another Goal-Derived categorization: “3D” includes topology optimization, 3D model generation and tools for texturing and rendering; “Graphics” provides materials for UI, presentations and integration of text and images; “Raster” generates images ranging from realistic depictions to fantasy-inspired artwork; “Text” provide textual responses and programming codes; “Utility” improves teamwork and streamlining work processes through management, analysis and problem-solving tools; “Vector” generates illustrations, icons and logos; “Audio & Video” aids in the generation and editing of multimedia.

The first step of the process was to build a database to store all the tools, including costs, benefits, drawbacks and input/output. The information was then catalogued to create an easily explorable, Figma-based mapping. Each tool is discussed in depth in an info sheet that includes functionality and unique characteristics, an analysis of advantages and disadvantages, and showcasing images. A visual map (Figure 1) summarizes the tools, highlighting the connection between the Design Thinking step they belong to and the output they provide. Finally, a more essential list consolidates all the tools into distinct output-based clusters, enabling users to easily locate the desired tool.

Our research at the time of writing found a total of 66 tools: 7 for Empathise & Define, 37 for Ideate, 51 for Prototype & Implement, and 11 for Validate. This systemization highlighted that only a few tools can help during the phases of process structuring, stakeholder engagement and final validation. Moreover, while most tools primarily target the Prototype & Implement step, they often aid designers in the Ideation phase as well. To test the effectiveness of the tools during the workflow, case studies were carried out where we tried to replicate the process of two already existing student project outputs in the field of Product Design (creation of bicycle repair furniture) and Interaction Design (creation of IoT system for parents) by repeating the tasks using AI tools.

Regarding the output clusters, 13 tools were identified for 3D, 4 for Graphics, 22 for Raster, 4 for Textual, 15 for Utility, 4 for Vector, and 4 for Video & Audio. Raster outputs are among the most popular, but there is also a growing interest in utility tools.

The recent rise in the popularity of AI models has opened new perspectives for students to experience the potential of these tools in Design (Bozkurt et al., 2023). Therefore, the map was created with educational application in mind and supports exercises described in section 5. The collection can be explored at the following link https://bit.ly/Design-AI.

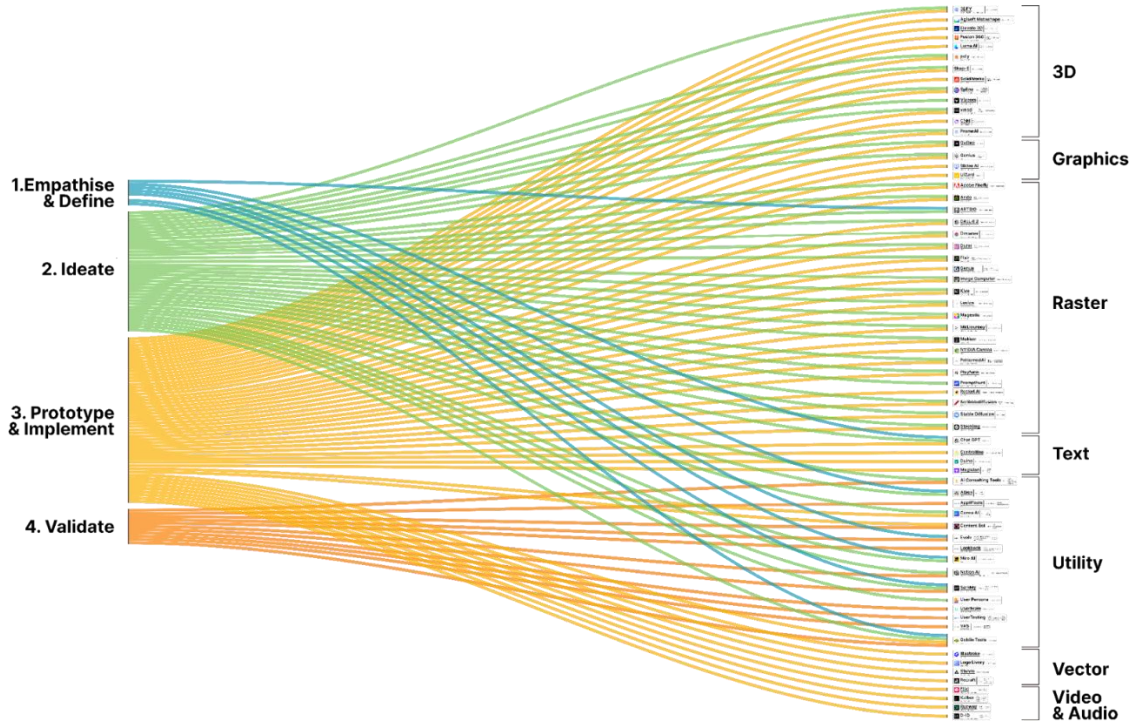


Figure 1 Alluvial diagram mapping state-of-the-art Generative AI tools for designers, categorized in Design Thinking phases and output typology. The collection can be explored at the link above.

4. AI and Design Fiction

Design Fiction is a speculative design approach merging design and science fiction to envision compelling narratives and artefacts of potential future scenarios through sketching and prototyping. This emerging field has gained prominence in recent years as a method to inspire innovation, challenge assumptions, and encourage critical thinking about the impact of emerging technologies (Bleecker, 2022; Dunne & Raby, 2013; Sterling, 2005). In a rapidly evolving present, addressing pressing issues and guiding innovation, particularly in technology's impact on society (Sturdee and Lindley, 2019), demands collective imagination and debate. In this sense, Design Fiction plays a pivotal role in critically exploring and responsibly planning for the future, tackling important societal and technological concerns through creative investigation. However, Design Fiction is a demanding approach due to its speculative and complex nature. Effective storytelling and ethical considerations are necessary, and its

interdisciplinarity can be challenging, requiring broad knowledge, the ability to bridge multiple domains, and creative thinking grounded in reality. While this makes Design Fiction hardly applicable in the daily design practice at a professional level, it represents an opportunity for creativity building in design education. In this context, Design Fiction can prompt wider discussions about various aspects related to emerging technologies - for example, fictional scenarios have been used to debate the possible impacts of Artificial Intelligence and robots on higher education (Cox, 2021) - and provide a conceptual framework for students to develop new perspectives on Design and challenge their relationship with reality (Banu Inanç, 2021). Nevertheless, constructing multiple scenarios and generating diverse design proposals can be particularly challenging for students, as the effort required to ideate, sketch and communicate effective fictional hypotheses may be daunting, mostly among undergraduate students, who typically possess lower design expertise.

Using AI can offer valuable support in the ideation and exploration of different design scenarios, enhancing the creative process and its outcomes. By processing vast amounts of data, it enables designers to generate novel concepts, identify trends, and create compelling narratives through realistic 3D models and animations, providing immersive fictional experiences for potential user insights.

With these assumptions, we aimed to investigate the possibility of enhancing Design Fiction and extending its capacity to envision a broader spectrum of potential futures by leveraging AI computational capabilities, potentially exploring all the boundaries of the Futures Cone (Voros, 2017). To experiment with this integration, two design workshops were carried out.

5. Experiments of AI-enhanced Design Fiction

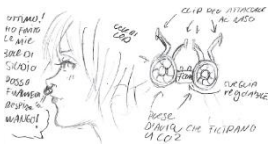
5.1 DFxHA workshop: Design Fiction for Human Augmentation

As a first experiment, a workshop was held for BSc design students to introduce the concept of Design Fiction for future-oriented brainstorming on wearable computing for Human Augmentation. The workshop utilized a custom deck of cards inspired by Julian Bleecker's Near Future Laboratory work, along with instructional sheets. The deck comprised three sets: Ability, Object, and Context, each with 12 cards. Students were prompted to brainstorm ideas for future wearable technologies that enhance, assist, or substitute human abilities, to be used with or for a specific object (tangible or intangible) in a particular environmental or social context. Students randomly selected one card from each set and filled in the prompt "A wearable technology to [Ability] [Object] in/at [Context].", used for writing a concept description and drawing a concept sketch of a future technology, focusing on fictional ideation rather than feasibility.

In total, 72 students divided into 18 groups participated in the workshop, with each group delivering one filled sheet. Subsequently, the sheets were digitized, and a following AI-driven phase was carried out to investigate the following two questions: How would student-generated concept texts compare to AI-generated (ChatGPT 3.5) concept texts based on the same

3 random cards? How would student-generated concept sketches compare to AI-generated (Midjourney 5.2) concept images based on the same 3 random cards?

Table 1 Example: Visual and Textual Concept comparison between HI and AI for the keywords "Smell", "Numbers", and "Office Desk"

Original Prompt	A wearable technology to Smell Numbers at the Office Desk		
Students' Concept	**Students' Sketch**	**ChatGPT Concept**	**Midjourney Images**
Device to attach to the nose with an integrated timer and fans that allow you to perceive study or work time through fragrances.		"Numaroma" is an olfactory wristband. It releases scents associated with numerical data, enhancing your office desk experience with a sensory, aromatic connection to the world of numbers.	

The concept descriptions provided by the students - i.e. the Human Intelligence component - were then translated from Italian into English using ChatGPT 3.5. For comparison with AI (see Table 1), we asked ChatGPT to write a concept description for each prompt collected, using the formula: "Write a design fiction concept of a wearable technology to [Ability Object Context], in 30 words." A comparative analysis between the student-generated and the AI-generated textual outcomes has enabled us to derive a few initial observations.

- Branding: ChatGPT has autonomously assigned a branding name to all student concepts, rendering the hypothetical technological scenario more vivid, conveying an impression of its plausible existence. Conversely, none of the students named their concepts.
- Sense-making: certain instances generated by ChatGPT may appear as mere juxtapositions of lexemes, potentially lacking substantive connotation. However, the degree of contemplation and discourse about the semantic content was questionable for many students as well.
- Empathy: ChatGPT uses an appeal to the reader (e.g., "allow you") or an imperative (e.g., "Explore the depths") to construct phrases that reinforce the storytelling around the product, which is consistent with the description of artefacts in Design Fiction.

Similarly, the concept sketches provided by the students were compared with concept images generated with Midjourney (Table 1). Specifically, we asked Midjourney to produce an image for each prompt collected, this time using the formula: "/imagine a human figure

wearing a wearable technology to [Ability] with [Object] in/at/at the [Context]", with prepositions varying as needed for syntax. A comparative analysis between the student-generated and the AI-generated visual outcomes has enabled us to derive additional observations.

- Visual quality and quantity: as expected, the comparison is rather unfair. Midjourney generates four professional-looking images (whether drawing, illustration or photo style) in minutes for each prompt, while students can discuss, define and draw concepts much more slowly;
- Concept solution: based on the same random input, usually ChatGPT and Midjourney provide completely different product types. For instance, for the prompt to "Feel Concepts at Night", students proposed a wrist accessory, ChatGPT suggested a sleep mask, and Midjourney pictured a helmet or even wearable wiring involving the head and torso.

This suggests that implementing a combination of Design Fiction methods and AI tools can represent a valuable source of creative thinking for designers, providing significant support in exploring, prototyping and evaluating a wide range of possibilities quickly.

5.2 HI.f.AI workshop protocol: Human Intelligence framing Artificial Intelligence

The described experiment with quick Design Fiction exercises has highlighted that AI can indeed provide interesting suggestions and responses to randomly constructed scenarios, but the AI outputs were hardly controllable. Therefore, subsequent experimentations had twofold objectives: on one hand, rooting the Design Fiction effort to real-world problems geared towards an actual project to be developed, and, on the other hand, promoting a critical reflection by the students on the results they obtain from AI in a more structured AI-enhanced design process.

To tackle the rooting in the real world, students were asked to reflect on issues of the city of Rome from different perspectives, coherently with the learning objectives of two different classes available at the time. In the first case, 79 MSc students worked on the 22 historic neighbourhoods of the city of Rome to develop tactical urbanism interventions through urban furniture. In the second case, 86 BSc students have worked around four problematic areas of everyday life in the city of Rome (waste, traffic, wellbeing, security), tackling these with smart objects that integrate sensors and actuators.

To stimulate critical thinking around the practical use of AI, a protocol has been developed with the title "HI.f.AI - Human Intelligence framing Artificial Intelligence", with alternating steps of AI-generated texts and images and HI selecting and revising the generated content and asking for further material. The protocol is practised through a simple shared document (Google Docs) with one-page tables, coloured orange or blue for HI and AI steps respectively (Figure 2). Each step's page contains the title, a brief description (50-100 words) of the activity, and a series of 2-8 fields to compile in 10-30 minutes, according to the technical or conceptual complexity of the step. The HI steps' fields ask for defining themes, purposes, ideas and insights, as well as building on the AI outputs that almost always need to be curated and

modified. The AI steps' fields are compiled with the prompt(s) used, the AI output and an evaluation of the generated text or image. The evaluation is a critical step and can be done qualitatively in a text field, and quantitatively in three numeric input fields, which asked for assessing the quality, originality and utility of the AI outputs. Students were provided with a prompt template to start with, where they could simply plug in their project-specific input, but they were also encouraged to try and document multiple prompt versions.

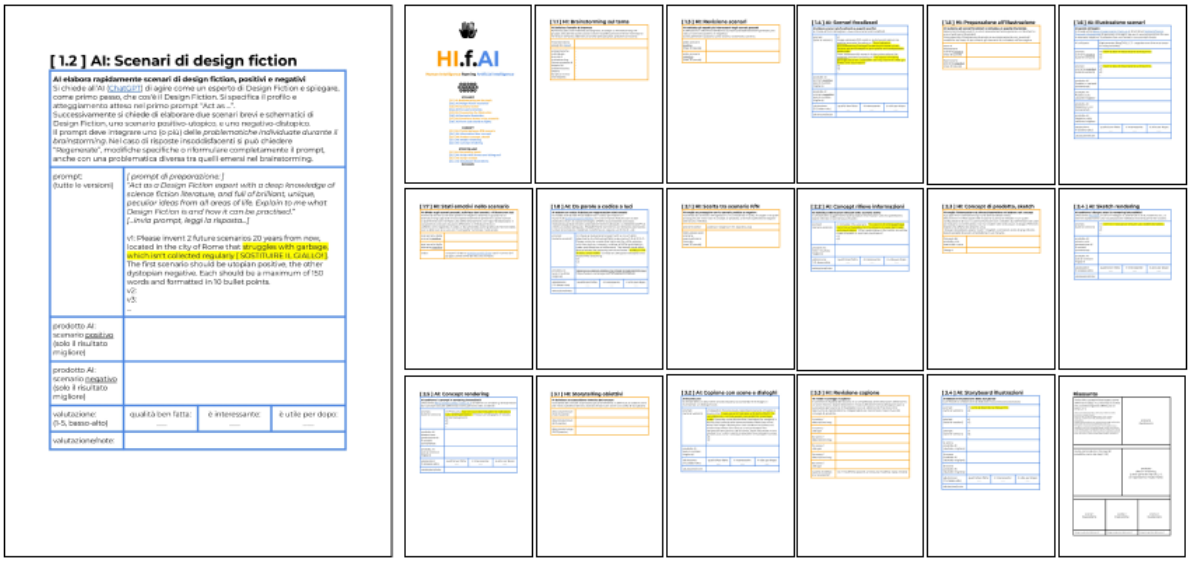


Figure 2 Overview of the HI.f.AI protocol template (BSc version), organised in 3 phases (Scenario, Concept, Storytelling): a second page "AI: Design fiction scenarios" on the left, a cover page, protocol pages and a summary page on the right.

Table 2 HI.f.AI protocol steps, MSc and BSc version

	HI.f.AI protocol v1 (with MSc students) topic: tactical urbanism with urban furniture	**HI.f.AI protocol v2 (with BSc students)** topic: smart objects for urban issues	
Scenario Building Design Fiction	HI: Deciding a urban context AI: Urban photo analysis: people, activities HI: Urban scene description, revised AI: Personas generation for the scene HI: Review and select personas AI: Imagines a conversation b/w personas HI: Selects interesting observations	HI: Brainstorming on the topic AI: Design fiction scenarios HI: Scenario review AI: Focused scenarios HI: Preparation for illustration AI: Scenario illustration HI: Emotional states in the scenario AI: From code words to lights HI: Choice between P/N scenario	Scenario Building Design Fiction
Product Concept	AI: Suggests design concepts HI: Selects and revises the concepts AI: Generates visuals (on photo & on white) HI: Sketches a more feasible version AI: Sketch rendering HI: Photoshop montage to the initial photo	AI: Information flow concept HI: Product concept, sketch AI: Sketch rendering | Concept rendering	Product Concept
Story-telling		HI: Storytelling goals AI: Script with scenes and dialogues HI: Script revision AI: Storyboard illustrations	Story-telling

Among HI and AI steps, the overall procedure consisted of 13 and 16 rigorously sequential steps, executed over 6 and 8 hours long of intense workshops comprising explanations, individually and in groups respectively (see Table 2).

Considering how AI outputs tend to be still quite error-prone (AI hallucination) and hard to steer to specific and consistent results, this protocol of HI-AI collaboration focuses on the initial conceptual steps of the design process. Relying on training data with more sci-fi literature than any human could read through, in these steps, AI imagination, could help to outline possible scenarios on a wide spectrum and come up with a variety of possible solutions. Practicing Design Fiction with imperfect AI tools does not pose particularly high risks but helps to launch the creative process by filling up the blank page - with an initial conceptual draft that must be used carefully. Therefore, the alternating steps of the HI.f.AI protocol concentrated on scenario and idea generation, with a similar format but different details according to the two topics, tactical urbanism with urban furniture (MSc) and smart objects for urban issues (BSc). In the first case (MSc), the Scenario building happens based on a specific urban spot, which was analyzed by free AI tools (Astica Vision Describe and Google Bard; ChatGPT-4V might have been a better but paid option), before populating it with ChatGPT-3.5 generated personas and an imaginary conversation between them, leading to a few observations made by HI. In the second case (BSc), the scenario is not site-specific and it started directly from a group brainstorming that identified problems, around which ChatGPT invented a positive (utopian) and a negative (dystopian) scenario. After a choice of focus by HI, both scenarios were further detailed by AI, then illustrated by DALL-E 3 through the free Microsoft Bing Image Creator (Figure 3).

Figure 3 Design Fiction Scenarios of 23 BSc student groups

Finally, to approach the topic of Smart Objects, students represented the scenarios with dynamic light patterns experimented through simple analogue tools, and then asked ChatGPT to do the same with Arduino code tested out with the online emulator Wokwi. In the following phase of Concept generation, students asked AI to reason about relevant information to monitor and communicate in the scenario, and then HI came up with the product concept and sketches, leading to AI-generated concept renderings in DALL-E 3 and sketch renderings

in PromeAI (Figure 4). The concept generation was quite similar for the tactical urbanism group (MSc), although in this case, the first round of AI visual concept generation happened directly in a photo, by selecting the area of intervention and asking PromeAI (Erase and replace) to insert the described concept. These visuals were used as inspiration material for sketches illustrating structurally more feasible options. Finally, a round of sketch rendering and photomontage led to the revised street furniture inserted into the original photo.

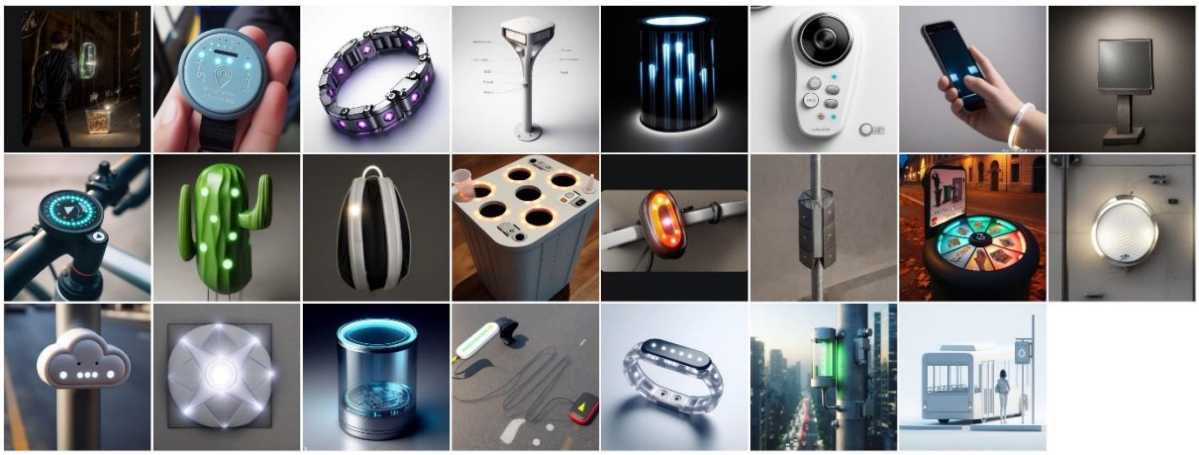


Figure 4 Smart Objects Concepts of 23 BSc student groups

A last phase of Storytelling was added to the smart object version (BSc), where AI was used to come up with a three-step storyboard with dialogues about the product concept in use within the reference scenario, illustrated by the specialized tool Recraft.

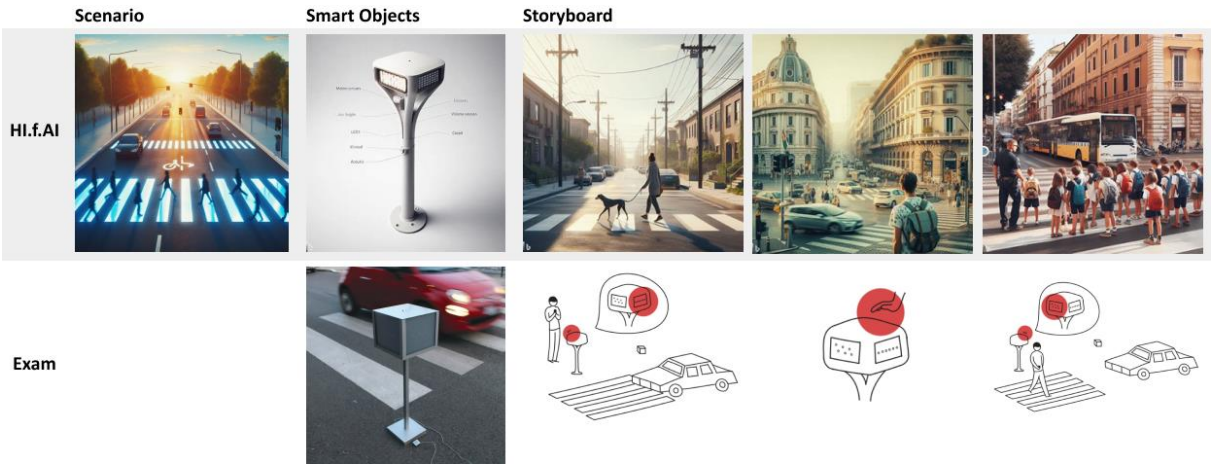


Figure 5 Example of HI.f.AI workshop results on the top line, compared to exam results on the bottom line, including Design Fiction Scenario - crossing safety problem (the same for both), Smart Objects - crossing safety device and Storyboard

For example, one BSc student group started with an idea after a brainstorming session about a city that "struggles with maintaining the safety of both pedestrians and drivers and therefore it is necessary to improve crosswalks". With the help of ChatGPT, it turned into a device with distance sensors, creating light indications for drivers and pedestrians, guaranteeing a

safe crossing (Figure 5). Next, HI created product concepts and sketches of this smart object to get photorealistic renderings. Finally, in the storytelling phase, a dialogue with illustrations was created, which came out more like three different stories than one consistent. If we compare the results of the workshop and the final exam, it can be seen that this student group implemented prototypes for the same product concept with quite similar shape and, moreover, it was much better than AI at creating storyboards.

6. Discussion of the results

The previous sections described how 150+ students in different degree programs (86 BSc in Design, 79 MSc in Product and Service Design) were introduced to generative AI in the design process, providing a first experience with various tools situated at various phases of the design process, focusing on the initial scenario, concept and storytelling. The day-long workshops were challenging to manage, with steps presented in a few minutes and the timer dictating an intensive pace, limiting deep reflection but providing a hands-on experience on a wide spectrum of approaches and tools. For students needing extra time, the workshop sheets were delivered within one week, then all results were united in a spreadsheet for statistical analysis.

Besides the students, this was an important learning opportunity for the instructors. As expert users of AI tools know, prompting is easy to start but satisfactory results require an iterative process, progressively crafting tool-specific mannerisms through tens of attempts. Current prompts require mainly verbal thinking (Dang et al., 2022), therefore, “Prompt designers” must have a mental image of what they want, the capacity for constructive critique towards the chatbot, but also an open mind to unexpected but stimulating results in AI conversations and images. Such skills can be expected from a design instructor, but not necessarily from design students or practitioners, often “visual thinkers” spending their time on visual and tangible artifacts, rather than verbal communication.

While the HI.f.AI protocol encouraged students to experiment with various prompts, they did it less than we expected, and the prompts were less detailed and specific than the examples provided. Most tasks (65%) were done with only one prompt, for 22% they tried a second prompt, and only a fraction of the tasks required more than two prompts (11%, 1%, 1% for 3, 4, 5 prompts).

The overall length of all prompts has shown a clear correlation to the perceived quality of AI results, as shown in Table 3: students who provided longer (and/or more numerous) prompts, rated generally more highly the outcomes as well. More specifically, during the Scenario Building started from image analysis (MSc), AI turned out to be much less effective than expected, as it seldom understands spatial relationships, activities and especially personalities, which could have been easily identified by humans. This caused considerable extra effort also in preparation for the subsequent steps, therefore it was dropped from the subsequent (BSc) version, together with the persona construction and imaginary conversations.

Table 3 Correlation between overall prompt length in characters throughout all steps, compared to the rated Quality/Originality/Utility (from 1 to 5) of the AI outputs. Class of BSc students in Design, except 3 of the 23 groups excluded due to low number of evaluations submitted.

PROMPT LENGTH (characters)	QUALITY	ORIGINALITY	UTILITY	AVERAGE
7203	3,7778	3,7778	4,4444	4,0000
5883	3,6667	3,8889	4,3333	3,9630
5755	3,8889	4,5556	4,3333	4,2593
5054	3,6667	3,5556	4,0000	3,7407
4411	3,3333	3,8889	3,7778	3,6667
4346	3,2778	4,6667	3,6250	3,8654
4054	3,3333	3,7778	3,5556	3,5556
3983	3,4444	3,0000	3,3333	3,2593
3936	3,4444	3,1111	2,9444	3,1667
3640	3,5000	3,2222	3,7778	3,5000
3573	3,4444	3,4444	3,4444	3,4444
3476	3,7778	3,7778	3,7778	3,7778
3352	3,6667	4,1111	3,6667	3,8148
3044	3,8889	2,8889	3,0000	3,2593
3005	2,7778	3,3333	3,3333	3,1481
2970	3,5000	3,0000	3,1250	3,2083
2907	2,7778	2,3333	3,6667	2,9259
2899	3,3333	3,8889	3,8333	3,6852
2827	3,4444	4,8889	4,7778	4,3704
2499	4,0000	3,1111	3,7143	3,6000

During the Design Fiction oriented Scenario Building (BSc), students started with problems identified by themselves based on a randomly assigned problem area (waste, traffic, wellbeing, security), to reach more specific problems. However, the subsequent analysis highlights that the variety of student group-generated problem ideas (10 by group) was not wider than the ChatGPT-3.5 generated range of issues. While time was limited to 20 minutes and students could not do focused field research, we expected that their daily life experience would have given better-than-AI insights in this brainstorming. However, two advantages of students over AI, in this case, were identified: first, that students could conceptualize the problem much better, while AI operated with a stereotypical idea of the city of Rome as a cultural and tourist capital, and second, that students relied more on their design education, while AI, even given its role as a designer, was very interdisciplinary and often referred to social, political and economic aspects of problems.

As far as the positive-negative scenario-building process concerned, the instructors' general observation was that the positive AI scenarios tended to be very generic, focusing already on systemic solutions, while negative AI scenarios managed to stay more specific and richer in details. According to the instructors' judgment, most positive scenarios were close to useless while negative scenarios were more stimulating, students were surprisingly inclined to draw inspiration from the positive ones, leading to many generic and unfeasible concepts.

Regarding concept generation, while ChatGPT can come up with some suitable ideas, students can choose a different one than the one we as instructors would have chosen. The main difficulties with BSc students were that they had just begun to delve into the topic of smart objects and often chose options that implied more advanced systems (such as IoT, for example using GPS for information about charging stations for sharing bicycles) or options that already exist (for example, a feature for indicating the battery level in a sharing bike, which is not innovative). In this case, a trained person can help in these aspects.

As far as generative AI visuals are concerned, controlling the output was difficult as expected. Many of the scenario visuals were very expressive representations, indeed resembling the city, albeit with mash-ups and off-topic elements. Product design visuals based on text prompts looked often very professional in terms of aesthetics and photorealism, far better than students would have done with an entire day of work. Generally, DALL-E 3 tended to include screens in its proposals, as opposed to Midjourney which tends to steampunk concepts. However, as expected, all these concepts rarely look technically feasible, which confirmed the necessity of our multi-layered approach, proceeding from AI visual concepts to HI sketches. AI sketch rendering performed extremely well, making even poorly drawn sketches into a well-lit rendering with credible materials, therefore this seems an area that should be considered for widespread adaptation immediately, even if really good AI sketch renderings still need a good sense of geometry from students.

With the BSc students, the AI-generated conversation was moved from the pre-concept steps to post-concept storytelling. However, it turned out that the lack of specific places and detailed personas, AI has generated less interesting conversations, usually focused too narrowly on the product concept. This was a mildly disappointing outcome since out own preliminary tests with the prompt templates provided more interesting results, with an apparently more human-like creativity. Finally, the two HI.f.AI workshops have provided an opportunity to confront “individual plus AI” with “group work plus AI”. On the one hand, direct prompt-to-image generators can be used well both in individual and group work, as all generations are fundamentally independent. However, mainstream text AI tools cannot enter the dynamics of group work effectively enough, yet. The dominant openly available LLM tool, ChatGPT, supports only one-to-one conversations, therefore there is typically one student interacting on their “home” device, while the others either watch, intervene indirectly, or interact with AI on their own accounts. All these cases are arguably problematic, as not all students can engage equally well with the AI teammate, and if they work with in different chats, then the conversation context is broken, therefore the AI cannot stay fully consistent. Therefore, at its current state AI tools better fit individual work as assistants that speed up the creative process, both by elaborating/detailing textual and visual drafts, and by providing a moderately creative but very well-informed teammate to chat with.

7. Conclusions: New designer skills

The presented experiments in concept development, design sketching and visualization with AI showed promising possibilities and helped to establish a dynamic relationship between Human Intelligence and Artificial Intelligence tools, thus foreshadowing a shift in the traditional creative roles, with designers emerging as curators of AI-powered processes.

As Verganti, Vendraminelli and Iansiti (2020) anticipate, the designer-AI symbiosis may elevate the designer to the role of leader, capable of identifying a problem and providing instructions on how to solve it, thus shifting the focus on sensemaking, which will require designers to acquire new competencies. Looking forward, some key considerations suggest paths for improving the application of AI in design.

Firstly, as we have seen in our mapping, there is a need to develop more effective and diverse AI tools tailored to the initial and final phases of empathizing and validating, areas that currently remain underrepresented in the plethora of tools. Additionally, integrating AI tools into group work and collaborative design processes deserves industry attention to enable more effective multi-party communication, which could ensure that the AI tools stay within the same context window and operate in the same conversation/project/scenario. Lastly, continuously evaluating the impact of AI tool adoption on design education outcomes is critical.

Understanding how AI tools influence students' learning performance, satisfaction, motivation, and creativity should guide the refinement of design education programs and curricula already very shortly. As we have demonstrated, sketching and visualizing Design Fiction scenarios in dialogue with AI facilitates the work on strategic foresight already today.

In this evolving landscape, the relationship between designers and AI is a dynamic partnership that, as it advances, will likely transform practices of creativity and innovation, redefining the Designers' roles, skills, and capabilities.

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