Steffen Mitschelen and Natalie Weinmann

Dialogues with the Unknown
Exploring the role of the unexpected in design processes through generative AI tools

Artificial intelligence (AI) has suddenly entered our everyday lives. Whether we use smartphones, browse websites, or shop online, we frequently interact with AI, often without being aware of it. Moreover, in professional domains like design, a variety of new tools has emerged, allegedly simplifying, enhancing, amalgamating, or supplementing processes and outcomes. This evolution prompts questions about the future roles of designers. Several AI-based tools have recently gained public attention, some of which hold significant promise for designers. First, image generators have captivated the design community by effortlessly producing high-quality images based on textual descriptions. This innovation streamlines the visualization of ideas, objects, or contexts, allowing for the creation of specific atmospheres in diverse graphical or photographic styles. Second, large language model-based chatbots offer an intriguing prospect, as they use familiar conversational language to assist in improving, summarizing, altering, or even generating textual content. Given that many designers are very good at social interactions but may struggle with writing, chatbots offer them a user-friendly approach to content creation.

In principle, all of these AI tools work in similar ways. First, large amounts of training material – either text or labeled images – are analyzed for contextual and formal relationships. Based on these findings, a data model is created that can then be searched for the

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inherent relations between this content. The model thereby forms a closed space of possibilities that allows for the creation of new artifacts based on its logic. Although it would naturally be possible to experiment with the possibilities of the technology itself, most designers are bound to encounter such systems in the form of the products of large companies. Designers using such tools are thus mostly limited to moving inside of these boundaries. Interestingly, the tools that are currently available and that are already making major waves in the industry are mostly not specialized software for specialist areas but are general-purpose tools. They were not developed for specific use cases but are technological demonstrators that are intended to give an initial impression of the possibilities that such technologies can offer. The development companies seem to be primarily interested in the collection of data about the areas of application found by their users, which explains the partly uncontrollable outcome; for example, in the form of generated images.
When designers engage with these novel and largely unfamiliar tools, they most probably approach them with preconceived notions about how to use them and a belief in supposed classifications of right or wrong outcomes. However, working with AI fundamentally differs from working with conventional design tools. This raises the question of how such tools will impact the design discipline in the long run: How do they affect design processes? How will they change our understanding of the design praxis in general?

This paper reports on a workshop in which the relationships between users and tools were addressed on multiple levels to approach such fundamental questions. The workshop was part of a series of design foundation course workshops at the Coburg University of Applied Sciences and Arts. It dealt with the topic of seeing and perceiving. The workshop was jointly conceived and conducted by the authors. In preparation for the workshop, one week in advance, we introduced image generation using AI tools. Next to showing state-

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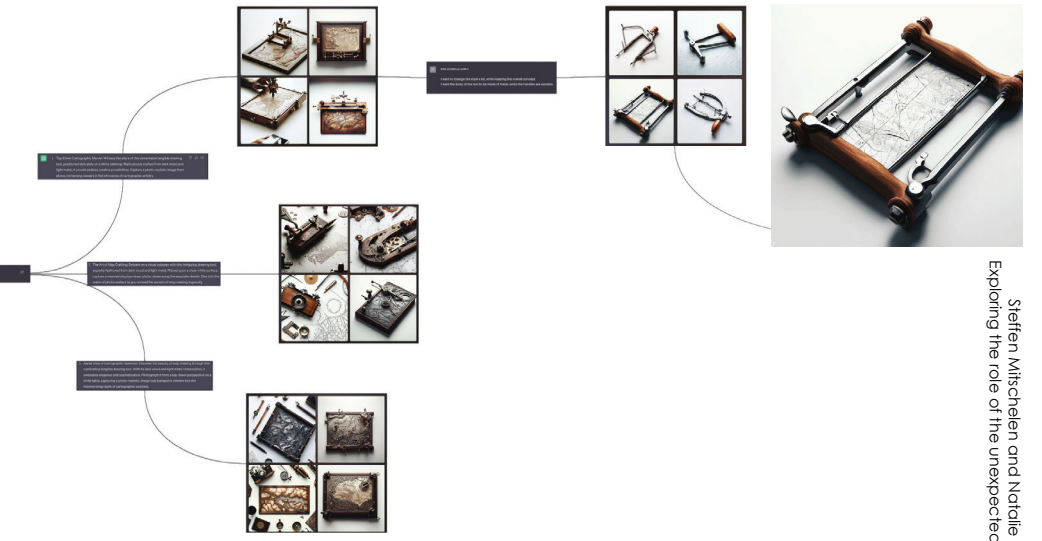
of-the-art examples, the question was discussed as to why generated images could be understood at all, even if the things depicted do not represent any real objects. Subsequently, the students were introduced to a technical pipeline that they were supposed to use in the workshop: a combination of Open AI's text generator ChatGPT[1] and Microsoft's Bing Image Creator.[2] ChatGPT was used for generating textual descriptions of objects which then served as input prompts for the Bing Image Creator. Both tools could be accessed easily and free of charge via the web browser. Their combined use allowed for a dialogical interaction between students and tools, in which images could be gradually developed in the form of a conversation between the students, ChatGPT, and the visualized text outcome by Bing. Similar workflows were since then added to the standard functionality of both, ChatGPT[3] and Bing's own Chatbot.[4] This highlights the importance of the timing of our experiment, which might already be perceived in completely different ways today.

The pipeline used for the workshop. It utilizes the combination of ChatGPT and Bing Image Creator to create generative images in a conversational situation. The steps oscillate between text inputs and image outputs.



1 "ChatGPT," accessed September 27, 2023, https://chat.openai.com
2 "Bing," Bing, accessed September 27, 2023, https://www.bing.com/create
3 Will Knight, "OpenAI's Dall-E 3 Is an Art Generator Powered by ChatGPT," Wired, accessed September 27, 2023, https://www.wired.com/story/dall-e-3-open-ai-chat-gpt/
4 Yusuf Mehdi, "Create Images with Your Words - Bing Image Creator Comes to the New Bing," The Official Microsoft Blog, March 21, 2023, https://blogs.microsoft.com/blog/2023/03/21/create-images-with-your-words-bing-image-creator-comes-to-the-new-bing/

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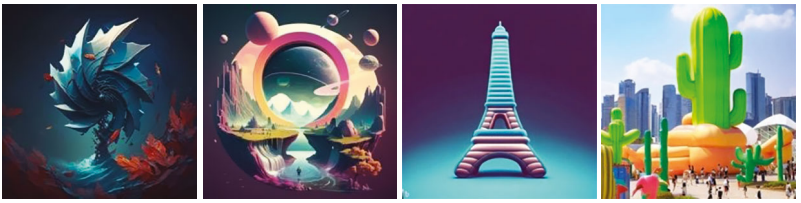
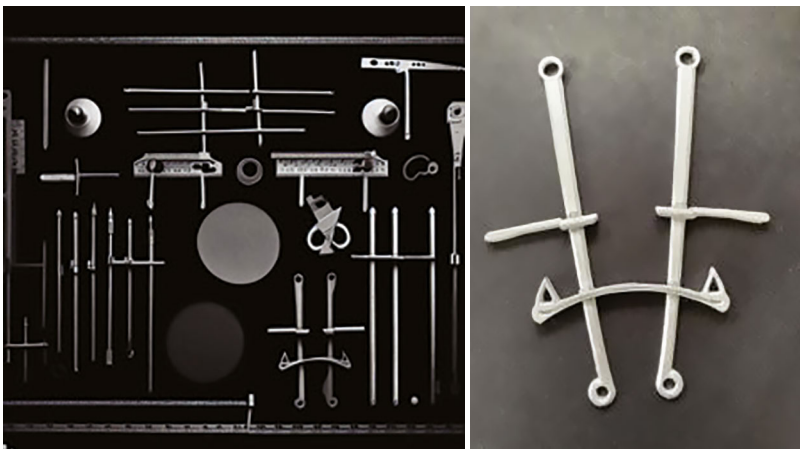
By offering this introduction in advance, we ensured that all students gathered their first experiences working with AI generators one week ahead of the workshop. We thus tried to minimize the number of technical difficulties during the workshop, which was important for us, as we planned only one day for the workshop.



Examples of the diversity of image styles that arose in the first experiments of the students with the pipeline.

The workshop itself took place on the second of June 2023, in the maker space Creapolis at the Coburg University of Applied Sciences and Arts.[5] It was conceived for students from the fourth semester of the Integrated Product Design program, and nineteen students participated in total. The workshop comprised two parts, in which students worked together in groups of two. In the first part of the workshop, the students were assigned the task of 'generating a picture of an unusual and interesting analog graphic tool' using the AI pipeline



A first experiment for the two parts of the workshop created by the tutors prior to the workshop. What could it possibly be good for?!

5 "CREAPOLIS Coburg: Connect - Create - Innovate," CREAPOLIS Coburg: connect - create - innovate, accessed September 27, 2023, https://www.creapolis-coburg.de/.

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described above. In the second part, each group then needed to build a quick functional prototype of their generated tool. Here, the focus was on the question of what the generated tools might possibly be good for. For this purpose, various materials and tools were available to the students via the maker space. In addition, in order to encourage diversity in the results, we also provided them with various colors, pencils, and inks that could be used with their individual prototypes to create graphics. The students had three hours for each of the two parts. As a final submission, each group had to hand in a final text prompt and the associated generated image, a photograph of their functioning prototype, a test graphic that was made using their prototype, and a sketch highlighting and naming the main components of their tool. At the end of the day, we concluded the workshop with a quick round of presentations.

The students in the maker space Creapolis.

In the following, the workshop will be reflected based on the two different research interests of the authors. In the first part, 'How do tools speak to us?' Steffen Mitschelen explores the question of how tools suggest and transport actions. How do their functions reveal themselves to their users? Why can they be used at all? In what way do they speak to us and are thus involved in our thinking about design problems? This first part explains how the workshop was conceived to tackle such questions using a method the author calls meta-tools. It also explores some of the students' results and discusses differences in their strategies for finding solutions.

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In the second part, 'A dialogue with the unknown,' Natalie Weinmann delves into how students perceive unfamiliar tools and unknown approaches during this workshop. It explores the impact of aspects such as theoretical and practical knowledge, past experiences, control, ingrained routines, and met or unmet expectations on students' actions from a retrospective perspective. This second part is primarily based on memories of students, conceived through semi-structured interviews, and complemented by observations made by the tutors during the workshop.

Part one: How do tools speak to us?
by Steffen Mitschelen

> *We live in a world filled with objects, many natural, the rest artificial. Every day we encounter thousands of objects, many of them new to us. Many of the new objects are similar to ones we already know, but many are unique, yet we manage quite well. How do we do this? Why is it that when we encounter many unusual natural objects, we know how to interact with them? Why is this true with many of the artificial, human-made objects we encounter?*[6]

The objects around us seem to speak to us, enabling us to go about our daily lives. They give us clues as to what they might be suitable for, what could be done with them, and what we must not do with them. A tree may suggest us climbing. A chair suggests sitting. And the red color of an active hotplate suggests that we would be better off not touching it. It is suggestions like these that psychologist Abraham Maslow refers to when he writes that it is "tempting, if the only tool you have is a hammer, to treat everything as if it were a nail."[7] The hammer speaks to its user, suggesting a solution that seems to be stored inside it. It issues instructions for action, namely hammering in some nails. As humans are creating tools to solve certain classes of problems, it is evident that applying any tool to a new problem means finding applications for already established procedures in new situations. Tools can thus be characterized as giving form to prefabricated solutions. Their suggestive nature guides us through their application. They are telling us how to deal with the unknown.

6 Donald A. Norman, The Design of Everyday Things, Revised and expanded edition (New York, New York: Basic Books, 2013), 10f.
7 Abraham Masslow, The Psychology of Science: A Reconnaissance (Chapel Hill: Maurice Bassett Publishing, 2002), 15.

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In design, this relationship holds a special position because design, by definition, always deals with (at least partially) unknown problems and situations. For example, an architect may have the task of finding the as-yet-unknown shape for a building, while a UX designer may have to come up with a coherent experience that satisfies his only vaguely defined user group. At the same time, design processes cannot take place without the use of design tools. I define design tools here as closed material systems that can be manipulated to create or represent artifacts. They translate design problems into tangible realities, making them processible for designers.

As the design theorists Rittel and Webber highlighted, there is never one right solution to any given design problem.[8] They described such problems as wicked problems, pointing to the fact that their solutions could take an infinite number of different forms depending on which requirements are considered. Different solutions to the same design problem may even be contradictory or may lead to completely new problems! Here, the importance of a reflective handling of the suggestive character of design tools becomes very clear: different design tools will suggest completely different approaches to the same problem, which, in turn, will lead to completely different results. The architect may arrive at a very different shape for his building if he starts with pen and paper than if he uses a CAD program. The UX designer considers different aspects of his design to be important while creating an interactive prototype compared to a static one.

In this context, my main interest in the workshop was to reflect on how (design) tools speak to their users. How do they store and convey their contents? How do they suggest certain actions? And how are they guiding us in the development of solutions? Our workshop offered an experimental approach to such questions, using a method I call meta-tools. Meta-tools are experimental settings that focus on individual properties of design tools and make them tangible through experimentation. They are simultaneously applicable design tools and tools for thinking about tools.

In the first part of this chapter, I will outline the theoretical framework on which the workshop was built. It offers an insight into the suggestive nature of tools from an interface design perspective. In the

8 Horst W. J. Rittel and Melvin M. Webber, "Dilemmas in a General Theory of Planning," Policy Sciences 4, no. 2 (June 1, 1973): 155–69, https://doi.org/10.1007/BF01405730.

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second part, I describe how the idea for the meta-tools was developed based on that. In the third part, I will go over some of the results that the students came up with during the workshop that show different strategies in their approaches. To conclude the first chapter of this paper, I will summarize some aspects of the experimental setting that I found particularly fruitful.

Affordances, signifiers, and mental models

In his 1979 book 'The Ecological Approach to Visual Perception,' psychologist James J. Gibson captures the suggestive nature of the things surrounding us under the term affordance. According to Gibson, the affordance of an object is "what it provides or furnishes, either for good or ill."[9] Cognitive scientist and usability engineer Don Norman later built upon Gibson's concept, making it suitable for design. He highlights that affordances are not simply attributes that could objectively be found in the things around us. He rather describes them as relationships established between individual users and objects. He defines: "An affordance is a relationship between the properties of an object and the capabilities of the agent that determine just how the object could possibly be used."[10] Norman focuses on the fact that different things may suggest very different actions to different users: "A chair affords ('is for') support and, therefore, affords sitting. Most chairs can also be carried by a single person (they afford lifting), but some can only be lifted by a strong person or by a team of people. If young or relatively weak people cannot lift a chair, then for these people, the chair does not have that affordance, it does not afford lifting."[11] Affordances differ not only based on physical differences. Knowledge, cultural imprints, and personal experiences all play an equally important role. Looking at an unknown traffic sign does not afford the required actions. To someone who has never surfed the web, an underlined word would not afford to click. And while the glass pane of a bus stop may afford shelter to passengers, it may afford demolition to hooligans. Norman summarizes: "An affordance is a relationship. Whether an affordance exists depends upon the properties of both the object and the agent."[12]

9 James J. Gibson, The Ecological Approach to Visual Perception: Classic Edition (New York: Psychology Press, 2014), 119, https://doi.org/10.4324/9781315740218.
10 Norman, The Design of Everyday Things, 11.
11 Ibid.
12 Ibid.

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The properties on the object's side, Norman calls signifiers. Signifiers are objectively present in each object. They are "signs, perceptible signals of what can be done."[13] They can send signals through all perceptible properties of an object. Functions can thus be indicated by means of all available attributes of a chosen material, such as shape, weight, size, color, sound, etc. Signifiers are the part of an affordance relationship over which designers have control while designing an artifact. Using interface design terminology, the properties on the agent's side can be described as mental models. Mental models are subjective systems of belief that each individual person holds. They determine how a user interprets the system of signifiers of a given object. Interface design luminary Jakob Nielson defines: "A mental model is what the user believes about the system at hand."[14] A mental model fuels a user's expectations of how a system behaves and leads them to approach it in certain ways. Nielson emphasizes: "A mental model is based on belief, not facts: that is, it's a model of what users know (or think they know) about a system such as your website."[15] Mental models, in contrast to the signifiers of an artifact, are never fixed. They change along with the users' experiences and learnings. A simple example of an affordance relationship between signifiers and mental models can be found in the design of doors. Every one of us has built a concept (mental model) of whether to push or pull (affordance) a door when looking at its knob or handle (signifier). And every one of us also knows the feeling of being disappointed by such assumptions.

In the following, I describe the idea for the meta-tools of this workshop and how they were conceptualized to reflect on the affordance relationships we form with tools.

AI excavations

As explained above, well-defined tools utilize clear signifiers to tell their target user group what they are made for and how they could be handled. They address their mental models, affording them the applications of certain types of actions. To enable the students to reflect on such relationships, the initial idea for the workshop setup was to

13 Ibid. xv.
14 Jakob Nielsen, "Mental Models and User Experience Design," Nielsen Norman Group, accessed September 20, 2023, https://www.nngroup.com/articles/mental-models/.
15 Ibid.

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A series of generated tools that were created during the preparation for the workshop. Each of them clearly contains signifiers that afford certain ways of handling them. As the image prompts were very detailed descriptions generated with ChatGPT, the generated images proved to be equally detailed.

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experiment with tools that no one intentionally designed and, for that reason, obviously do not carry any intended functionality. This is where the AI generators came into play. When asked for images of tools, the Bing Image Creator produces some interesting results. Most of these images can immediately be recognized as showing some sort of tool. The reader will recognize familiar elements within them, such as handles, scales, adjustable angles, drawing tips, knife blades, etc. However, their purpose remains entirely unclear. Of course, this is true because they have no purpose. The associative power of the general-purpose image AI – which was not specifically trained on the individual parts of tools – simply assembles visual elements, each of which can often be found in tools. What we are looking at here are collages of common signifiers that have been arranged and combined in uncommon ways. Interestingly, that is already sufficient to arouse curiosity: How do the depicted tools work? What are they made from? What could they be good for?

The idea of using unfamiliar elements to reflect on affordances and mental models in the application of tools was directly inspired by another discipline interested in such questions, namely experimental archaeology. Experimental archaeologists are dealing with excavated artifacts and ask themselves how they might have been used in the past. Their practice is "the use of controllable, imitative experiments to replicate and/or simulate past objects, materials, processes, behaviors," etc.[16] Experimental Archaeologists are looking at ancient tools to develop a plausible theory for their purpose. To test their theories, they take an experimental approach. If they want to know – for example – whether certain materials could have been worked on with a stone axe, they simply try it out. For this purpose, they would go and build a replica of the axe to put it to the test.

What is interesting in the context of this paper is not only, that experimental archaeologists clearly reflect on signifiers. Moreover, they reflect on them from a certain perspective. To form a plausible theory of how a stone axe would have been used, it is first necessary to come up with a plausible mental model of a caveman. The archaeologists Fox et al. summarize: "Starting from this perspective,

16 Heather Margaret-Louise Miller, Archaeological Approaches to Technology (Amsterdam, Boston: Elsevier/Academic Press, 2007), 34.

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it is not only necessary to examine several possible applications offered by the materiality of the artifact. Rather, it is also a matter of determining exactly which of these applications fits into each social context."[17] Such a twofold reflective behavior was the intention underlying the workshop.

Similar to the archaeologist, while working with the generated images and on the functional prototypes of their tools, the students had to constantly reflect on both the signifiers in the images, and their mental models that led them to see certain functions within them. The second point was emphasized by the fact that the students had to work in groups. Discussions regarding the usefulness or uselessness of the individual results and their potential applicability quickly developed among all groups. To agree to an approach, they needed to consciously adapt their mental models throughout the generating, prototyping, and testing of their tools. The resulting mental models are particularly evident in the labeled sketches of the tools the students had to hand in. On those, it becomes visible which signifiers of the initial images came out to be the most relevant throughout the process, how these were interpreted, and what aspects they ignored. Next, I review some of the results and describe some interesting observations I made there.

Exemplary results

In the following, I go over the results of four of the groups. Each of them illustrates a different approach that was taken in the interpretation of the generated images. These approaches to interpretation are (1) Function-, (2) Aesthetic-, (3) Mechanism-, and (4) Material-oriented. They led to very different affordance relationships between the students and their generated images. They strongly influenced the prototyping processes, the students' priorities in their results, as well as the possible usages of their finished tools. These examples highlight differences in the mental models of the groups and how these mental models were steering them through the workshop.

17 Richard Fox, Diamantis Panagiotopoulos, and Christina Tsouparopoulou, "Affordanz," in Affordanz (De Gruyter, 2015), 69, https://doi.org/10.1515/9783110371291.63.

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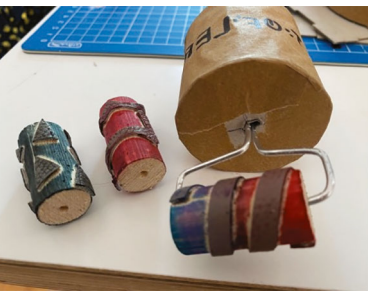
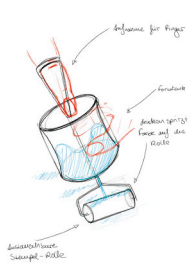
1. *Function-oriented interpretation: The T:OF:LER*




From left to right: The generated image, the first prototype, and two of the patterns created by using exchangeable rolls.

During the generation phase with ChatGPT and Bing, the group quickly decided on a certain functionality they wanted to create. They chose to opt for the combination of two tools with which they were already familiar, namely ink rolls and stamps. They used the pipeline to ascertain what such a combination could look like by asking the AI tools for very specific things. The generated image that they came up with shows some kind of roll that gets pushed over a surface covered in uniform patterns.

While the roll in the picture does not seem to contain any sign of a pattern, their initial idea guided the team to read the picture as if the roll would leave a trace of regular patterns behind. In the prototype they built later, this function was at the center of their attention. Their self-set mental model strongly influenced their interpretation of the found signifiers. The implementation in the final prototype was achieved by gluing cut-out pieces of leather to an old cork. The students' idea about this functionality was so strong that they even created a variety of exchangeable stamp rolls that could be used to produce a variety of different patterns.


From left to right: The exchangeable rolls, the schematic drawing of the tool, and a second, more advanced prototype.

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Their focus on the creation of patterns made other aspects of the image fade into the background. Until the very end, they were unsure what the large cylindrical element at the center of the tool could possibly be good for. They started talking about it long after the prototype was finished, as they found it to be rather annoying for their function. They decided that, in the next version, it could be an ink tank that could be squeezed to drip ink on the roll. They captured this idea in their sketch of the tool and implemented it in a second prototype that they built after the workshop.
The name of the tool started as a joke. The image generators back then often included broken-looking text fragments in their results. In one of their generated images, the students found the word 'T:OF:LER.' What started as a joke, the group quickly adapted as a name when they were talking about their tool. The way in which they made use of this is a good example of how even unassuming signifiers can be loaded with meaning when they are found and interpreted by the right mental model. Ultimately, all generated results only become meaningful when they are considered.

2. ***Aesthetic-oriented interpretation: The Octopen***

From left to right: The generated image, the prototype, and a resulting test graphic.

This group was instantly mesmerized by the sci-fi look of their initial generated images. The unusual visuals that they were able to create using the AI pipeline guided them throughout their entire process. While they very much liked their results, it took them some effort to come up with something they could consider to be a graphic tool in the broadest sense. Therefore, at one point, they started to write their image prompts by themselves, relying on keywords that they found to

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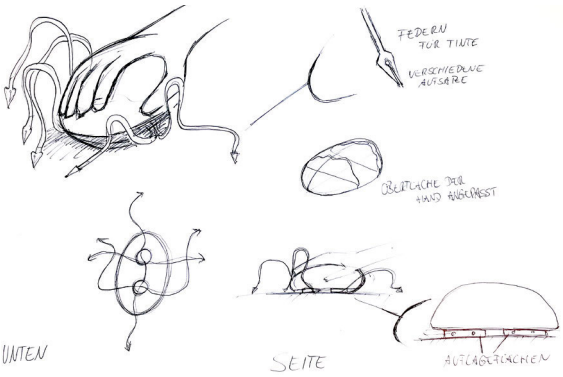
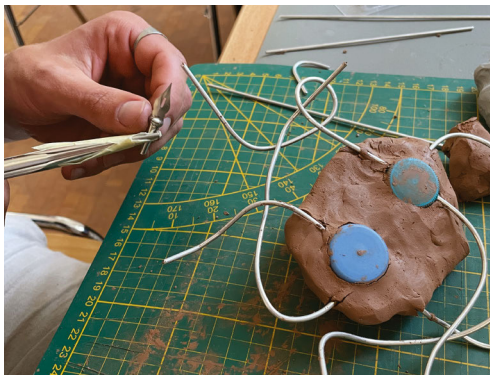
be useful in working with ChatGPT to generate the desired look. After they generated their final image, their work took a very associative character. The elements of the image were interpreted as organic tentacles, which led them to refer to the tool as a kind of octopus pen, hence the name 'Octopen.' They thought of it as crawling across a sheet of paper, leaving behind a trail of ink. This inspired them to think of the arms or tentacles as somehow mechanically moving, spitting ink from their tips. The body then would act as a container for the ink.





From left to right: The schematic drawing of the tool and a scene of the material prototyping process.

Nevertheless, aesthetics and ergonomic considerations were more important to them during the prototyping process than the implementation of any mechanisms. For that reason, they created a rather ridged structure from clay and wire for the prototype. As they assumed the object could be held and pushed around pleasantly with one hand, its clay body became reminiscent of a computer mouse. At the end of the wires, they attached ink feather tips. To test the prototype, each tip needed to be inked up individually. The wires could be bent as desired to create different patterns while pushing the tool over the paper. Based on different patterns that the different configurations of the tentacles could produce, the group continued to discuss what possible movement for the tentacles would be desirable for the next version of the tool.

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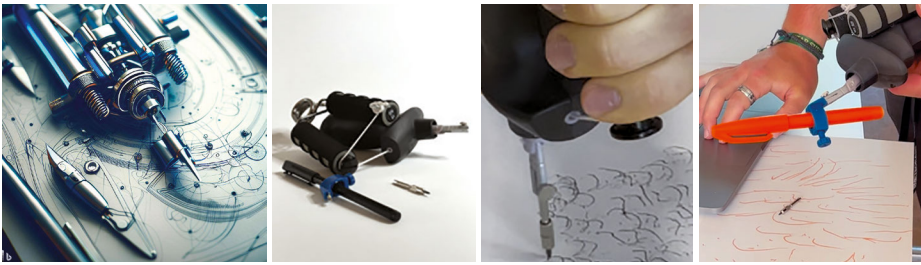
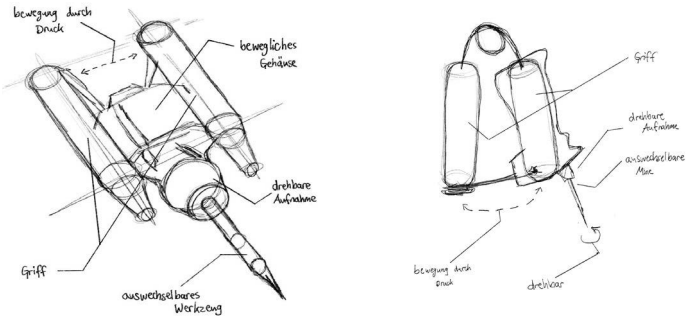
3. *Mechanism-oriented interpretation: The PressPen*



From left to right: The generated image, the prototype, and the creation of different patterns using the tool.

This group generated the final image of the tool that they ended up using very early during the first few minutes of the workshop. While they kept on generating further images for a little longer, they always returned to their favorite one. They were fascinated by the results' mechanical character, which guided them in the interpretation of its signifiers. While the picture also contained aesthetically interesting features, like different materials, corrugations, or even a drawing beneath the tool, they focused exclusively on the mechanical characteristics that the image afforded to them.

In their first sketch, they captured the mechanism they found. Here they agreed on the idea that the tool needs to be squeezed together.



On the left: An analytic sketch of the mechanism of the generated image. On the right: The schematic drawing of the final prototype.

This action would then trigger a rotational movement in an interchangeable pen tip on the front of the tool.

I was quite fascinated by how they approached the prototyping

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of this functional structure. They went to a non-food-discounter near the university and returned with a few different products: a finger trainer that was reminiscent of the squeezing movement, a toy propeller launcher that contained the circular motion they were looking for, and a drawing compass, that represented the mechanism of interchangeable pen tips. They then disassembled these objects and put them together to form their prototype. A second sketch they made after they finished the prototype shows a similar mechanism, to what they found in their generated image but in a completely different form factor. They were so engaged in creating the mechanism that until the very end they had no clear idea what a possible application for their prototype could be. They joked that this tool and its seemingly uncontrollable character would be their drawing teacher's nightmare. However, when they tested it, both students were quite delighted by the unexpectedly wide variety of quick pencil patterns that could be created with it. These patterns differed depending on the way the tool was held and which tip they attached to it. Based on the mechanism, they named their tool 'PressPen.'

4. ***Material-oriented interpretation: The Chaint***

From left to right: The generated image, the built prototype, and a test graphic produced with the tool.

Both members of this group were connected to us via Zoom and thus had no access to the materials and tools in the maker space. The fact that they were limited to the things they had at home led them to adopt an interesting upcycling approach: they asked ChatGPT for a list of household items that could be used with paint or ink to create interesting graphics. From the list they received, they decided to go with a combination of two of the suggested things, namely a sweep and an old bicycle chain. They stated that they went along with these two things, as they happened to have them both available.

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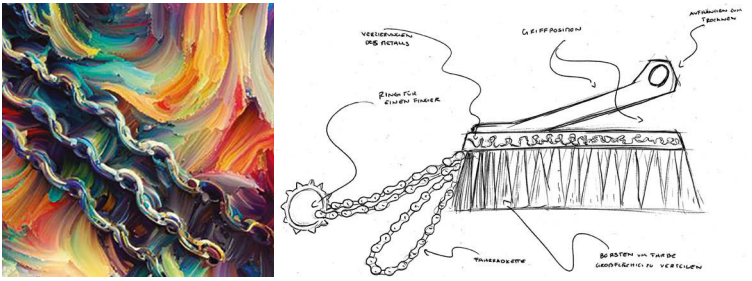
Taking those two elements as a base, they started to generate images that were combinations of them until they received a result that they found to be interesting and interpreted as tool-like.
As they were still unsure about how that tool could be applied after they finished building it, they took an interesting additional step: they asked ChatGPT for an image prompt that would create images of what results could come out when using their tool. Based on these graphics, they built their mental model of how the tool could be handled, which became visible in their schematic drawing. They did that by trying to figure out how to handle the tool to come close to the generated visuals.



From left to right: A generated visual of a possible result and the schematic sketch of the group that tries to ascertain how to handle the tool to come to such a result.

The students then went on and put their theories to the test. Therefore, they applied paint to a piece of paper and distributed it in different ways using their tool. While they seemed to be slightly unsatisfied with the graphics that they could create with their prototype in comparison to the computer-generated ones, I found this approach to be very inspiring. The reconstruction of a graphic tool – starting from a goal image – could be an entire meta-tool workshop on its own.

Concluding thoughts on the workshop

Tools speak to us by addressing our mental models through signifiers. Thereby, they afford certain ways of use that lead to different approaches to problems. The presented projects highlight how affordance relationships between users and tools are established and how such relationships form our expectations towards the tools we are using. The workshop can be understood as an intervention to classical design processes. By reversing the usual design paradigm of 'form follows function' to 'function follows form,' it focuses on the impact of affordances on problem-solving behavior.

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The process clearly showcased the importance of the designer's interpretation skills. This offers a hint about what the design discipline may look like in the future and how it may remain relevant in a world of generative AIs. One could even argue that the designer's ability to make sense of unknown situations and objects becomes increasingly important as increasingly more things become generatable. To sum it up with the philosopher of technology Don Ihde: "A technological object, whatever else it is, becomes what it 'is' through its uses,"[18] and – I would like to emphasize – through its users. This is one way of harnessing the potential of AI technologies for the creation of new things and to escape the repetitive nature of generative technologies. To conclude this chapter, I list some aspects of the planning and implementation of the workshop that I found particularly fruitful, both in preparing the tasks and in encouraging reflective behavior among the participants. Aspects 1-8 can be considered patterns that could find their way into the planning and implementation of further meta-tool workshops. The last three points (9-11) describe some further ideas, that emerged during the workshop, and that I would propose for further experimentation.

1. In the preparation of the workshop, the simple *theoretical framework* of signifiers, mental models, and affordances was very useful in outlining a clear goal for what exactly should be reflected on. It also made it very easy to talk about image generators and what they produce.
2. The *working metaphor* of experimental archaeology proved to be a great way to simply convey the theoretical framework and set the tone of the workshop. It provided an intuitive understanding of a process that could otherwise have been somewhat confusing for the participants.
3. The relatively *open task* that simply asked for an unusual analog graphic tool forced the students to think about their own mental models and presumptions.
4. The same was true for the *atmosphere* of the maker space and the wide variety of equipment and materials available there. It encouraged the students to make informed decisions about what tools and materials to use.

18 Don Ihde, Technology and the Lifeworld: From Garden to Earth, Nachdr., The Indiana Series in the Philosophy of Technology 560 (Bloomington, Ind.: Indiana University Press, 1996), 70.

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5. Thereby, the *pipeline* of the two chosen easy-to-use but at the time difficult-to-control AI tools, ChatGPT and Bing, kept the tasks very free yet subject to explicit constraints.
6. The fact that *interpretation* was a necessary part of all of the steps of the process promoted discussions among all participants. This encouraged reflective behavior in all design decisions.
7. The short *time frame* for the individual tasks, in combination with the clear requirements for what had to be submitted at the end, let the focus on decision-making. This was useful as it strengthened the students' sense that there would have been alternative paths along the way that were not taken.
8. I found the *schematic drawings* particularly insightful. The labeling of parts offered a good way of visualizing the reflective processes of the students. This could have been thought further; for example, by letting the students write a manual for their tools.
9. If we had had more time on a second day, it would have been very interesting to ask the students to tackle a *unified design task* with their new tools. This could have been used to reflect on the different solutions that their tools suggested to the same question (e.g. design a promotional poster for your study program).
10. The tools could also have been evaluated further by *exchanging the tools* between the groups and letting the other groups work with them. This could have revealed how their understanding of them differed and what could have been learned from that.
11. As highlighted above, the process of *starting from a final graphic* that the 'Chaint' group generated prior to producing their prototype could be the foundation of a future workshop.

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Part two: A dialogue with the unknown
by Natalie Weinmann

> *Maybe it was also a kind of debate to be honest. In the beginning, you want to say what you want to get rid of or what you think is the right opinion … But then somehow there is a counterattack or a completely different opinion and then you try to respond to it again and then you always respond to the other person or non-person. Then maybe in the end you have reached a compromise through the result that we have chosen. Or worked out. Developed.*[19]

The introductory quote comes from a design student who reflects on her experiences during the workshop six weeks later. It captures her perception of the workshop process, emphasizing the effort needed to master the unfamiliar tools to create desired outcomes. Her description of the process goes beyond tool usage, resembling a social interaction, evident in her use of terms like 'debate' and 'opinion' to characterize her interaction with the AI. This not only raises questions about how designers approach new and unknown tools but also sparks curiosity about their experiences and recollections. This chapter delves into specific memories of two participating students, aiming to unravel the significance of retrospection as a valuable teaching tool in design education.

My motivation in this workshop was to provide students with an initial encounter with unfamiliar tools in a playful manner, creating a secure environment for them to explore the tool's limits and possibilities experimentally. This engagement was facilitated through a dialogical interaction with both the tool and the team partner. Post-workshop semi-structured interviews were conducted to explore the students' remembered experiences and enable retrospection. This additional information, unattainable through observations alone, centers on the students' individual perspectives and memories, enriching our understanding of their viewpoints and the situations they encountered. The dialogical nature of the interviews, akin to a trialogue involving the two students and myself as one of the tutors, contributed valuable pedagogical insights.

In the initial section, I will provide various examples to illustrate the students' recollections concerning their encounters with unfamiliarity throughout the process. Subsequently, I will delve into

19 Nadja, Student, Interviews by the author. July 2023.

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the students' perceptions of unknown tools and their interpretation of a 'typical design process.' In addition, I aim to discuss key aspects of the workshop, including issues related to control or lack thereof, past experiences, ingrained routines, expectations, the overall workshop setup, and how students navigate emotions and feelings in the design process. In conclusion, I will outline the research's limitations and implications, emphasizing valuable insights. Finally, I will emphasize the need to align higher education with future demands when encountering unfamiliar tools, proposing self-reflection formats as a transformative academic approach.

Dialogues

A crucial element in this workshop was the dialogical exchange, necessitating students to engage with AI programs in a dialogical manner. The initial phase of the workshop mirrored a sparring process among humans, involving dialogical communication, occasionally entailing disputes, as noted in the preceding quote. Students had to discover how to interact with these programs, first through chat with ChatGPT and subsequently by allowing Bing to generate images with limited control. Upon reviewing the written conversations students had with ChatGPT, one might easily mistake them for interactions with a real person. Polite phrases like "Dear ChatGPT. I need … Please give me …" marked the beginning of conversations, reflecting an anthropomorphic interaction. Don Ihde categorizes this relationship between students and technology as an alterity relation, making them encounter "the otherness of technology."[20] Their approach was shaped by experiences in conversational interactions with humans, given that ChatGPT's user interface resembled that of conventional chat programs. A participating student, without any experience in using AI programs, remarked:

> *The first words with the AI were completely strange. I really thought I was chatting with someone somewhere else in the world. Because I was polite, and this AI also answered me politely, and that was a very, very creepy feeling.*[21]

In this human-technology dynamic, this student also recalled encountering the "problem of anthropomorphism, the personalization

20 Ihde, Technology and the Lifeworld, 97-98.
21 Vanessa, Student, Interviews by the author. July 2023.

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of artifacts."[22] Reflecting on her behavior, she recognized the uncanny feeling associated with conversing with technology instead of a human being. Despite this realization, she struggled to alter her interaction style, as could be viewed in the chat history. Conversely, other students employed commanding communication, issuing directives like 'Describe' or 'Shorten,' initiating varied dialogues that impacted the outcomes. This student seemed to draw from past experiences of commanding technology, shaping a commanding interaction.
The question of acceptance and letting go of control played an important role during the whole workshop, which is evident in the written dialogues with the AI. Students sought to minimize undesired program reactions by specifying, correcting, or changing specific words, believing it would grant them greater control over the seemingly random feedback. This can be viewed as an uncertainty absorption mechanism, aligning with the organizational theory of Herbert A. Simon and James G. March. Students needed to trust the conversation without constant questioning, as each reformulation in the dialogue had the potential to alter the entire process significantly. Sociologist Dirk Baecker articulated this trust concept:

> *Any communication can reach a point at any time where it can only find the courage to trust itself by taking over previous communication unchecked and encouraging subsequent communication with its trust in itself. Just as in the organisation, however, this trust is not a blind trust, but a constantly checked trust. It reaches forward and back, introduces the past into the future and the future into the present; it relies on experience and anticipates future experience; it orients itself to approval and rejection and relies on finding further approval and rejection.*[23]

Trusting themselves and the process proved challenging for some students, which was evident in the emotional reactions observed by us tutors. As explored in the initial chapter, the second part of the workshop also constituted a form of dialogue, with tools communicating with the students. The students had to interpret relevant signifiers and construct a chosen visualized object. While building and testing the prototypes, the students gained more understanding of their possible properties and uses. In contrast to the first part of the workshop, which involved a dialogue with AI programs using language

22 Ihde, Technology and the Lifeworld, 98.
23 Dirk Baecker, "Designvertrauen: Unsicherheitsabsorption in Der Nächsten Gesellschaft," in Merkur, vol. 799 (Stuttgart: Klett-Cotta, 2015), 89 (translated by the author); See also Charles F. Sabel, "Studied Trust: Building New Forms of Cooperation in a Volatile Economy.," Human Relations, 1993; Niklas Luhmann, Vertrauen: e. Mechanismus d. Reduktion sozialer Komplexität (Enke, 1973).

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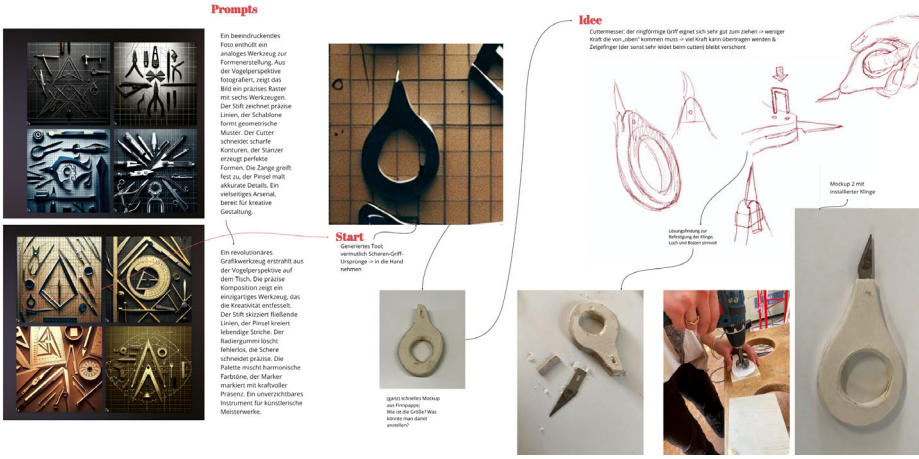

Non-verbal dialogue between students and prototyping materials during the exploration process.

and visuals, the second part featured a non-verbal dialogue with the crafted tools through hands-on interaction.

Focusing on how students navigate the unknown with unfamiliar tools, I integrated observations with semi-structured interviews six weeks post-workshop. This text emphasizes the distinction between students' actions and their memory thereof through their verbal accounts. It acknowledges the influence of factors like prior knowledge, memory, or specific self-perception. This special form of introspection, called retrospection, relies on the memory of experienced events.[24] During this interview, "participants verbalize a variety of different thoughts while carrying out stimulated recall," as Petra Knorr highlights. She further notes: "The collected data reveal that some of the participants' responses do refer to thoughts that occurred during the action whereas other responses refer to hindsight thoughts that were only evoked during the retrospective interview."[25] Hence, these interviews may not unveil the actual processes or emotions, but they provide insights into the interviewees' remembered perceptions, serving as an interpretation of the events.[26]

Four groups were interviewed in total, and one group particularly stood out in terms of their process, team dynamics, individual behaviors, reactions, and backgrounds. Consequently, I will concentrate

24 Cf. Karen Schramm, and Lena Heine. 'Introspektion.' In Forschungsmethoden in der Fremdsprachendidaktik: Ein Handbuch, edited by Daniela Caspari, Friederike Klippel, Michael K. Legutke, and Karen Schramm, 181-189. (Narr, 2016).

25 Petra Knorr, 'Zur Differenzierung retrospektiver verbaler Daten: Protokolle Lauten Erinnerns erheben, verstehen und analysieren.' In Introspektive Verfahren und Qualitative Inhaltsanalyse in der Fremdsprachenforschung, edited by Karin Aguado, Lena Heine, and Karen Schramm, 31–53. (Peter Lang, 2013), 31.

26 Cf. Cornelia Helfferich, *Die Qualität qualitativer Daten: Manual für die Durchführung qualitativer Interviews.* 4th ed. (Wiesbaden: VS, Verl. für Sozialwiss, 2011), 31.

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on this specific group. All subsequent quotes without direct reference are extracted from the recorded interview with two students called Nadja and Niklas. The translation into English was provided by me.[27]

Perceptions of the unknown tools

The selected team stood out in my research due to their contrasting reactions when faced with unfamiliar programs and unforeseeable results, as observed by the tutors. The team comprised Niklas – a fourth-semester student – and Nadja, an eighth-semester student. Nadja vividly recalled perceiving the unforeseeable as a loss of control triggered by the outcomes Bing produced. She described such a moment, stating: "It was completely in the wrong direction. But you could never really know which word would somehow make the whole construct collapse again." Nadja's memory suggests preconceived notions about a process having a right and wrong way of handling such a tool. Coupled with her assumed sense of control due to some more predictable results at the beginning of the process, she was genuinely surprised by the outcomes when they continued to simply alter single words in the prompt. Her use of terms like 'wrong direction' and 'the whole construct collapse' illustrates the impact of the unknown process and the partly uncontrollable programs on her. By contrast, Niklas remembered the same process differently, describing the program's unforeseeable results as 'interesting' and

27 Weinmann, Interview mit Nadja und Niklas zum Workshop 'See.'

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recognizing their potential through experimentation. He remarked, "you sit there and enter something full of expectation, and then the one thing comes that we have been waiting for all this time." According to Niklas' memory, the results produced by the unknown program were awaited with great optimism.

Both memories were consistent with our observations made during the workshop. The difference in how they described these moments resembled how they behaved during the workshop. This harbors individual expectations not only for the results but also for the process itself. However, they both agreed on remembering perceiving a similar moment when they inserted the information 'used by hand' into their prompt. They recalled having specific expectations of receiving more graphic tools designed for manual use but were surprised to find images primarily featuring hands, often disregarding the tools completely. This unexpected shift irritated them. Drawing on Luhmann's understanding of irritation[28], the students encountered disruptions, surprises, or deviations based on expectation structures. One can react to this with deviation, ignorance, or structural change, of which the latter was done by these two students. They had to change their approach to move forward.

A series of unforeseeable outcomes generated with Bing by Niklas and Nadja. After inserting 'used by hand' into the prompts, suddenly, the focus shifted from showing tools to primarily highlighting hands.

The students' initial approach to unfamiliar tools and their reaction to unpredictable results were influenced by their expectations of a structured design process. In the subsequent sections, I will discuss what these design students consider to be a 'typical design process' and how it shaped their expectations.

28 Cf. Niklas Luhmann, Die Gesellschaft der Gesellschaft. 1st ed. Vol. 2. Suhrkamp-Taschenbuch Wissenschaft 1360. (Frankfurt am Main: Suhrkamp, 1997), 790.

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A typical design process

In the interview, both Nadja and Niklas labeled the AI programs as 'inspiration tools,' likening them to search engines and platforms like Google or Pinterest. They stressed that these tools recombine existing elements instead of creating entirely new things, fostering an expectation of predictability. Nadja's mention of "a feeling of superiority over the machine" reflected her perspective on interacting with these AI tools. Attending an introductory lecture a week before the workshop, Niklas and Nadja were exposed to examples, especially those featuring a grid view for creating multiple tools within a single image. The presented image primed their expectations, leading them to strongly anticipate such a view in their results. This expectation limited their perception, making them overlook the potential in images without the grid view, a realization that occurred weeks later.

Two approaches for creating images with Bing. On the left: Atmospheric images in perspective with a single visible tool only. On the right: An immense collection of tools shown in grid view.

Niklas also referenced their perception of a 'usual' or 'typical' design process, seemingly representing industry practices. This process, which they learned in a different course, follows a linear sequence: initiation, research, analysis, ideation, realization, and launch.[29] Our workshop introduced an inverted process, challenging their accustomed methodology. While entering their ideas into Bing, akin to simultaneous researching, sketching, and ideating, they were confronted

29 Wolfgang Schabbach, "Designpilot," accessed August 31, 2023, https://www.designpilot.info/toolbox/.

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with launch-like images but lacked a concrete use case based on which they could follow the sequence.

On the one hand, the practical know-how from those past courses enabled them to follow a design process under controlled and predictable conditions but exposed a lack of comprehensive understanding of underlying principles. This absence of theoretical knowledge (knowing-that) impacted their ability to adapt approaches to various, unknown, or novel situations in the design field. On the other hand, they had some theoretical knowledge of how and why their 'typical design process' has to be approached. Still, they did not have the embodied practical experiences of dealing productively with unknown situations (knowing-how), which is a crucial part of any creative practice.[30] This specific type of knowledge involves always controlled and uncontrollable forms of action, which will be explained in the coming section.

Controllability

In the inverted process of this workshop, students faced challenges due to a lack of theoretical understanding regarding when and how to apply specific design methods (and when they do not make sense). Additionally, they also gathered limited practical experience in handling unknown situations. For instance, attempting to refine results by adding the phrase 'used by hand' on Bing resulted in unpredictable outcomes, disrupting their planned approach, and leading to irritation. The result was an entirely new style of images that were incomparable to the previous ones. Reflecting on this experience, Nadja noted, "The human brain always tries to foresee what the result will be … And maybe this experience of this structure, which you normally have in the design process, didn't help … or rather confused [us]." This quote illustrates how the structured thinking inherent in their learned design process might hinder adaptability. In retrospect, Nadja discovers and expresses her need for structure and control, emphasizing the importance of predictability during the workshop: "You gradually find out in which direction and with which words … you get the AI in the direction you want it to go." Hence, in hindsight, she also focused on the necessity of control in a design process, not considering the confusion and lack of structure

30 For a more detailed definition of knowledge, see also Tolksdorf, Stefan, ed. Conceptions of Knowledge. Berlin Studies in Knowledge Research, v. 4. (Berlin; Boston: De Gruyter, 2012).

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during the workshop as somewhat fruitful. Nevertheless, through experimentation, she gained new insights into interacting with the unfamiliar AI tool.

Niklas initially found the workshop challenging as it also deviated from his expectations. However, a transformative moment occurred when the team abandoned their familiar design approach, allowing for a new perspective on uncontrollable outcomes. He recalls that once they had a prompt that produced a picture displaying multiple tools, each time they reused the corresponding text, new useful results showed up. This made them both feel very enthusiastic and suggested a feeling of control.

Observing the workshop, we recognized that prior experiences with AI tools undoubtedly eased their participation and expedited the start. However, memories revealed the development of specific expectations and a strong desire for control. As they became more acquainted with framing texts using ChatGPT, they anticipated a smoother, more controllable process with Bing. This anticipation is linked to routines, in which the students follow a sequence of actions based on past experiences. This could be habits in working with digital tools, including text command fields, hence long-established routines. Furthermore, recent familiar responses from ChatGPT can trigger automatic behaviors and constitute specific expectations. Next, I will therefore focus on how routines influenced action in this design process.

Actions based on routines

During their early design studies, these students acquired fundamental skills in structuring design processes systematically. They became adept at using various analog and digital methods and tools, knowing how to apply them optimally. However, as Nadja mentioned, these structured skills, ingrained through repetition without comprehensive understanding, proved confusing in this workshop. The students were accustomed to following a routine and applying tools and methods they knew well, but they struggled when confronted with unforeseeable moments, deviating from their trained structure. Their expertise in platforms like Google or Pinterest did not seamlessly translate to Bing, as exemplified by the hands-related examples, and attempts to delve deeper did

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not yield similar results. Through trial and error, they developed new skills, such as reiterating the generation process without altering the prompt, resulting in slightly more comparable outcomes, as Niklas recalled. Relevant for the second part of the workshop, the students possessed valuable skills and routines, such as model making, handling craft tools, and machinery use. Unfortunately, this led to routine-based judgment, which influenced their choice of an object seemingly easy to build.

In hindsight, the value of further unconscious actions became apparent. Their photography skills aided in evaluating generated images and recognizing nuances in style and perspective. For example, they reacted differently to atmospheric images compared to those in a top view, commonly encountered in viewports from CAD programs. Additionally, they approached interpreting generated images similarly to examining hand-drawn sketches as both students jointly reflected. They relied on a skill very common in design: finding meaning through interpretation without explicit explanation.

Faced with frustration, at one point, a routine shift, or 'break,' occurred. Initially, both Nadja and Niklas worked on the same laptop, with one person inputting text into ChatGPT and prompts into Bing while the other observed, suggested ideas, and took notes. However, after encountering persistent frustration with the results, Niklas decided to shift to working simultaneously on his laptop. This 'break,' as they referred to it, interrupted their existing process and allowed for a fresh start, similar to beginning with a blank sheet of paper when drawing with a pencil. Seen as an event, French philosopher Henri Bergson explains that those moments have the potential to break with existing orders and enable establishing new ones.[31] For Niklas, the frustration led to action, interrupting the process flow, and allowing the team a new process structure, which was very present in his memory. Working on a new computer with no recorded work history in ChatGPT or Bing prevented his past interactions from influencing new actions.

In the second part of the workshop, the prototyping phase, students built a chosen tool and intuitively engaged with it. This mirrored their approach to familiar design tools, as a regular practice from their known design process routine. In this routine, after the concept and drawing

31 Cf. Henri Bergson, Schöpferische Entwicklung (Jena: E. Diederichs, 1912), 278.

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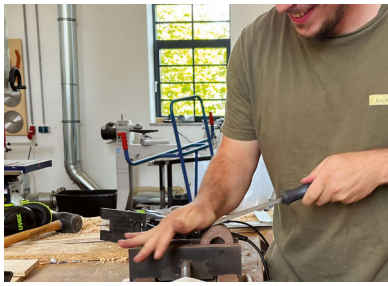
Niklas and Nadja sitting next to each other sharing one laptop in the beginning compared to other students working with two laptops.



Niklas feels much more comfortable working in the workshop using familiar tools such as a saw and file to shape a piece of timber.

phase comes the phase of building and testing a prototype. The only difference is the necessity of still figuring out how to best use the built tool. For the two students, this second part of the workshop did not seem as arousing since they did not spend a lot of time recollecting their memories during the interview in comparison to the first part.

Observationally, the moments described unveiled the unconscious use of the students' acquired practical skills: photography expertise, interpretation proficiency, the ability to interrupt and restart a process, and the possibility of discovering various ways to use a tool through iterations. These skills, developed through consistent practice over time, were applied with minimal conscious thought, showcasing intuitive actions rather than purposeful decisions. Referring to Michael Polanyi's quote: "we can know more than we can tell,"[32] designers have a specific kind of knowledge, an expertise, which emerges exclusively through practice. On the one hand, a designer can use a tool without necessarily being fully aware of it and can create new things through action without specific instructions or plans for action. On the other hand, they might not know about the impact this expertise has on one's actions; for example, considering the limit in the associated application without a focused retrospection.

In addition to those very practical skills, Niklas demonstrated another noteworthy use of a social skill. This might not be based on a routine but was used rather strategically. Amidst frustration in the team, he drew upon dispute management and mediation skills briefly acquired in a school course. To maintain team motivation and productivity, he applied a combination of skills, including empathy, active listening, negotiation, flexibility, and self-regulation. Such skills proved crucial in

32 Michael Polanyi, *The Tacit Dimension,* ed. Amartya Sen (Chicago, IL: University of Chicago Press, 2009), 16.

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managing team dynamics and fostering productive collaboration, especially in unknown situations that can trigger strong emotions.
Individual use of routines or strategies is contextual, responding to challenges and requirements. Design process habits involve the mostly unconscious application of tools or skills, which can be beneficial, restrictive, or even irritating when known patterns do not align with the context, as stated above. In situations where routines could not be relied upon, Niklas and Nadja remembered reacting differently. Nadja felt frustration due to unmet expectations, while Niklas, devoid of frustration and rather curious about the unexpected, sought social skills to navigate the stressful situation in the team effectively. This enabled the team to deal with the unexpected results productively.
In the following, I would like to discuss further what relevance expectations and especially unfulfilled expectations have on the design process.

Navigating expectations in design learning

The different reactions towards this unknown situation by Niklas and Nadja are based on their experiences from the past and their constituted expectations towards the future during this process.[33] As Reinhard Koselleck defines:

> *Experience is the present past, the events of which have been incorporated and can be remembered. Both rational processing and unconscious behavior, which need not or no longer be present in knowledge, come together in experience… Expectation takes place in the present, is the future made present, it aims at the not-yet, at what has not yet been experienced, at what can only be grasped. Hope and fear, desire and will, worry, but also rational analysis, receptive vision or curiosity enter into expectation by constituting it.*[34]

In the workshop, students drew on past experiences with tools and methods, forming hope about the images generated by AI and a strong will to produce great final results during this course. Based on past experiences and the presumed predictability due to some produced expected results by the AI, the rational analysis constituted their expectations. However, in the case of Nadja and Niklas, these expectations were not met. Nadja perceived unexpected results as a problem, echoing Luhmann's notion that the absence of an expected

33 For a more in-depth discussion on experience, expectations, risk and resilience see Gransche, Bruno. Vorausschauendes Denken. 1st ed. Edition panta rei. (Bielefeld, Germany: transcript Verlag, 2015).
34 Reinhart Koselleck, *Vergangene Zukunft*. 3th ed. Suhrkamp-Taschenbuch Wissenschaft 757. (Frankfurt am Main: Suhrkamp, 2020), 354–355 (translated by the author).

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advantage constitutes damage.[35] By contrast, Niklas demonstrated resilience and antifragility. This not only helped him to cope with disruptions but also included the ability to benefit from these disruptions for renewal and innovative thinking.[36] During the interview, he recalled how beneficial it was to use the social skills that he previously mentioned, which made him appreciate his skills even more.

Despite gaining completely new experiences through the workshop, the students, in retrospect, still referred to phrases like 'normal design process' and 'right or wrong direction.' This suggests a persistent belief in a controllable and predictable process, hindering their perception of AI not as a controllable tool but as a tool used for a process compared to – for example – 'scribbling' to generate new ideas. Nadja's belief in "superiority over the machine" led to frustration several times during the process when her expectations were unmet.

Both students shared the goal of a favorable final outcome of this course and anticipated good grades, creating significant pressure, as revealed in the interview. This insight was crucial considering the initial motivation of this workshop. Despite offering an open and safe space for exploration, the students were still confined by their understanding of the university system's inner workings. The workshop – however open in structure – remains part of an existing education system. The university system continues to emphasize grading and assessing success, but the definition of success may vary depending on the evaluator. This dynamic poses a challenge to the intended playful exploration of unfamiliar tools, which was envisioned as an alternative to the more conventional methods of teaching design processes. Transitioning to the next section, we will explore the workshop's structure in light of the anticipated ideas and motivation of the tutors, comparing them to the experiences and memories of the students.

Workshop setup

Initially, the motivation was to provide a secure space for design students to engage openly, playfully, and curiously with unfamiliar tools and novel approaches. As previously mentioned, the workshop included different aspects such as (1) the physical space, (2) time

35 Cf. Niklas Luhmann, *Soziologie Des Risikos.* (Berlin ; New York: W. de Gruyter, 1991), 36.

36 Cf. Bruno Gransche, *Vorausschauendes Denken.* 1st ed. Edition panta rei. (Bielefeld, Germany: transcript Verlag, 2015), 221 (translated by the author).

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constraints, (3) collaborative work in pairs, (4) an open workshop program, and (5) submission criteria, out of which some did not provoke the expected reaction from the students.

1. *Physical space:* The maker space Creapolis was chosen to break students from routine, fostering innovation and enabling a playful approach. The space should provoke new ways of thinking and working since it was not associated with other courses from the university. Notably, Nadja and Niklas remembered feeling uneasy in the maker space due to constantly seeing and being so close to the other students. While they sat opposite or next to others, they experienced a confrontation with seemingly constant production activities by their fellow students, making their own progress seem slower in comparison. However, they later found the workspace very valuable, especially during the second phase of the workshop. During the production phase, they could freely use all of the machines and tools available and fruitfully rely on their routines, which is an outstanding benefit of an open maker space.

2. *Time constraints:* The one-day workshop was aimed at preventing overthinking and adding lightness to the brief. While the strict time constraints successfully accelerated decision-making, they also resulted in pressure and frustration when results fell short, as revealed in the interviews. Niklas and Nadja recalled feelings of competition with other students, which lingered due to the limited timeframe, unlike a more extended period that would allow for putting such thoughts aside.

3. *Collaborative work in pairs:* The intention behind pairing students was to foster encouragement within the teams and help them discover their unique team dynamics. Decisions were meant to be a gradual outcome of discussions from various perspectives. However, working in pairs posed significant challenges for Nadja and Niklas. The decision to share a single laptop, initially considered an effective team approach, did not unfold as anticipated. Only when Niklas worked separately did they manage to refocus. Nadja initially took the lead, but she welcomed Niklas taking charge later when their expectations were not met. This letting go of team leadership provided Nadja with the external guidance she needed, as she recalls, which intentionally was not fully provided by us tutors.

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4. *Workshop program:* The workshop comprised a two-phase task: generating an AI-based graphical tool image with the given programs and building/testing a prototype within the day. Intended to encourage intuition and exploration, the open approach proved challenging for Nadja, who preferred clear guidelines. The workshop's separation into phases, limited program choices (ChatGPT and Bing), and strict deadlines aimed at promoting fast decision-making. For Nadja, these constraints proved beneficial, helping her make decisions without overthinking. This underscores her struggle between needing structure and desiring exploration. By contrast, Niklas, suggested an even more open design brief during our interview, proposing that students define tasks themselves. Unusually didactic for a fourth-semester student, Niklas' ability to see potential in any process propelled the team forward during challenging moments.

5. *Submission criteria:* The submission, encompassing the final text prompt, associated image, functioning prototype photo, prototype test graphic, and tool sketch, aimed to showcase the process to the team but also to other students and tutors. However, it also influenced Niklas' and Nadja's tool selection. Despite exploring various options initially, they ultimately chose a simpler tool due to time pressure. Running short on time in the first part of the workshop due to the mentioned challenges led them to select 'the ring' as their final graphic tool, interpreting it as a standard cutter. This choice appeared less adventurous, with their preference to stay within their comfort zone. Niklas expressed his fear, reflecting on concerns about evaluation in design studies and past experiences, influencing his decision-making towards a feasible and safe choice: "I think that in the end, there is always the evaluation … I'm trying to develop this tool, but it doesn't work. Then, in the next step, I can't implement it, and then comes the grade… and it's bad." Despite tutors emphasizing the importance of process over a perfect outcome, the fear of bad external judgment and receiving poor grades – based on past experiences with other tutors – significantly impacted their decision-making process.

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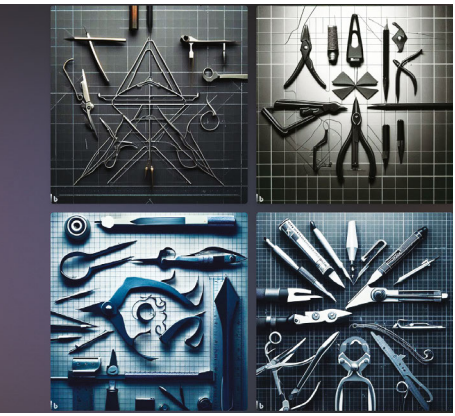
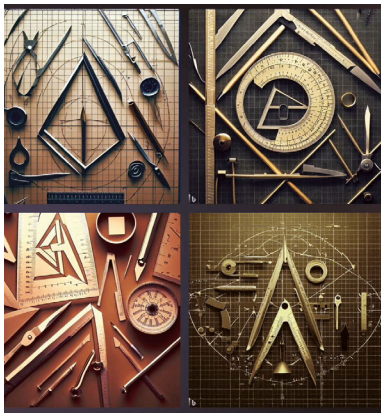
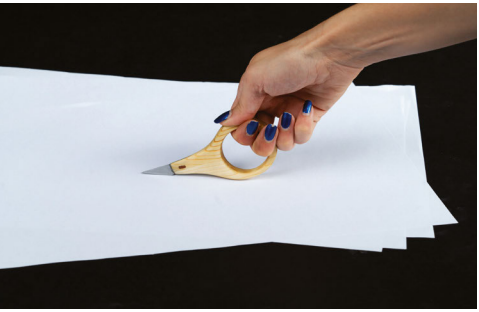


The options of generated graphic tools by Nadja and Niklas.



The final results from Bing show graphic tools, including the chosen object, 'the ring,' for phase two, visible in the top-left image. The first prototype of 'the ring' was made from cardboard and metal, as seen in the image on the right.



'The ring' final prototype out of timber and metal, being tested by Nadja, was used as a standard cutter.

During the final presentation, a few weeks after the workshop, Nadja's and Niklas' tool produced unexpected results. Retrospectively they discovered unexpected potentials of the tool. For example, when using it on paper hanging vertically in space, they harnessed gravity to generate intricate graphical patterns.

The judgment of the given situation or produced outcomes is an essential part of a design process since it defines the further action of the designer. In the following, we delve into how this judgment may evolve over time.

Altering perceptions

Niklas and Nadja entered the workshop with specific expectations shaped by their prior knowledge of graphic tools. Envisioning analog tools in a grid layout, unmet expectations led them to judge alternative outcomes as 'uncontrollable,' 'not useful,' or simply 'wrong,' even in retrospection. However, a shift occurred in Niklas' perspective a few

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weeks post-workshop. He found the situation challenging because the results did not turn out as imagined. Nonetheless, during the interview, he expressed enthusiasm, recognizing numerous possibilities he had not previously considered. Petra Knorr distinguishes between "recall thoughts (memorized thoughts)" and "hindsight thoughts (post-actional thoughts that arise in retrospect)."[37] Therefore, dealing with the produced outcomes proved challenging for Niklas during the workshop, but reflecting on them during the interview allowed him to identify potential value in what he initially dismissed. This change in judgment, from useless to valuable, unfolded through hindsight thoughts facilitated by the interview.

As can be seen now, the assessment of outcomes, initially tied to the students' expectations of controllability during the workshop, transformed retrospectively. Explored in-depth during the interview, this shift underscores the significance of time and reflection in altering perceptions. Furthermore, the influence of past experiences and societal factors on judgments has to be acknowledged both during and after the design process. While the workshop's pedagogical success might be debatable, the interviews prompted profound self-reflection by the students, raising crucial questions about how the higher education system fosters learning through stimulated recall and enabling retrospection in design education.

Rethinking design education for the future

Unknowability will play a prominent role in the future of design practice. Introducing new and 'intelligent' tools necessitates dealing with the unknown. In general, dealing with the unknown is not fundamentally new in design, since creating new ideas and design outcomes must have inherent unknown aspects to be called a design process. Nevertheless, when explaining a design process, this aspect is often ignored. Dealing with unknown tools, materials, processes, etc., requires specific beyond traditional ones. Educational researcher Ulf Ehlers identifies three key skill types needed in the future: subject-specific individual skills emphasizing self-organization, object-related individual skills focusing on creative development, and world/organizational skills promoting fluid and agile cultures.[38]

37 Knorr, Petra. Zur Differenzierung retrospektiver verbaler Daten: Protokolle Lauten Erinnerns erheben, verstehen und analysieren, 39.

38 Cf. Ulf Ehlers, "Future Skills Und Hochschulbildung" 75 (December 31, 2019), 42.

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These essential skills are often absent in current curricula, but – as highlighted through this workshop and retrospection – a stronger focus on those skills is required. Design education must proactively equip students for evolving demands, encouraging critical reflection regularly. Curricula and tutors should cultivate these skills and offer a safe learning environment, which is not always given in the competitive field of design. Many design tutors mistakenly believe these skills are taught incidentally. This research addresses this oversight in design education today.

Acknowledging limitations, this text focuses on a single team of students during the described workshop. Broader analysis involving multiple teams, semesters, universities, and tutor influence could provide deeper insights. No general conclusion should be drawn from the students' experiences in one workshop, but observations point to potential gaps in the design education system.

To conclude, design education must recognize the significance of open-ended processes, self-directed learning, and guided retrospection alongside traditional teaching. Competencies like self-efficacy, critical reflection, and decision-making are crucial for future success but are often neglected in design curricula or incomprehensibly taken for granted. Guided reflection, such as post-workshop interviews, fosters critical thinking. Considering students' ability to reflect on creative practice helps identify missing and existing skills and fosters future transformation. Combining formats of practical creation and in-depth reflection enables students to recognize conflicts, discover potential in discarded outcomes, and gain experience in handling the unknown. A stronger focus on training students in those skills and providing space for retrospection prepares them when facing challenges in an unknown future work environment.

Throughout this workshop, students encountered the unknown in various forms, as unknown tools, results, or actions. Design education should support students in developing future skills, gaining experience, and guided reflection, avoiding imposing 'right' and 'wrong,' 'good' and 'bad' design results. This transformative approach encourages meta-level reflection, cultivating trust in students' ability to handle unknown tools and navigate unfamiliar situations.

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