# Experiential Speculation in Vision-Based AI Design Education: *Designing Conventional and Progressive AI Futures*

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Artificial Intelligence (AI) will change how designers design, what they design, and why they design. Recent efforts have extended design education with AI and related machine learning (ML) concepts and technologies. Often, these courses are grounded in other fields such as Computer Science, Electrical and Mechanical Engineering, and Social Sciences. However, few courses teach AI concepts and technologies in combination with creativity, aesthetics, and speculation to leverage the expertise of design. We explored this combination to allow students to creatively design AI exemplars. In a nine-week design activity, students envision and prototype AI exemplars that are based on their personal vision and aesthetic values. This paper reports on our vision, course design, educational context, and learning activities with a focus on developing and integrating different areas of design expertise with AI technology. We contribute insights into 1) what was designed: six design cases, resulting in design speculations, prototypes, and critical reflections as well as our design critiques of these AI exemplars. Then, 2) how to design with a vision-based approach to AI design education in comparison to other approaches, and 3) a futuring landscape with three horizons unpacking why to design with AI.

***Keywords*** – Vision-Based Design Education, AI Design Education, Experiential Speculation, AI-based Scenarios, Vision-Based Futuring Landscape.

***Relevance to Design Practice*** – This work contributes an alternative perspective on AI education in design, including a vision-based futuring landscape aligned with six exemplars and design critiques as well as an analysis of different approaches for AI design education. These insights will open a new design space for designers to envision possible futures from various angles.

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## Introduction

The advancement of new technologies always had an influence on the practices and perspectives in design. The influence of Artificial Intelligence (AI) on design already dates back to the 1970s when one of the founding parents of Artificial Intelligence in the 1950s, Herb Simon made his first contributions to the principles of Design Thinking (Simon, 1969). However, the recent advancements and availability of data, computation, and AI technologies and tools have broader and deeper implications for design. AI is now increasingly embedded in various products and systems, and services to support our everyday activities. AI will continue to change how designers work, what they design, and why they design.

While prior literature has argued that computers or advanced technology can offer new modes of exploration and experimentation, they can be limiting in terms of the types of forms and designs they can generate (Steenson, 2017). When it comes to AI, designers are facing similar situations but great challenges here: first, examples of novel and interesting applications of a combination of AI and design are missing. Current AI-infused applications (e.g., self-driving cars, smart thermostats, etc.) focus on an improved performance, efficiency, usability, or user experience of conventional product categories. What we miss are critical perspectives on design that are beyond what we have known so far. Second, current design education struggles to teach accessible AI to designers (Dove et al., 2017), or is only recently progressing. Moreover, there is little consensus about what designers should know about AI and how to combine this knowledge with the design competences in creativity and aesthetics.

The current design education and on-the-job training has no place for extensive AI components due to curricula being tightly packed with other topics. While there is progress on easy-to-understand resources for novice learners (Hebron, 2016a, 2016b), relevant materials or courses to educate designers what they should know about AI and how they could envision AI futures in a diverse way are lacking. We use AI here synonymously with a broader definition of machine intelligence, including data, machine learning algorithms (ML), and other modern AI

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technology (e.g., generative models). What we currently see in Design and AI education is mostly playing-with, designing-around, or designing-for, but not designing-with[1]. We propose experiential speculation, an amalgam of speculative, vision-based conceptual design and experiential making, as a way to educate design students about the essential characteristics of designing with AI/ML technology.

## Teaching AI in Design

In the last years, trailing the beginning of the current AI hype by a few years, various design (engineering) programs in higher education have incorporated elements of AI and ML into their curriculum. Some institutions even have created new AI-centric courses. As much as this captures a technology trend and inspires education innovation, this also presents considerable challenges. Teaching AI at technical depth in design is mostly unfeasible due to the broad scope of the domain, its rapid progression, and the substantial complexity of required background knowledge. AI and ML technologies are deeply rooted in various academic fields, each carrying its own legacy of knowledge, methods, and paradigms.

First, there are courses that focus on teaching design students to gain knowledge and skills regarding a variety of AI techniques or algorithms (e.g., classifications, clustering, reinforcement learning, neural networks, etc.), essentially a radically lightened form of a conventional computer science or data science curriculum. This approach has its merits for a design education program: it establishes a solid working vocabulary for future multi-disciplinary collaboration with engineers and data scientists. There is by now an abundance of teaching material and the structure is compatible with external resources that can be accessed online by students. Common results of this teaching approach as applied to design are technology-driven design projects that start with a dataset or model and restructure, reframe, and repurpose it towards a new application area. In this way, designers take the role of the junior technologist designing with AI techniques, yet mostly not reaching a stage of actual design. The high pace of development remains a threat to this approach.

Second, another strategy for incorporating AI and ML into design programs is to let design students take a more disciplinary stance and design with the special properties of AI/ML applications. Here, educators focus on user interface (UI) and user experience (UX) challenges that emerge with the uncertainty and probabilistic nature of ML applications, essentially framing and packaging an unstable core of sought-after functionality (Dove et al., 2017). This approach also has merits in terms of hands-on skills and understanding of specific new properties, strong links to commercial or industrial use-cases, future employment prospects, and multi-disciplinary team skills. The drawback is that this designing-around will unlikely lead to entirely new applications and use-cases. The learning experience is tailored to mediating and improving raw technology, targeting a contemporary user base. This, ultimately, reinforces a conventional view of design as giving form to what has been engineered.

Lastly, the third approach emphasizes creating new experiences that involve data and AI, and that embrace the inherent uncertainty and openness of AI and ML technologies. We see that this approach can be operationalized in two ways: (1) working with a fixed set of exemplary tools in the computational creativity space (*Artistic design with ML tools*, see Table 1), or (2) following a vision and value-based journey that touches on both speculative design or design futuring, and experiential making (*Experiential ML-based speculation*, see Table 1). The former has its merits in artistically exploring a design space spanned by the employed tooling (playing-with), which is attractive and inspiring to design students at different levels. The potential downside lies in the conceptual and technical limitations of specific tools. The latter, more open-ended approach can help realize broader visions of designing for AI, with the potential caveat of limits in how far AI-based prototyping can be pushed in the given time and with the available background knowledge. A common implementation of this perspective is largely conceptual with traces of low-fi making. In the following, we deal with these two operationalizations separately.

## A Vision of AI Education in Design

Taking the last approach further into experiential speculation, we envision design education dealing with AI knowledge and skills in a constructive way, resulting in experiential future scenarios that are supported, but not dominated by designing with AI. This, facilitated by a course design that allows students to explore the opportunities of combining creativity and aesthetics with AI, and specific challenges in design education where, so far, (1) examples of meaningful (near-future) applications are missing, (2) AI as a new design material is difficult for designers to access due to technicality and depth needed, (3) a balance between

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*technology push*, *designerly pull*, and *user needs* is difficult to operationalize, and (4) process stages, design activities, and tools might be missing or might not fit this new type of ideation. Our vision on design and AI education is indeed along the lines of three horizons: new perspectives on sensory experiences, new conceptual designs for products and services, and new discourse on ways of living. Design cases in this vision borrow from all three horizons, emphasizing one of them.

### Contributions

This paper presents experiential speculation, an alternative perspective on vision-based AI education in design, using a course design that operationalizes this vision in a university-level Industrial Design Master program. This course resulted in six projects created by student teams who explored diverse topics with the given design brief and visionary foci, including two conventional design cases, two progressive design cases, and two in-between cases. We use these cases to (1) exemplify the diverse directions that the teams took and (2) analyze and interpret the design space for the AI education in design. The six design cases serve as a portfolio of exemplars, along with our design critiques. Furthermore, we present our analysis of the cases based on identified design qualities and the aforementioned vision-based directions: new perspectives on sensory experiences, new conceptual designs for products and services, and new discourse on ways of living. Finally, we reflect on our approach and discuss key challenges and struggles from both teacher and student perspectives. Concluding, we return to our vision for AI education in design, which combines AI technologies with creativity and aesthetics.

## Related Work

### Challenges of Designing with AI

With the rapid advancement of AI technology, designers face immense challenges when it comes to designing AI-infused systems. Oftentimes, designers overlook the potential design opportunities that ML presents and struggle to envision novel uses of ML (Dove et al., 2017). While designers may have a broad understanding of how ML works, they still lack a clear grasp of what it takes to design with it. Moreover, design-led innovation of ML remains uncommon in the current practice (Yang, 2018). Thus, design researchers are not exploring ways to empower designers to work with AI/ML as a new design material (Dove et al., 2017; Holmquist, 2017; Yang et al., 2018).

To tackle these challenges, recent work proposes new approaches and tools aimed at supporting designers to understand ML as a creative material (Yang et al., 2020). Moreover, there is a growing need to educate future designers in ways that enable them not only to acquire fundamental knowledge and skills for prototyping with AI, but also to collaborate effectively with engineers or data scientists while maintaining an open-ended mindset and creative approach to this complex technology in various contexts. Recent work has investigated the current practices and experiences of experienced UX designers who closely worked with AI practitioners in industry (Yang et al., 2018). This work argues that designers do not necessarily require an in-depth practical understanding of AI/ML to create AI prototypes or systems, but rather need to focus on grasping the abstract capabilities of the technology. Therefore, suggestions have been put forth regarding the development of design-oriented abstractions of ML's technological capabilities, the use of exemplars and sensitizing concepts of ML-enhanced designs, and the creation of boundary objects that bridge the domains of UX and ML expertise. However, these suggestions conflict with other lines of education, with emphasis on teaching designers the statistical knowledge of ML (Hebron, 2016a, 2016b).

While the prevailing approach focuses on understanding particular ML capabilities and promoting collaboration within multidisciplinary teams, we adopt a different perspective that embraces openness and freedom when dealing with the challenge of designing with AI. Rather than attempting to teach how to design or implement AI-infused systems in a course context, we encourage students to design entire propositions with AI. This approach fosters an open exploration of how to live with AI and what the opportunities of AI can be. Our goal is not to strive for incremental improvements, but rather to inspire ground-breaking leaps in what we can think of and design.

### Challenges for AI Design Education

There are two distinct approaches to educating designers on how to design with data and AI (Yang et al., 2018). The first approach argues that designers cannot effectively work with a material they do not fully understand. As such, it places emphasis on teaching designers about the statistical knowledge and process of ML products (Cartwright, 2016; Treseler, 2017). Numerous books, courses, and online resources have been developed to assist designers in gaining a fundamental understanding of AI/ML (Hebron, 2016a, 2016b). For example, the book *Machine Learning for Designers* provides a brief introduction to essential concepts of various learning algorithms, including supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning (Hebron, 2016a). The second approach aligns with the argument that designers do not necessarily need a full understanding of AI/ML technologies to use them in their designs. This highlights the importance of grasping the abstractions of ML's capabilities and employing exemplars to help designers envision how these technologies can be applied in their work. In line with this suggestion, researchers have developed design patterns and boundary objects to facilitate effective communication between designers, data scientist, and AI engineers within multidisciplinary teams (Yang et al., 2018). In response to the emerging challenges of AI design education, several courses have recently emerged. One notable course, developed by Zimmerman and Pangaro, aims to guide design students in acquiring a foundational understanding of various types of AI/ML systems and teaches them how to apply AI in today's commercial products through in-class discussion, design sprint, and a series of mini design projects (Yang, 2020). Instead of technology realization and software development, the focus is on engaging students in gaining hands-on experience and having a conversation with AI as a design material through *reflection-in and on-action*. Through this process, students envision AI-infused products and services addressing user needs.

Kaspersen (2023), inspired by the three key dimensions of Computational Thinking (Brennan & Resnick, 2012), proposes a framework for Machine Learning (ML) education for K-12 children with ML *concepts* (knowledge about, e.g., data, models), *practices* (skills in, e.g., data gathering, training, evaluation), and ML *perspectives* (attitudes towards life and society, e.g., transparency, fairness). Whereas the first approach seems to focus primarily on the knowledge concepts around AI, the second approach focusses more on the design practices to work with AI engineers. The recent courses try to combine concepts and practices. Kaspersen (2023) also points out that educational tools and activities that address concepts and practices rarely address the perspectives and implication of ML and vice versa. In our course, we aim to combine AI concepts and practices with perspectives. We encourage students to explore the ideas that not only align with personal vision and societal value (*perspectives*) but also match the intersection of AI technology and aesthetics. We encourage students to build (*practice*) experiential prototypes that demonstrate qualities of integrating AI *concepts* into products or services.

Apart from the connection of AI to computer science, engineering, or UX, there is a line of ML education for artists, musicians, and other creatives. Fiebrink et al. (2019) describe courses and tools for ML education that can lead to new creative outputs, means for self-expression, and economic impact from ML in creative technologies. This work singles out supervised machine learning and interactive machine learning as the primary ML techniques and promotes the Wekinator software as the primary ML tool.

Like our course, one course designed by van Allen and Hooker aims for an open-ended exploration for the design of AI and ML. This course investigates how AI impacts urban, human-scale environment. In the course, students create a *useless AI* product and engage in making sense of AI through open experimentation (van Allen & Hooker, 2017). Our approach aligns with such aims to create an open space for designers to envision how AI could be embedded in a context: designers use their creativity to speculate diverse, visionary applications. These applications can be speculative, *strange,* and experimental, but engaged with real issues in the field.

## Creativity & Aesthetics as Driver for Data and AI

Creativity and aesthetics have always been the essential competences of designers. Both depend on technology, as every advancement in technology offers new opportunities for the creative process. Industrial designers have, for decades, explored the relationship between the latest production technologies and the appearance of products. In the early 2000s, however, industrial designers started a paradigmatic shift from *aesthetics of appearance*, primarily visual, towards an *aesthetics of interaction* with different underlying qualities and principles (Djajadiningrat et al., 2000; Petersen et al., 2004). This shift was made possible and even necessary with the advancements in technology, from physical materials and production technologies towards digital materials, computation, and information technologies. Where before the 2000s, metal, textiles, and plastics were the primary design materials, after, interactivity and computation became the primary design materials. Artificial intelligence and data are the next emerging technologies and materials for design, and future design tools will seamlessly include data and intelligence. Designs embedded with AI-technologies have the potential for novel aesthetic experiences beyond appearance and interaction, with yet to explore underlying qualities and principles. This can lead to the next paradigmatic shift for design aesthetics, which Wensveen (2018, p. 26) refers to as the *aesthetics of intelligence.*

In our course, we explore how these new AI technologies and data will influence the aesthetics of intelligent products, services, and systems and how the aesthetic values of designers will influence the use of intelligence.

While aesthetics has its origins in the philosophy of art, we provide our design students with a more general introduction, and frame aesthetics both as a set of underlying qualities and principles for a design, and as a *critical reflection of how people create, use, enjoy, or dislike design*. These reflections can treat design on three different levels (Folkmann, 2013), the sensual, the conceptual, and the discursive level. On the *sensual level*, design aesthetics emphasizes how design creates novel kinds of sensorial experiences and has innovative effects on the look, feel, or sound of the designed experience. This sensual level is generally understood as the meaning of design aesthetics. However, our interest goes beyond the purely sensorial experience that new AI technologies may provide for design. On the next level of design aesthetics, the *conceptual level*, the critical reflection happens on how the designs themselves become carriers of new concepts and the designed technology allows for new everyday experiences. On the *discursive level* of design aesthetics, the design provides critical reflections and perspectives on current society or speculations on future ways of living with technologies.

In alignment with our vision, we want students to critically engage with the diverse possibilities of AI technologies and explore the sensual, conceptual, and discursive aesthetics of these technologies and deviate from the conventional trends surrounding AI. We want them to imagine and design new aesthetic experiences and perspectives of understanding and engaging with the current world through AI, or design with AI technologies to debate entire new worlds made possible. The focus on aesthetics supports the experiential speculation, as it foregrounds both the experiential and sensual qualities of design, and the critical exploration of novel perspectives.

From a creativity perspective we expect our students to stretch their imagination, take risks in exploring novel and uncertain areas, and make decisions based on little information. To kick-start the creative design exploration, we ask the students to make explicit combinations between aspects of design aesthetics, their personal values, and aspects of AI technologies, making use of a common creative strategy of combining seemingly unrelated topics into new ideas.

## Course Design

This section introduces the educational context in which design students explore the alternative perspective. We describe the overall course structure, the educational activities, and the deliverables. The learning objective of the course is to allow design students to explore the interplay between data and intelligence, creativity and aesthetics, and their personal inspiration and vision.

### Design Education Philosophy

Our design education philosophy is largely inspired by Schön to appreciate learning through doing and reflection in action. Similar to Schön, we focus more on the role of intuition, creativity, and improvisation in design practice and explore new ways of adequately dealing with the messiness and ambiguity of real-world design problems (Schön, 1983). We also emphasize the importance of *reflection-in-action*, a process in which designers actively reflect on and adapt their designs as they are working on them. We strive for a more collaborative and iterative approach to design, in which designers work closely with users and other stakeholders to co-create solutions to complex problems. What makes our approach in the course unique is to incorporate personal visions as a drive for encouraging students to take bold steps to experiment with wild ideas by combining two distinct disciplines.

Similar to our approach, Dubberly Design Office (Dubberly & Pangaro, 2015) has been actively involved in design education and has contributed to the development of design curricula. They endorse a holistic approach to design education that goes beyond traditional design disciplines and emphasize the importance of interdisciplinary collaboration, system thinking, and understanding the broader context in which design operates. They further encourage designers to think critically, explore multiple perspectives, and embrace complexity. Where they differ from us, however, lies in their major focus on human-centered design approach. We, on the other hand, maintain an openness to exploring new methodologies and looking into the opportunities of a more-than-human centered design approach. We urge design students to be more curious, adaptable, and open to continuous learning.

### Educational Context

Each school of design is unique in its own context and in the specific ways it educates designers. The key elements of our educational context are competence-centered education, and self-directed and vision-based learning allowing students to develop their unique professional identity. Our Industrial Design Master program at Eindhoven University of Technology is a two-year program where students with prior background in design or engineering specialize in their self-chosen direction. Students choose projects and courses to develop their own competence aligned with the Attitude, Skills, Knowledge (ASK) model (Bakarman, 2005) (see also Discussion for how we adapt ASK in the design education context). In addition, students develop a personal design vision that reflects their ideas and beliefs about the future of society and technology, and their role as designer in bridging the two and making an impact. The vision provides guidance to their professional specialization and gives personal meaning and motivation to their learning.

In 2020, we introduced the Master course *Creativity and Aesthetics of Data and AI (DCM210)* with three goals in mind: 1) to broaden our (students, staff, and the wider design research community) existing competency in AI beyond technology and user focus, 2) to introduce AI to students with an interest in creativity and aesthetics, but not (yet) in data and computational technologies, 3) to allow students to explore AI technologies in relation to their personal vision on society and technology.

While all students in the course have a prior background in design (BDes, BSc) or engineering (BSc), their proficiency in technology, hands-on prototyping skills, and theoretical knowledge differs in level and specifics. In a sense, students' prior *baggage* and specific interest for why they chose the course differ.

### Overall Structure and Course Design

The course is structured along three lines: 1) Creativity and Aesthetics, 2) Math, Data, and Computing and 3) Interplay between the two. Lines 1 and 2 have the same structure and learning activities: Introductory lectures and individual readings that introduce knowledge concepts, plenary discussions on their mutual relevance, and synthesis and communication of their personal insights into an *annotated poster* (Miro board, teams of two students), which is inspired by annotated portfolios (Bowers, 2012), as sensitizing concepts to open a space for design exploration and innovations. For the creation of a poster, students need to make use of their aesthetic and creative skills and explore the sensorial aspect of a graphical poster with a composition that balances the variety of visual elements, while the annotations require their analytical and argumentative skills. All posters are aggregated in one overview of all concepts for all students to share.

**Creativity & Aesthetics (CA):** For the knowledge concepts in Creativity & Aesthetics we choose a diversity of philosophies, theories, and design frameworks with their exemplary design cases. They range from well-established, e.g., Aesthetics of Interaction (Ross & Wensveen, 2010) to more recent topics, e.g., Post-humanism (Forlano, 2017). Concepts also range in their backgrounds, coming from a more academic, e.g., Perceptual Crossing (Deckers et al., 2012) or more artistic context, e.g., New Aesthetics (Bridle, 2011). All concepts are introduced with visuals and design exemplars for inspiration in an opening lecture.

**Math, Data & Computing (MDC):** Our choice for knowledge concepts in Math, Data & Computing is based on technological diversity, ranging from data, e.g., Collective Intelligence & Crowdsourcing (Kittur et al., 2013; Vaughan, 2018), Data Programming and Data Augmentation (Ratner et al., 2016), algorithmic models, e.g., Reinforcement Learning (Ramesh et al., 2020), Generative Models (Foster, 2019), to recent trending topics, e.g., Interactive Machine Learning (Amershi et al., 2014), Human-AI Collaboration (Bansal et al., 2021), Explainable AI (Abdul et al., 2018; Wang et al., 2019). The concepts are not mutual exclusive and might have some degrees of overlap. Also, they are making-focused; that is, each concept covers several techniques or algorithms to be implemented. We provide visual and conceptual design exemplars for inspiration in an introductory-level lecture around the knowledge concepts for Math, Data, and AI.

For each CA and MDC concept, we select one or two academic papers as seed papers for students to start with. They need to use the design exemplars and those seed papers to further develop their knowledge and understandings around the chosen topics.

When we talk about technology in this paper, we express that the student teams select concrete technology for their cases from three overlapping areas of technology accessible to them: creative computing, physical computing (e.g., sensors and signal process, tangible interaction, etc.), and AI and ML technology (e.g., generative models, reinforcement learning, interactive machine learning, etc.). In the remainder of the paper, we will refer to this as *technology* as opposed to creativity and aesthetic aspects of the design cases.

**Personal and professional inspiration and vision:** In the first week, students also explore and frame their personal and professional inspiration and their vision. We ask them to create a digital (e.g., Miro) annotated poster (images plus keywords, short pieces of text) that communicates their inspirational subjects. Our suggested list of potential subjects is inspired by the *History of Beauty* (Eco & McEwen, 2004): Beauty in ...nature (e.g., your love for out-door activities, flora, and fauna) ...cultural, moral values (interest in philosophy, religion, ethics) ...the arts, ...the everyday, ...technology and machines (e.g., mathematics, kinetic art, science fiction) ...functionality, ...the material (e.g., crafting soft materials, ceramics, wood) ...the provocation (e.g., critical design, dark scenarios). The poster needs to be a visual and textual communication of their personal and/or professional interest, their personal and socio-cultural values, and their vision on technology, society, and design.

The third line combines and integrates the knowledge of the first two lines to give *form*, beauty, expression, and meaning to user experiences as they are shaped by data and artificial intelligence (teams of 2 × 2). The activities in the third line are: envisioning, designing, prototyping, and design critiques. This line starts with a creative session combining all posters. The goal of the creative session is finding and deciding on the most inspiring *triptych* (combination of three posters) which will be worked out further during the design process.

The suggested design process for the course follows a rough double diamond structure (Tschimmel, 2012); *Discover* the topics, combine them, and generate ideas, *Define* a first concept and receive mid-term design critique, *Develop* the concept and technology, *Deliver* the demonstrator in a plenary design critique and write the pictorial to communicate your academic argument. Each stage takes about two weeks.

The final deliverables include a *visionary and experiential demonstrator*, i.e., a high-quality artifact, prototype, movie, intervention, or performance, a *pictorial,* and a *personal reflection*. The demonstrator should provide a convincing aesthetic experience or discursive argument. We communicate the following criteria for this: Engages the audience into the underlying concepts and topics; has aesthetic quality of materials, interactions, and intelligence that showcases the values and perspectives of the design team; shows the computational and making-related competence of the design team.

For the *pictorial* we ask each team for a written and illustrated dissemination (rough draft, 4-10 pages) of the aesthetic experience and/or academic argument (article, pictorial) with a critical reflection or discussion. Appendices are added with short backgrounds of the different authors and their main roles in the research process, and additional information to give depth and detail to the specific design decisions.

The *personal reflection* (4 pages maximum: 2 pages of text, 2 pages of images) describes what they have learned, and the (un)expected insights they have gained from doing the course. Individual reflections are on three levels: 1) Knowledge: What do you know now about the different topics?; 2) Skills: Which skills did you acquire, what did you struggle with, what did you overcome, and how?; and 3) Attitude: What does this mean for the development of your professional identity and your vision?

## Course Outcomes: *Six Design Cases*

This section presents six design cases from a single iteration of the course. We selected the cases from a single course to be comparable in terms of initial briefing, support, and collective sense-making of the design challenge. We order the cases on a scale ranging from being close to the status quo to approaching a near-future scenario. Each case is also discussed and reflected on the qualities we defined, which supports a constructive discussion of strengths and weaknesses.

### Educational Qualities

We assess the six cases in terms of disciplinary-aligned dimensions. The dimensions are derived from the course setup as a novel combination of designerly (*creativity and aesthetics*) and technical topics (*AI/ML technology use*) within design education. In this context, we find it important to look at both designerly and technical topics also in integration, i.e., how well are the teams able to find and develop links between them and express those in their designs (*consistency/coherence of design*). Finally, as part of our Master's program, we want student teams to take an academic approach to designing with creativity and AI. That means, we assess their *design and research process* in terms of a balance between intuitive and enthusiastic pushing-forward, and a reflective and even critical approach to making sense of their design iterations, investigating starting points, development of momentum, pivots and turning points, and how the final design case emerges in the end. The detailed items are derived from the course rubrics, in essence, what we find important to teach our students–both to keep it open and sustainable in the light of technology development, and to direct and guide students in their development around a complex technology. The increasing numbering scheme does not imply order, it is merely a means to reference different aspects in an unambiguous way.

The first dimension, *creativity and aesthetics* (CAx), deals with qualities of creativity and aesthetics that appear in a case. For creativity, we look at how **novel** a case is for the (CA1) intended context of use and (CA2) in conceptual focus. Further, we look at (CA3) **diversity and contras**t in combining different ideas in a case. Finally, (CA4) **risk-taking based** on personal inspiration and acquired knowledge of AI technology contributes to creativity. For aesthetic qualities, we look at (CA5) **sensual quality**, (CA6) **new aesthetics**, the (CA7) **exploratory experience**, and (CA8) how the **designed experience augments** the Everyday or how far it sketches a new world.

The second dimension, *technology use* (TUx), deals with (TU1) technological **feasibility** and **practicality**, but also (TU2) **depth**, i.e., whether AI/ML technology is basically applied or more deeply understood and incorporated, or even changed. In this context, we also look for how **AI/ML** technology is **integrated into a larger technical ecosystem** (TU3), which can take considerable resources and skills to accomplish, but also facilitates a better, more high-fidelity integrated experience in the end. Further, we are interested in (TU4) how student teams **explore technologies**, whether they settle quickly on a single solution or take the time to research, evaluate, and discuss alternatives. Finally, we look at (TU5) how **appropriate** the **technology** use is in the context of the design case, (TU6) how deep the **conceptual need** is for advanced technology, and (TU7) how the implementation corresponds to that, including how well **ethical concerns** are discussed.

The third dimension, *consistency/coherence of design* (CDx), focuses on (CD1) the **interplay** of creativity, aesthetics, and technology in the design case, considering whether there are clear connections between creativity and aesthetics, AI/ML technology, and whether this is reflected in (CD2) **conceptual** and (CD3) **discursive** qualities.

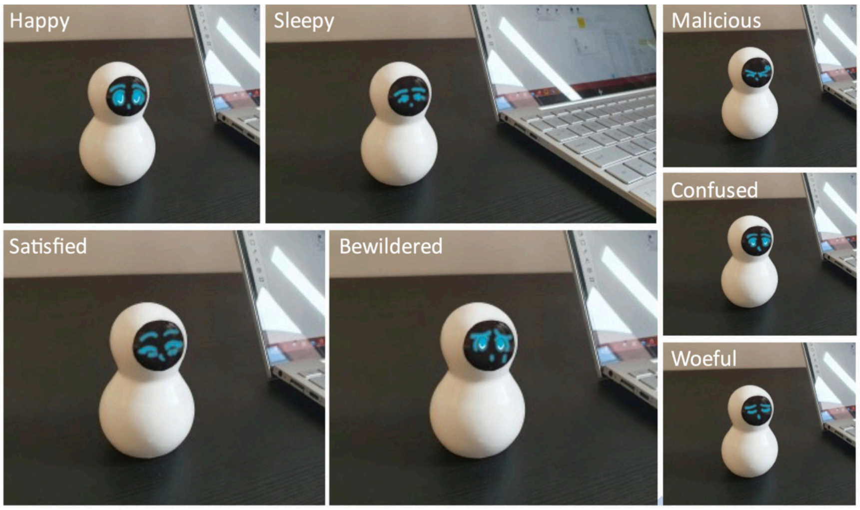
Finally, the fourth dimension, *design and research process* (DRPx), deals with explorative aspects, such as (DRP1) how far **beyond user-centered design** the case is, (DRP2) whether **post-human interaction** is explored, and (DRP3) whether **multiple perspectives** are explored and presented, next to (DRP4) the degree of **curiosity** that inspires and drives the exploration. Another quality is risk-taking in the process, (DRP5) **breaking the** *fourth wall* or (DRP6) permitting *meta-level* **aspects** in the work, and (DRP7) whether there is an account of **interacting with unpredictable actors** (possible in relation to post-human interaction). Further, we are interested in how far the student teams (DRP8) **explore by making** and then deploy their demonstrators into a real-life context (as far as possible given the degree of futurism). This is complemented by a final focus on the process, (DRP9) whether the team primarily pays attention to **process or final outcomes**. With these qualities and structuring dimensions as a background, we present six design cases and use the qualities to pinpoint highlights in the students' work. The cases are presented in pairs of two, ordered by their conceptual being-removed-from the status quo.

## Two Cases Indicating Conventional AI Futures

Conventional AI Futures deal with a modest extrapolation of the current Everyday, in which AI products or services are integrated. This category essentially takes the world as we know it and focuses on enhancing it with AI, which is a conceptually low-risk approach. However, it invites more scrutiny in terms of conceptual consistency and coherence. Conventional AI futures stay close to the modus operandi of designing products and services, just with AI.

### *Case 1: Robby: Conversational Agent as a Language Teacher*

The first case is Robby, a conversational agent with a physical embodiment that supports people in learning a foreign language through conversational interactions. To engage people in a conversation, this work incorporates emotional feedback and provides corresponding responses, and facial and body expressions while people make distinct types of errors (e.g., grammar errors, wrong context, wrong pronunciation, etc.). This project found inspiration in the combination of the topics *Human-AI Collaboration* and *Aesthetics of Interaction.*




| Error | Facial expression | Body expresssion | Response |
|---|---|---|---|
| Grammar error | | Eyes tilting from one side to another | The word order is wrong. The correct way is: |
| Wrong pronunciation | | Eyes get narrower by every mistake | |
| Talking too softly | | Eyes get bigger | Can you repeat that, but a bit louder please? |
| Wrong context | | Eyes shake slightly | |
| Repeat mistakes | | Sight sound and eyebrows move slightly | You said .... wrong again |
| Overly polite | | Drops run down the face | |
| Impolite | | | I don't like the way you are talking to me |

**Figure 1. Sequence of different scenarios of Robby giving emotional feedback to a user.**

The concept shows qualities of being a sensible application, being useful for supporting a difficult activity (CD2, CD3), yet implementing new ways to do so (CA8). Although the team did not advance far into making and realizing a working prototype (TU1, TU2), they consistently focused on embodiment besides a computer or smart phone (DRP8), and on embedding machine learning technology in a tight interaction loop (TU3, CD1). They used emotional expressions as a feedback modality (CA7, CA7), engaging the user in a fluent interaction sequence with little processing-related friction. The concept also allows for extension into more useful applications (CD2), in which the embodiment would become a sidecar to a conversation with another human or application, while providing continuous feedback. This already hints at the critique that this case did not make large conceptual jumps in the process (CA1, CA2, CA4), the focus was and remained on solving a particular problem (DRP1, DRP3), and thus did not open to creative influence (CA3). A second critical point is that the technological grounding is not convincing: while speech to text technology exists, understanding and providing constructive feedback on contextual errors or dealing with heavy pronunciation issues is currently not solved in the state of the art of machine learning (TU1, TU2). A final point of critique is that the emotional responses are rather crude and follow a very reductive model of human emotion expression (TU6), which might not even be appropriate for an artificial agent to peruse (TU7).

### *Case 2: CAENA: Enchant the Dining Experience using Spatial AR and AI*

The second case, CAENA, aims to create an *enchanting dining experience* using spatial Augmented Reality and Artificial Intelligence. The final concept is a system that enhances a dining experience with personalized projections by leveraging users' personal and environment data before, during, and after the dining event. This project combines *Everyday aesthetics* and *Interactive Machine Learning* technology to create AI-generated elements that visually complement the dining experience. A mobile app is used to set personal preferences before dining and for giving feedback to the system throughout and after the experience.

The concept is realized as a combination of different technologies, including hardware, software, and interface and smart phone application (TU1, TU3). The team chose appropriate technology (TU5) and found a conceptually consistent form of enhancing the physical dining experience through projections (CA5, CA8, CD1). Critical points for this case are around the lack of depth in the engagement with AI/ML technology (TU2, TU6), and how the interplay between creativity, aesthetics, and technology (CD1, CD2) contributes to a rather unsurprising experience (CA5, CA6). A second point is that the role of augmented reality in this concept is not well-accentuated and could have been designed with more curiosity and risk-taking (CA3, CA4, DRP7). Finally, the concept stays at a problem-solving user-centered developmental stage (DRP1) forgoing more interesting opportunities (DRP3, DRP4, DRP9) in enhancing a dinner experience with unpredictability (DRP7) or meta-level engagements (DRP6).

In summary, the two conventional AI futures cases show that more attention to the design and research process was needed. This way, more diversity and curiosity create bigger leaps in conceptual development combining creativity, aesthetics, and technology in more surprising ways.

## Two Cases Indicating AI Future In Between

The next two cases indicate an in-between stage between conventional AI futures and progressive, visionary views of what else we could design. Like the first two cases, we see cases that can in principle be realized in the current Everyday, however, noting that the following two cases take steps into a different, future affirming, conceptual framing of the Everyday.

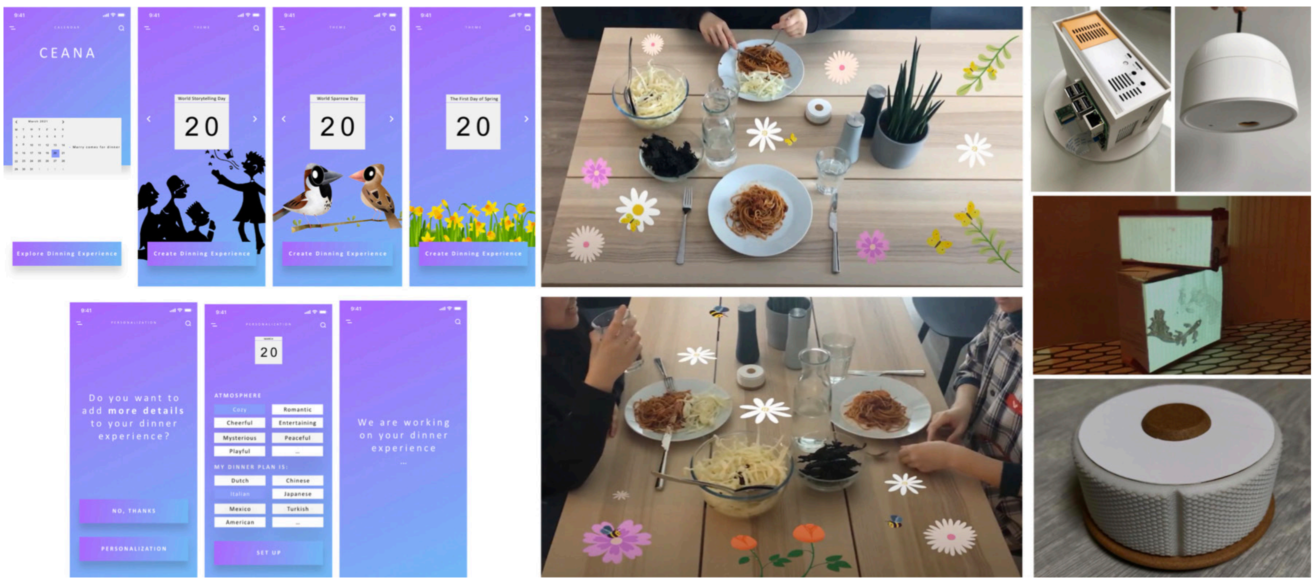



**Figure 2. CAENA creates a visually augmented dining experience by using an integrated system.**

### *Case 3: Breakfast Soundscape: Exploring Aesthetics of the Auditory Environment*

The third case, Breakfast Soundscape[2], aims to combine the insights of *everyday aesthetics*, *extended reality*, and *generative models* for sound exploration. This work presents a prototype that augments everyday food consumption practices with a unique soundscape that is experienced, e.g., while eating breakfast. Tableware and cutlery are digitally enhanced to record movements and translate them into fitting soundscapes. This potentially creates an unusual experience to de-familiarize the user from the mundane, familiar Everyday. While this case resembles the enhanced dining experience in case 2, the core sensual practice of consuming food is changed through the soundscape in rather disruptive ways.

The concept capitalizes on the unusual interplay between natural acoustic and artificial digital sounds produced in the process of preparing and consuming food, as well as the mixing of physical and digital realm, creating a new, focused experience (CA1, CA2). The design realizes sensual qualities and new aesthetics (CA5, CA6), and potentially leads to exploratory experiences, especially on first encounters of this *experience augmentation* (CA7, CA8). The project was technically feasible and resulted in working prototypes (TU1, TU2), but it was not further integrated into a larger ecosystem of applications. The use of technology was appropriate and in accordance with a conceptual need (TU5, TU6). While the team focused on the interplay between creativity, aesthetics, and technology (CD1), and this is reflected in the concept (CD2), there was little discourse and reflection on the implications for the future. The design process emphasizes working with curiosity (DRP4) and a focus on making (DRP8), especially using intermediate *internal* tools to make sense of interaction and use. There was also a focus on early, physical prototypes and on the final outcomes (DRP9), yet little self-reflection.

### *Case 4: Transire, an Exploration to Ease up the Grieving Process*

The fourth project, Transire[3], explores a tangible artefact that allows people in mourning to maintain a connection with the lost one and ease through the grieving process. The project features a multi-modal, partly visual, partly tactile, experience that embodies a contemporary interpretation of self, soul, and being. The designers outlined a connected service around the experience that would facilitate data collection from social media and use machine learning to predict the personality of the deceased. Based on the personality, the aesthetics of interaction through light, color, and movement would change accordingly. The concept found inspiration in the topics *perceptual-crossing*, *aesthetic interaction, data programming, and machine learning* all with a strong emphasis on physical visualization.

This project touches on the complexity of letting go and grasping at what it is that we (think we) let go. This has been explored before in contemporary artworks (Houser, 2020), but not deeply in the design context (CA1). The team took risks in engaging with the difficult topic of death and grief (CA4) through a sensual experience with the artefact (CA5). While following a making approach (DRP8), the technology choices regarding the content acquisition and generative AI are less clearly articulated, especially when dealing with arbitrary data sources that are meant to provide all information needed to generate a truthful, recognizable representation of the deceased (TU3). The appropriateness of a technological solution is questionable, and the work does not fully correspond to the many ethical concerns that could be raised about the chosen topic (TU5, TU7). The design shows an interplay between creativity, aesthetics, and technology (CD1) and this is followed through in the concept to some extent (CD2). While focusing on individual end-users, there is a notion of post-human interaction present (DRP2) with possible implications on "breaking the fourth wall" and facilitating metalevel reflection (DRP5, DRP6).

In summary, the two intermediate AI futures cases show more focus on personal experiences and depth in empathizing with the Everyday or a special life situation like mourning. The two projects demonstrate very different forms of impact, also at the emotional level, and how the interplay between AI technology and creativity and aesthetics can enhance different situations. They also show that more attention to the design and research process in terms of proactive reflection and critical engagement with their concepts could have helped realize more coherent concepts–and that a grounding of speculative design in ethics is and should be a paramount concern in design education.


**Figure 3. Breakfast Soundscape augments breakfast eating experience with a unique soundscape in everyday practice.**

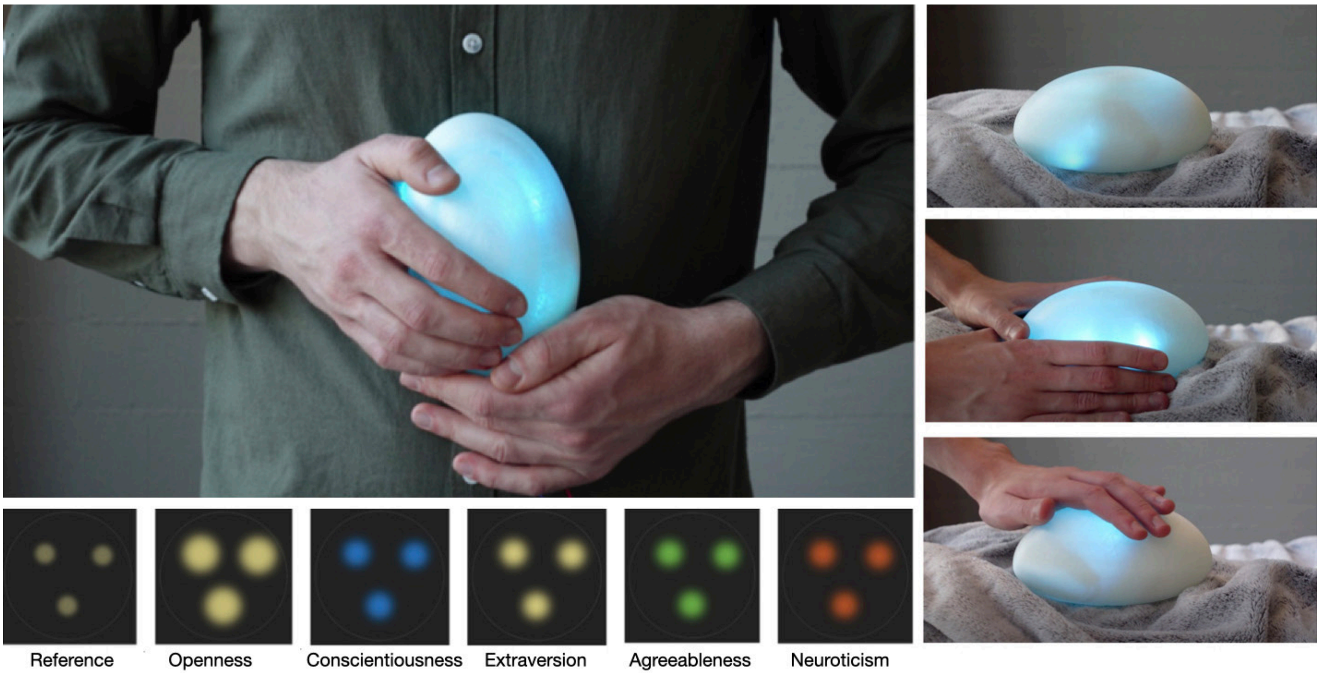



**Figure 4. Transire explores a tangible artefact that enables people to interact with the deceased one.**

## Two Cases Detailing Progressive Visions

The final two cases are firmly rooted in the future; they are progressive in terms of reframing the way people view their identity in public spaces or fostering personal relationships with non-human entities. Yet, they are neutral about the future context, utopia or dystopia.

### *Case 5: Iden: Using Generative Models for Public Privacy in the Hybrid Space*

The fifth project, Iden[4], aims to address public privacy issues in a hybrid space. This work presents a concept of an independent company that protects people's identity from being revealed in unwanted situations. This company would search online for uploaded videos to identify clients who wear their identifiers and then replace their client's identity in the online video with the client's self-selected anonymized version. This work invites participants to experience a *what-if* imaginary scenario by using visionary videos highlighting the socio-cultural values of the characters in the video and their reasons for privacy and identity. The videos were accompanied by a website for the imaginary company and used interviews to understand the perception of participants on this speculative future. The project also touches on sensitive issues around the generative model being used for the hybrid identity creation. This concept was inspired by the combination of topics *Human values* and *Generative models*.

The concept is scoped larger than previous projects, as a *company* instead of a single product or application. There is strong emphasis on novelty in context and conceptual focus (CA1, CA2) as well as elements of diversity and risk-taking (CA3, CA4) by boldly


**Figure 5. Iden discusses sensitive issues around a hybrid identity generated by a future company.**

projecting a future scenario that might be entirely invalidated by future developments. The visual qualities of the concept video are particularly striking in how the team explores new aesthetics of *worn identities* (CA5, CA6). The concept challenges us with a new perspective on the future *identity-augmented* Everyday (CA8, CA9). As far as explored, technology use is appropriate and requires broad integration (TU3, TU5). The technology directly responds to an ethical issue at the heart of the project (TU7). The team explored multiple perspectives (DRP3), worked with curiosity, and attempted to break the fourth wall for the co-speculator (DRP4, DRP5). We also see traces of engaging with uncertainty and unpredictable actors in this work (DRP7). As a speculative project, there is much less focus on feasibility, scalability, integration with other technologies, and technological depth compared to the projects presented above. Also, the interplay between creativity, aesthetics, and technology was less developed. Conceptually, the design team focused on provocation and facilitating a discourse around identity (CD3), identifiability, and the (future) state of privacy in the public.

### *Case 6: Bird Whisperer*

The sixth project, Bird Whisperer[5], takes a more-than-human approach and targets interrelations between people and birds. The team designed a research artefact, an object that outputs bird songs produced by a generative algorithm (e.g., WaveGAN[6]) with the objective to explore new ways of living and investigate relationships between humans, artificial objects, and non-human entities (i.e., birds). This concept was inspired by the combination of topics *Post-humanism* and *Generative models*.

The concept played with the novelty of human-bird communication (DRP2) both for the target context and as a concept (CA1, CA2). The team took risks in their deployment (CA4, DRP7) and in how the concept augments the experience of the Everyday with new aesthetics (CA6, CA8). Unlike the previous speculative project, this project was realized as a working prototype and deployed in the wild (TU1, TU2). The team capitalized on their strong making skills and actively sought expert help throughout the process (DRP8), exploring different appropriate technologies (TU4, TU5). The project shows an interesting animal interaction approach, yet the team missed opportunities for deeper reflection on how the AI aspects, specifically the GAN, relate to and have shaped the post-human design approach.

In summary, the two progressive AI futures cases show diversity in how a team could approach speculative futures in this learning context. Both projects are conceptually deep, self-contained, and consistent, while taking liberties in assuming the world around the direct conceptual scope. It is interesting to note the differences in using AI technology in either speculation or making. The projects share commonalities like a strongly connected team, active reflection in teamwork, and following through on an initial ambitious idea instead of relying on intermediate pivots.

## Discussion

We first reflect on our approach and compare the course design with other education approaches. Then, we discuss the implementation of the course and the limitations of our approach.

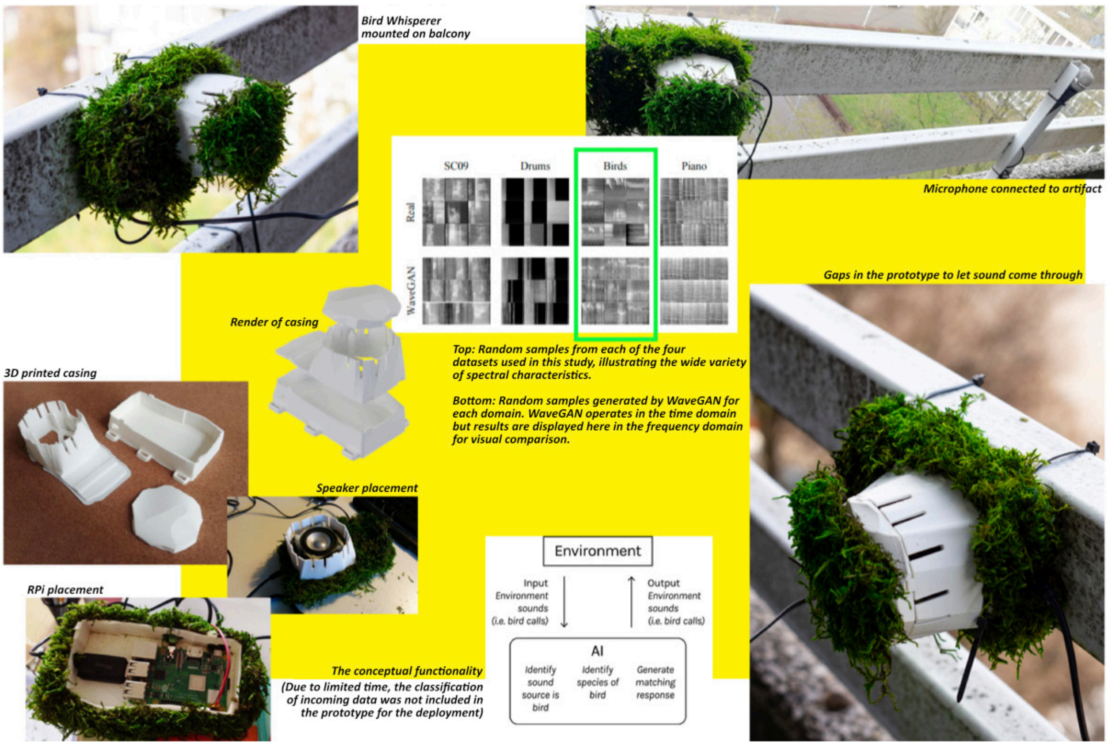



**Figure 6. Bird Whisperer explores a novel interrelation between people and birds.**

## Reflection on the Approach

To our knowledge, we are pioneering a vision-first design exploration approach in an elective Master course in a design program. The AI context and related expectations of students and staff on experiential artefacts made this a challenge after all: first, we had only few education resources to consult. Second, we leave the learning environment open-ended, which enables not only students but also teachers to embrace uncertainty during the process. Third, it is a fundamentally challenging approach to allow students to bring *their own baggage* into the course. Instead of viewing students as blank slates that need to be filled with knowledge, we value and build upon students' diverse strengths, skills, and perspectives. Therefore, we created multi-disciplinary teams to guide the student teams towards interesting results and satisfying learning experiences.

Figure 7 shows the evolution of the course design process. The course started with exploring the inspiration of the disciplinary overlap between Data & Intelligence and Creativity & Aesthetics and kept the visionary focus as an implicit criterion (Figure 7, left side). We specified 12 topics, which are indicated as blue or pink circles in each discipline. Each topic has sufficient depth to set the student teams on a strongly conceptual process with experiential results. Later, the exploration moved toward further development and vision-based design with selected disciplinary components. In the end, design discussions and decisions became more explicitly informed by Personal Inspiration & Vision (Figure 7, right side). While our approach at the highest level aligns with the Attitude, Skills, Knowledge (ASK) model, we argue for a translation for research-based design education, tailored to advanced students facing a complex socio-technical problem space: we translate attitude to *perspectives*, skills to *practices*, and knowledge to *concepts* (PPC). The resulting PPC model can be traced in our design decisions on the course content, execution, and assessment. For instance, we aim to provide our students with perspectives on AI in a future society that link to a strong expression of values. We assign practice-based learning activities to develop essential skills in prototyping with AI technologies, in which we want students not only to align their directions of deepening to their own learning goals, but also to steer the depth to which they navigate as teams. Finally, we provide our students with central knowledge concepts on creativity and aesthetics, and AI/ML technology use, to allow them to navigate the design space confidently. Students can then decide to go further in a particular direction to build expertise that is intentionally beyond the curriculum.

In addition, our post-course findings showed that our approach was successful beyond case analysis. Students' self-reflections revealed that this course and process have broadened their perspectives and equipped them with the ability to engage in meaningful discussion on relevant topics. As one student indicated, "...this course has broadened my sense of the multitude of perspectives...I now am able to take part in discussions surrounding the topic in a more meaningful manner." Another student reported that the approach has transformed their way of managing complexity, "...This process has been enlightening to my own approach on working with complexity..." Moreover, students found that our approach, particularly in relation to the poster-making activities, facilitated them to explore new concepts and technologies. It also enhanced their comprehension of theoretical concepts from both philosophical and technical aspects. They then were able to apply the newly acquired knowledge in practice, as reflected in the comment, "...In the short duration of this course, ...we were able to quickly explore, and get a sense of theoretical concepts (both philosophical and technical), and therefore utilize GAN models despite the fact that most of us do not have any prior knowledge on this subject..." These evidences showed the successful aspects of this approach.

## Comparison of Different Approaches to Teaching Design with AI

We compare our approach to existing AI design education approaches, which are divided into four categories based on nine dimensions (see Table 1, our approach in highlighted cells). The first category, *adapted CS/ML programs*, focuses on education approaches that are grounded in computer science or artificial intelligence curricula, and that let design students approach AI/ML methods and tools in a simplified and narrowed-down way, e.g., by using Python as a comparatively easy-to-learn programming language with readymade datasets, models, and example cases for classification or clustering:

> While designers probably won't become machine learning engineers after taking one course, it gives them the opportunity to get comfortable with using data, learn how to set and improve algorithms, and understand the output enough to be able to evaluate any performance problems. (Andersen, 2019, para. 9)

Such programs aim to teach fundamentals of AI/ML and often follow the traditional structure of technical artificial intelligence programs, certainly taking short-cuts, but with the objective to provide designers

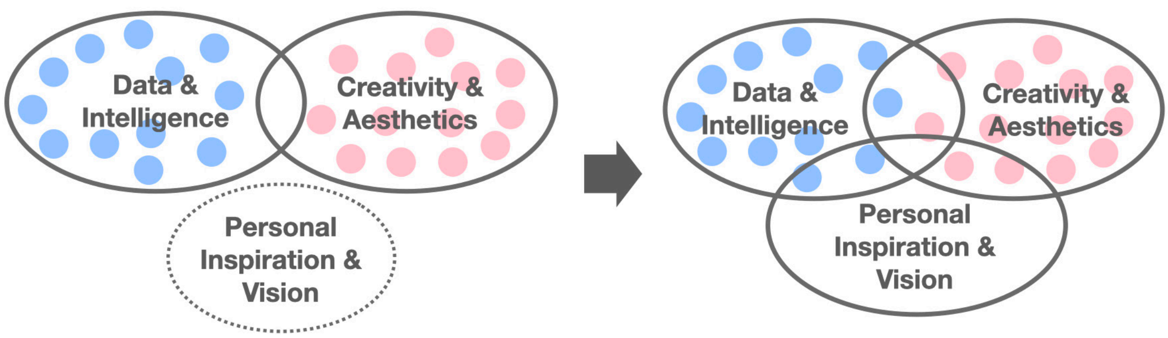



**Figure 7. The course started from the disciplinary overlap toward vision-based design with selected disciplinary components.**

with a mechanistic understanding of the technology, where it can be applied, where not, and facing which risks. A second category, *user-centered with UI/UX focus*, is grounded in UI/UX design curricula addressing AI/ML application as a levelled-up challenge from existing digital applications to design for. This category may follow industrial trends of gradually involving and integrating machine learning in consumer and business application across sectors. On the one hand, design guidelines for AI/ML cater to the perspective of *extending existing design briefs with AI*, and to some extent can help with the decision making. On the other hand, education in this category focuses comparatively much on data visualization, dataful interfaces, and UI-mediated decision-making based on uncertain information. Third, the *artistic design with AI/ML tools* category focuses most on the creative industry and deals with art and design education in the sense of "those who get hands-on experience with AI while in school will have a better understanding of its creative possibilities as well as its ethical implications on culture and society" (Andersen, 2019). Educators in this space

> […] feel it's important for artists, designers, and other creative people to have a seat at the table and figure out what AI systems can do, what risks they entail, and have the willingness to express the possibilities they afford and predict the future by starting to use them as early as we can. (Andersen, 2019)

This education puts students' creativity and vision first, supplying them with a curated set of tools for expression: students "[…] will survey the history and theories behind today's creative AI, analyze the unorthodox approaches that have advanced the field, and experience cutting-edge creative AI tools" (Lim, 2022). AI/ML technology is explored in making and more in what it can produce than what it *is* and how it works. Deconstruction of AI/ML tools and *black box* technology is accepted when it serves concrete individual expression, not for knowledge gain as such. Fourth, the category of *experiential ML-based speculation* takes an entirely different creative approach to AI/ML design education: here, design education takes a technology-speculative turn towards the general capabilities of currently emerging or near-future AI/ML technology. In this approach, design activities not necessarily engage with AI/ML technology in making, but in consideration, speculation, critique, and reflection with a strong societal and ethical focus.

Based on the above overview, we have visualized our own approach as a combination of highlighted cells in Table 1. For instance, we combined a *creativity first, design for expression* approach with *open-ended ideation and speculation, followed by experiential making*; for the employed AI/ML technology, we provided a *broad introduction, then converging to specific models and algorithms*. In other words, our approach introduced a broad spectrum of available techniques, and design students selected and deepened on their own. The envisioned outcomes can be artistic results of creative making with AI/ML technology or more descriptive artefacts; audience experience and engagement are key to high quality outcomes. Moreover, design students focused on selected target users or societal actors, drawing from personal inspiration or related research. We employed *selected data science and ML tools, open-source/ academic, self-built* at the beginning and allowed for self-directed tool choice and presentation approach depending on the design direction: *ideation tools, conceptual design tools, low-fi prototyping, anything-goes*. We also valued the expression of design qualities and creativity more than applicability or algorithmic innovation or originality. The AI/ML technology and concrete making techniques were present throughout the design process, including frequent (moderated) moments of reflection and critique.

**Table 1. Comparison between four approaches.** Our approach is provided in the highlighted cells.

| | Adapted CS / ML programs | User-centered, UI/UX focus | Artistic design with ML tools | Experiential ML-based speculation |
|---|---|---|---|---|
| **Approach** | Model/algorithm first, design for application | Application first, design for users | **Creativity first, design for expression** | **Open-ended ideation and speculation, followed by experiential making** |
| **AI/ML Technology** | **Broad introduction, then converging to specific models and algorithms** | Specific to application, limited | Specific to tools, limited | Unspecified, open, or does not matter |
| **Outcomes** | Computational notebooks, Python, limited interactive prototypes | GUI wireframes and prototypes, mobile apps | **Artistic designs, art-works, installations** | **Descriptive, non-interactive artifacts, movies, scenarios** |
| **Design focus** | Technology | **User** | Artistic directions | **Personal inspiration** |
| **Clients** | **Research** | Commercial | Personal/Societal | **Societal** |
| **Education tools** | **Selected data science and ML tools, open-source/ academic, self-built** | UI/UX design tools, prototyping applications, commercial | Generative and creativity support tools, open-source/ academic | **Ideation tools, conceptual design tools, low-fi prototyping, anything-goes** |
| **Education style** | Lecture-based, content-driven | Coaching-based, application-driven | **Show and tell, open-ended, explorative** | **Self-directed, open-ended, explorative** |
| **Assessment criteria** | AI knowledge and skills | **Design qualities** | **Creativity** | Applicability |
| **Creativity and Aesthetics** | Limited, not a focus | Yes, beginning of process | Yes, various parts of process | **Yes, entire process** |

Returning to our education vision, it is important to note that we are not teaching AI, but *teaching with AI*. We use AI as a carrier to understand what students learned from this course, arriving at a new understanding of AI embedded in design education: We propose to extend the educational design space with respect to AI and ML. As we have explained in the beginning and also in Table 1, design educators have by now several options to build a "*Design + AI"* curriculum, from following the rationale of Computer Science education to more conceptual education to tools-based education. Each of these options projects underlying concepts, educational needs, and educational techniques into the curriculum. While we acknowledge the merits of building onto established foundations or using ready-made tools and materials, we embrace openness for *outcome*, invite complexity of AI technology, appreciate technology depth, and define dimensions for *teaching with AI*. Our vision-first approach has shown that creativity can happen as a diverse form at different stages in the process.

## Vision-Based Futuring Landscape

The six design cases have been assessed separately on the four dimensions (i.e., creativity and aesthetics, technology use, consistency/coherence of design, and design & research process) in a previous section of this paper. When we now plot the six concepts in relation to each other on the three levels of aesthetic value (low to high) and along a time axis that runs from conventional futures towards more progressive futures, we see a landscape with different horizons (see Figure 8).

This landscape can help to answer our question: "How will the new AI technologies and data influence the aesthetics of intelligent products, services, and systems?" It shows three visions:

- **Creating new sensory experiences:** for example, a conversational agent that detects language mistakes and generates emotional reactions to smoothen the language learning experience, or an enchantment of a dining experience using spatial augmented reality and generating personalized projections.
- **Beyond creating a sensory experience:** the use of AI technology can lead to new conceptual designs for everyday experiences. For example, *Breakfast Soundscape* creates a new auditory experience for the user. Beyond that, it can also be viewed as a new conceptual framing of the everyday life of non-human agents, i.e., breakfast objects, such as a knife, plate, and cup, that have a certain independence of their user and of physical reality. *Transire* is a new concept for the grieving experience; a digital service that collects social media data about a deceased person and uses machine learning to generate a synthetic *personality*. This personality is embodied in a new conceptual product, exhibiting an enhanced experience of grief.
- **Critical reflections and a new discourse on ways of living:** this vision is beyond showing new concepts and sensory experiences. *Iden* is designed as more than a new concept, but as an example of a product-service system within a larger system including a commercial company, multiple creators-consumers with conflicting values, and operating both in the physical and virtual domain. The project critically reflects on the commercialization of public-virtual privacy and personal identity in hybrid space made possible through different AI technologies. *The Bird Whisperer* project explores the sensory experience of AI-generated bird songs and proposes a new design concept for an everyday experience of relating to local birds. However, the real aesthetic value

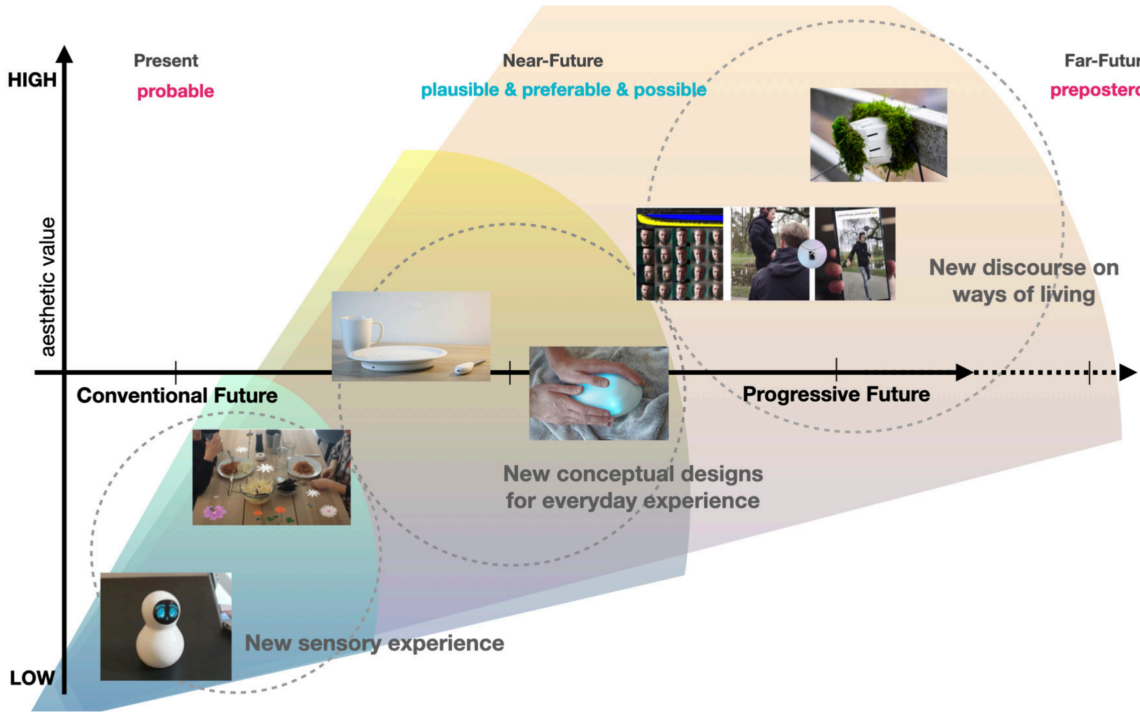



**Figure 8. Vision-based futuring landscape maps out six design cases, from conventional concepts to progressive concepts.**

of the project is in avoiding human-centered design and instead discussing the interrelations between human agents, artificial agents, and biological agents (i.e., birds) and in the exploration of post-human issues around nature-cultures, uncertainty, and care.

The question of "How will the aesthetic values of designers influence the use of intelligence?" is harder to answer. From the annotated posters and the written reflections, we do see that most students' personal aesthetics and values have influenced (elements of) the final design and the use of intelligence. But, as each team consisted of four designers, it is hard to see clear relations on how their values had an influence. The relations that are clear are perhaps also obvious: those with an interest in speculative design, science fiction, and post-human design explore the third horizon, those with more conventional or less defined values tend to stay closer to the first horizon.

## Reflection on the Implementation

We have found several challenges on the implementation of this course, including uncertainty, timing of introducing new knowledge, and coaching direction. Due to the novelty of this approach, we faced challenges in dealing with uncertainty about choosing and preparing learning materials, deciding on open-ended target outcomes, and how to achieve the best outcomes through the deliverables. More importantly, which assessment criteria and methods would guide students towards the best outcomes. We do not know the answer yet and we, as teachers, are still learning from the courses over time.

The timing and the format of introducing new knowledge are difficult to determine. To cover diverse topics, ranging from well-known topics to new ones, we selected several topics with corresponding papers from both CA and MDC disciplines. If introduced too early, students might not be able to relate topics and their own ideas. If too late, the new knowledge might not fit the progress of the design process or delay it.

While we provided extensive materials, support, coaching, and facilities, students could not always translate this into a process of expected intensity. We observed gaps between the complexity of their concepts and the feasibility of the state-of-the-art technology: students struggled in finding a balance between creativity and feasibility towards a convincing futuring story. In the future, we expect to see more creativity to fill this gap and students deepening critical aspects of their concepts to envision progressive visions.

In this course, we chose 10-12 *diverse* knowledge concepts for the two distinct areas. For instance, we focused on a broader range of MDC topics than only machine learning, looking at data collection, crowdsourcing, data augmentation, and symbolic AI. Ultimately, however, students converged to machine learning related topics (e.g., generative models, or interactive machine learning) driven by their interests and a strong sense of relevance. In terms of CA topics, students converged on established and easy-to-grasp topics of Everyday Aesthetics and Aesthetics of Interaction. These topics were used for integration and reflection for Case 1, 2, 3, and 4 (Horizon 1 and 2). The more fundamental topic of Human Values and contemporary topic of Post-Human Design were used in Case 5 and 6 (Horizon 3) respectively. Overall, it appears that CA topics strongly influenced the horizon of the final design.

## Limitations

This paper presents a case study with six exemplars of an education design and course structure supporting experiential speculation with AI. While this approach works well in the context of our educational system, it might not work well in other educational contexts. In our program, design students have developed knowledge and skills from both CA and MDC areas. Moreover, challenge-based learning is a common mode of education, which suits a self-directed learning style for open-ended societal problems. To apply this course design in other contexts, operational modifications and programmatic adaptations might be needed to integrate well with prior learning activities.

We want to acknowledge the heterogeneous student population with diverse skills, backgrounds, and learning goals. The course catered to this particular population, and at the same time relied on it setting the bar relatively high regarding conceptual design skills, experiential making, technological learning ability, and research mindset. Similarly, the lecturer team had different backgrounds in design, engineering, and computer science, and essentially never taught together in this setup. It is fair to say that the mixed backgrounds of students and teachers were very important to the success of the course.

We could expect a reasonable chance of success for the chosen approach because the targeted student population is heterogeneous and consists of students with various interests, from AI and ML technology or user-focused design, to storytelling and futuring approaches. This, and our nudges towards mixed, diverse, and inclusive teams led us to expect successful operationalizations of the approach in education: students would formulate and follow their own learning goals in their team's context and contribute a variety of skills and knowledge to the design cases. This, however, cannot be expected as a given in other design education contexts. Other design programs might deal with a far more homogeneous population, with less interests in getting the machine-learning components to work, with exploring and creatively realizing an initially vague vision.

We have recognized that students lacking knowledge, design experience, and attitudes were struggling with this approach. These students got a conceptual understanding of how AI works in theory and know the limitations of AI in general but could not translate this to a conceptual design of AI concrete enough to be implemented in practice. To resolve this issue in the future, enrolment prerequisites for the course and explicitly guiding the development of narrative design concepts and their practical implementation might be appropriate measures. Also, we could investigate diverse ways of introducing designers to emerging design materials, facilitating more in-depth discussion and learning around topics, and restricting the cope of technology to prevent student teams from getting lost in exploring the complex technology.

## Conclusion and Future Work

Artificial Intelligence will change *how* designers design, *what* they design, and *why* they design. This paper presents two primary contributions.

First, we contribute an alternative approach to extend AI education in design beyond teaching AI concepts and AI practices by integrating personal and societal perspectives, and focus on the creativity and aesthetics of designing-with AI. We discuss the design opportunities of our approach compared to other education approaches. We invite design educators to consider the existing and our alternative approach (Table 1) for AI design education and draw inspiration from our implementation and the exemplary outcomes.

What does this consideration mean for AI education integration in a design program? The breadth and depth, and rapid development of AI and ML technologies can be challenging to keep abreast of in technical education. Much less so, in a design program. As responsible design educators, our role is to distill the essential AI/ML concepts and practices for design, contextualizing them in a societal and personal perspective. This takes time and multiple iterations. We present our choice for AI concepts and practices, and invite other design educators to explore and share their own iterations and alternatives of teaching AI in design.

Second, we contribute a novel futuring landscape with a first set of AI design exemplars that could be used to facilitate designers in envisioning possible scenarios from conventional futures toward progressive futures and discussing the aesthetic values of these concepts at various levels. We invite design researchers to further populate the futuring landscape with their exemplars, and jointly explore values and visions for the future.

In this paper, we showcase examples of what designers design relating to why they design, and we discuss how the futuring landscape could be used to support the exploration of the possible design scenarios with data and AI technologies. However, we consider the complex topic of *how designers design* when using data and AI as design materials to be outside the scope of this paper. Further research is needed to delve into the methods or tools that facilitate designing with AI with the integration of creativity and aesthetics, and to shed more light on the underlying qualities and principles of aesthetics of intelligence.

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## Endnotes

1. In the paper, when we use 'designing-with AI' we refer to AI in the broad sense including its technologies, tools, and the related concepts.
2. Video of Case 3: Breakfast Soundscape. https://youtu.be/xTHDVC10j4Y
3. Video of Case 4: Transire. https://youtu.be/Hn0resIjdVU
4. Video of Case 5: Iden. https://www.iden-ai.nl/
5. Video of Case 6: Bird Whisperer. https://vimeo.com/530194266
6. WaveGAN. https://github.com/chrisdonahue/wavegan

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