Fostering Co-creativity with Tangible Materials

Johanna Okerlund[1], Bethany Vasquez[1], Zoe Mitchell[1] and Orit Shaer[1]

[1] *Wellesley College, Wellesley, MA, USA*

Abstract

We explore the relationship between GenAI and one of the hallmarks of human exploration and creativity: playing with materials. We ran a tangible design activity with students in an introductory CS class that was designed to promote critical reflection on the role of GenAI in the creative process. The activity asked students to respond to design prompts by building physical prototypes with simple materials alone, with teammates, and then with teammates and GenAI. We present results from the activity and discuss implications for co-creativity with physical materials and design education.

Keywords

Human-AI Collaboration, Playful Creation, Tangible Play, Novice Designers

1. Introduction

The prevalence of GenAI presents challenges and opportunities for human creativity. While concerns exist about the possibility of GenAI to replace human creativity, we believe co-creativity can unlock new creative potential [1]. While many co-creative projects aim to increase the quality or novelty of the creative outputs, we focus on improving the quality of the creative *process*, particularly for students in an introductory CS class. While seasoned designers have a toolkit of techniques, sensibilities, and processes to draw on in creative experiences with or without GenAI, novice designers are developing creative sensibilities for the first time and ideally do not learn to depend on GenAI to do the creative work for them [2, 1].

We also build on the work of GenAI researchers who see the value of material play as part of the creative process [3]. Not only do tangible materials allow individuals to externalize their ideas, they also influence the way individuals think, brainstorm, and discover new design ideas [4, 5, 6, 7]. It would be helpful for novice designers to have opportunities to develop strategies for material play as part of their creative process, so we explore the role of co-creation with AI during material play. Specifically, we examined the following research questions through the design of a co-creative activity with tangible materials that we held in an introductory course: **RQ1)** Where does GenAI fit in a creative process that centers around playing with physical materials? How do students co-create with AI in such a task? How do students who are novice AI users view the co-creative process? and **RQ2)** Does a creative task with physical materials help students think critically about the use of GenAI for co-creativity?

Therefore, this paper contributes findings from an educational activity that explores how GenAI supports tangible material-based creative tasks for students with little formal design experience and fosters critical reflection on GenAI's limitations and affordances. Our findings

Joint Proceedings of the ACM IUI Workshops 2025, March 24, 2025, Cagliari, Italy

CEUR Workshop Proceedings (CEUR-WS.org)

demonstrate the ways students integrate and view GenAI within a creative process with physical materials. In addition, this paper offers strategies to enhance AI literacy, promote creative agency, and further integrate GenAI in educational contexts. In the rest of the paper, we situate the study within related work on co-creativity, agency, and materiality; we outline the educational activity's design, implementation, and goals; we present results on student engagement and use of GenAI; and discuss implications for education and co-creativity with tangible materials.

2. Related Work

2.1. Design practice and process in co-creative tools

Many projects that explore co-creativity focus on how GenAI can help with ideation and divergent thinking [8, 9, 10, 11, 12]. These endeavors aim to increase the creativity of the output. Other researchers argue that it is important to consider opportunities for co-creativity at all stages of the creative process, not just ideation or in terms of final output [2, 13]. Researchers have also looked at ways GenAI can support specific parts of the design process such as how novice designers can use GenAI to create design personas [14].

While physical prototyping is an important part of design, outside the field of robotics, few studies have looked at ways to incorporate GenAI in physical design processes. Examples include systems that generate digital designs with low fidelity prototypes or block structures as input [15, 16]. Another project renders digitally generated designs with traditional craft materials, showing the hallmarks and importance of physicality [17].

Not only is it important to consider GenAI at various stages of the design process, we also suggest that it is important to consider how co-creativity with GenAI can teach novice designers about the design process itself. Studies with expert creators have shown that professionals are intentional and deliberate about how they incorporate GenAI into their practice because they have an established practice [10, 18].

2.2. Agency and autonomy in co-creative tools

Hwang suggests that a worthwhile co-creative tool should give users the autonomy to decide whether GenAI "works with them or for them" [2]. Watkins and Barak-Medina similarly argue that GenAI both poses a risk to human creative agency as well as a potential for creative growth [1]. They suggest that several factors influence the extent to which GenAI impacts human creative agency including whether it is perceived as a competitor or complement to the human. Mueller et al. make the distinction between technology-centric and human-centric approaches to co-creativity[19].

Agency and autonomy are particularly important for novice designers, who ideally do not learn to rely on GenAI for skills or creative strategies that they might otherwise learn themselves. Several studies show that GenAI can increase confidence and agency. Gu et al. asked students to interpret poetry in the form of a LEGO structure and compared the complexity of the structures created by a group of students who used AI to generate images for inspiration and a group who did not [3]. While the group that used GenAI did have more complex LEGO structures, what is perhaps an even more desirable output is that this group had more confidence in their creative process. In the domain of computer programming, interacting with GenAI was shown to increase students' self-efficacy and motivation [20].

Another reason that encouraging autonomy and agency in co-creative tools is important for novice designers in particular is that they may be developing future generations of GenAI-enabled tools. Dove et al. found through a survey of UX professionals that it was challenging for them to work with machine learning as a design material [21]. While the designers had a broad sense of what it was capable of, they did not understand the specifics in ways that enabled them to incorporate machine learning in novel creative ways that live up to its full potential. In the same way that playing with physical LEGOs can be a mechanism to discover possibilities for design [5], the activity we describe in this paper orients students to GenAI as a design material to play with and discover.

In this paper, we extend the work on co-creativity with AI by integrating the three dimensions discussed above: GenAI's role in various stages of the creative process, preserving creative agency for students who may not have extensive design experience, and co-creativity with AI for physical prototyping.

3. User Study: Co-Creativity with AI Activity

In this section we describe a study that we conducted as an educational activity in an introductory computing course.

3.1. Course Context

The course, "Sociotechnical Dimensions of Computing in the Age of AI," introduces students to foundational concepts in computing while addressing the complex sociotechnical challenges posed by GenAI [22]. Combining hands-on technical labs with critical discussions, topics include introduction to programming, data privacy, algorithmic bias, and autonomous systems' decision-making processes. This approach aims to prepare students as responsible digital citizens, capable of engaging deeply with the societal impacts of GenAI-powered computing. Learning goals focus not only on fundamental programming skills, but also contextualize these skills in relation to societal perspectives on GenAI. The course is structured into twice-weekly 75-minute sessions. Our co-creation activity was held in one 75 minutes session during the Fall 2024 iteration of the course. Before the session, students had a lection about what is machine learning and possible bias in ML data adapted from AI4All [23].

3.2. Activity Learning Goals

We designed an activity to introduce students to GenAI in a way that was in line with the course goals and would provide a foundation for additional instruction about AI throughout the semester. The activity assumed no prior formal GenAI instruction and was thus designed to offer playful and critical exploration of GenAI in a human creative process.

The first set of goals for the activity was to prompt students to reflect on individual and collaborative creative processes with physical materials in the absence of GenAI. We wanted them to develop a sense of where their ideas come from, how they build on the ideas of their

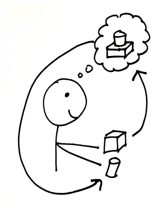

Figure 1: Example graphic used to illustrate how to draw the creative process

peers, and how they leverage physical materials in the process. We aimed for students to begin developing a definition of co-creativity with other people and notice the types of dynamics and interactions between humans that make co-creation possible. Only after dedicating some time to the first goal could the activity aim for the second learning goal, which was for the students to consider AI as a co-creator and develop strategies for critically incorporating it into their material creative process.

3.3. Procedure

Students participated in a 75-minute activity consisting of 3 creative tasks of increasing complexity, linked on the course website [22]. All tasks asked students to respond to a design prompt by creating an artifact with an assigned set of physical materials. In *task 1* students created individually; then in *task 2* students created with teammates; finally in *task 3* students created with both teammates and GenAI. We provided context for the tasks with a brief lecture that scaffolded the concept of co-creativity with AI in the same way as the creative tasks: first introducing the creative process, then collaborative creativity, then co-creativity with AI.

One of the goals of this introduction was to introduce creativity as a process and encourage tinkering as an experimental dialogue with the materials - 'I'm going to try this, I see what happens, then I try something else' [7]. Inspired by diagrams from Rosenbaum's dissertation on tinkering [24], we used graphics with lines and arrows to illustrate this concept (Figure 1).

All three tasks asked students to use only the materials at their table to create an artifact in response to a design prompt. After each task, students were asked to sketch their creative process in the style of Rosenbaum's diagram of tinkering that we introduced earlier (Figure 1).

Task 1 (Individual only) asked students to take 5 minutes to create at least 3 containers for transporting personal objects across campus. **Task 2** (Co-create with teammates) asked students to take another 5 minutes to work with their teammates and the same set of materials to generate at least 3 new ideas for the same prompt. For **Task 3** (Co-create with teammates and GenAI), students switched tables so they had new materials and they responded to a new design prompt: Create at least 3 new vessels for drinking hot liquids on the go. The groups could decide where to start and how to interact with each other, the new materials, and GenAI. The activity suggested students use Gemini and gave students some starter prompts. Some starter prompts were image based, suggesting students take a photo of the materials and ask GenAI to "use these materials to create 10 prototypes of a novel coffee mug". The rest of the starter prompts were text-based, such as “I need to build some prototypes of a novel coffee mug using [describe your building materials]. Generate 10 ideas”. The assignment aimed to frame

Figure 2: Examples of materials. 3D printer plastic scraps, Play-Doh, interlocking paper pieces, wooden block planks, foam cubes, LEGOs (clockwise starting in top left)

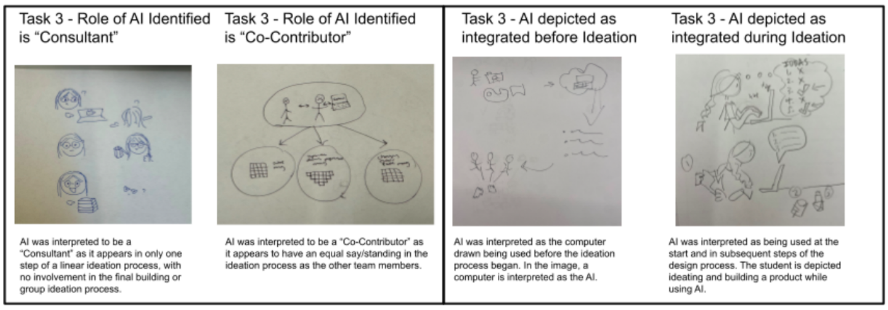

Figure 3: Sample diagrams along with their codes and reasoning

the AI neutrally, allowing students to consider if and where it fits in the creative process.

Each group of students only had access to one type of material (Figure 2). These materials were chosen to elicit different responses from GenAI. Some, like the LEGOs and Play-Doh, were chosen as materials that GenAI would reasonably be expected to generate realistic examples of what could be built with since there are many pictures and descriptions of LEGO and Play-Doh projects online. Others, like the interlocking papers and plastic scraps were at the other end of the spectrum, representing a material that would likely yield nonsensical ideas from GenAI since there is likely little reference to these unique shapes in the training set. Even though GenAI might not generate realistic ideas with these materials, they might generate responses that prompt the students to think of novel ideas.

The procedure generated several outputs that we collected and analyzed: sketched diagrams of the creative process from each of the three tasks and answers to a set of written questions such as how GenAI influenced their ideas and whether they considered AI as a co-creator. Below are three sample diagrams along with their codes and reasoning (Figure 3).

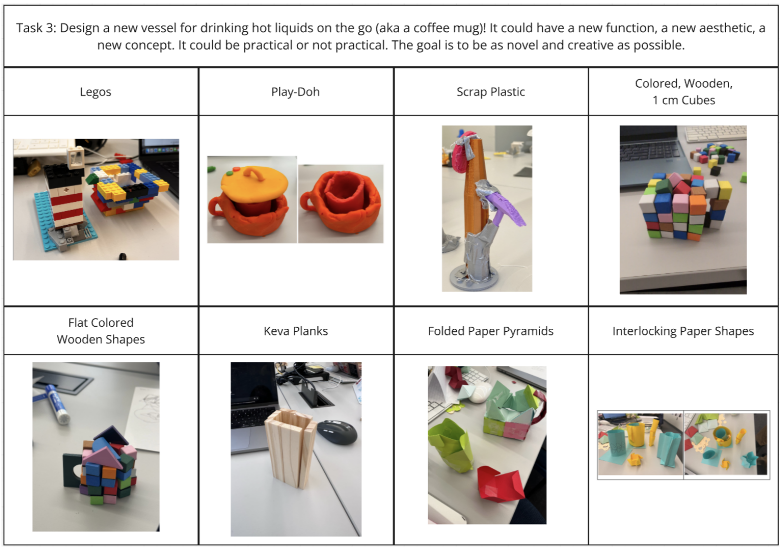

Figure 4: Sample of student creations using the different materials.

4. Results

32 students submitted pictures and reflections for Task 1. 16 groups of students submitted for Tasks 2 and 3, as well as individual reflections. Some students did not answer all the reflection questions or submit all the sketches or photos requested. Figure 4 shows a sample of student creations using the different materials. To analyze the results, we performed thematic analysis on the sketched diagrams and answers to reflection questions.

4.1. RQ1: Where does GenAI fit in a creative process? How do students co-create with AI? How do students in an introductory CS class view the co-creative process?

4.2. AI Integration and Role

In analyzing the diagrams across all three tasks we examined the following themes: 1) Emphasis - What aspects of the creative process are most prominent in the depiction? 2) Process Structure - How is the creative thinking process depicted? We analyzed structure based on the relationships between components as indicated by topology and arrows. 3) Main Activity - What step of the creative process is emphasized in the diagram? Figure 7 in the Appendix shows the code book used for the analysis, and the results in terms of the number of diagrams in each code category.

Across the three tasks, most diagrams depicted ideation as the *main activity* (12/32, 16/31, 17/30, respectively), highlighting a process that focuses on brainstorming ideas. When examining the emphasis of the diagrams, most students who completed Task 2 (17/31) placed *emphasis* on the artifact - the output or the final product. This is not surprising as students began Task 2 with more familiarity of their assigned materials.

We then further analyzed Task 3 diagrams, examining the *AI integration* - the point at which

Theme	Code	# Students
AI Integration When is AI brought into the process?	**Before Ideation** AI is shown being used in the first step or before team members are shown.	8
	During Ideation AI is shown in subsequent steps or is continuously present in the ideation depiction.	17
	No AI Depicted Diagram showed no interactions with AI.	5
Role of AI What role does AI take on during the creative thinking process?	**Co-Contributor** AI is shown to have an equal say/standing in the ideation process as team members.	8
	Consultant AI is shown in only one step or as an unequal contributor compared to team members.	17

Figure 5: Results of analyzing student diagrams from the AI task

GenAI is incorporated into the thinking process, and *role of AI* - how GenAI is used during the thinking process, as depicted in the diagrams. Figure 5 shows the code book and results for these themes.

Students depict the role of GenAI as either a *consultant* (17/30) or a *co-contributor* (8/30). As a consultant, GenAI serves as a secondary contributor, offering suggestions or feedback without being deeply integrated into the team's decision-making or ideation process. In contrast, a co-contributor is depicted as an equally valued member of the team, with its input considered and weighted as that of human team members. Most students (17/30) depicted using GenAI during the ideation phase, primarily as a consultant. Additionally, 8 students depicted using GenAI before ideation, engaging with it to validate or check their initial ideas and artifacts. Among these 8 students, 6 described GenAI as a co-contributor in their written reflections, while the remaining 2 did not provide a response. Interestingly, when reflecting in writing on whether GenAI took on a co-contributor role in their process, most students (22/32) responded that they did consider GenAI to be a co-contributor. Among the students who stated that the GenAI was not a co-contributor (7/32), one student wrote "it contributed to the idea creation process, but not to the creation of the prototype, so no.", indicating different ways the students may place the value in the co-creativity activity (ideation and process vs product). One student said that "It was the main contributor, we gave it input it told us what to and we followed," alluding to a phenomena we noticed in the diagram depictions for Task 3 where 13 out of 22 students depicted their process as linear describing an "input → output" usage of GenAI.

4.3. AI's support for specific materials

When asked whether GenAI gave reasonable responses given the materials they were working with, more than half the students said no (19/31) (Table 1). One student who worked with the scrap plastic material stated that "when given very specific constraints (don't have to use all

Material	AI did not give reasonable responses	AI did give responses responses
LEGOs	3	1
Play-Doh	2	4
Scrap plastic	3	1
Colored wooden 1-cm cubes	3	0
Flat colored wooden shapes	1	2
Keva planks	5	0
Folded paper pyramids	1	1
Interlocking paper shapes	1	1

Table 1
Number of students per material on whether GenAI did or did not give reasonable instructions given the material they had to work with.

materials, but can't use more than what's available) the AI had reasonable advice for how to use the materials." Of these students, 3 also responded that GenAI was not a co-contributor, one of which who used the Keva planks material stated that "the AI struggled at times to 'understand' the limitations of our materials, often proposing solutions that were too abstract or resource-intensive (especially given time constraints)." This indicates that understanding the material was an important factor for the students to consider GenAI as a co-creator.

We were curious to see what students did in light of these limitations and whether they were still able to use GenAI for the co-creative task. Out of the 19 students who said GenAI did not offer ideas that made sense given the materials, 16 said they still found the output from GenAI helpful in some other way. Three students explicitly mentioned being inspired by what the AI generated. In a similar vein, two students say that GenAI gave creative suggestions or approaches "by pushing us to think beyond immediate constraints", according to one student who used the Keva planks material.

4.4. RQ2: Does a creative task with physical materials help students think critically about the use of GenAI for co-creativity?

4.4.1. Material-AI Dynamics: Limitations and Influences

Since the activity was designed to draw attention to the limits of GenAI relative to the physical brainstorming, we looked for evidence of whether students recognized these material limitations. When asked whether GenAI "understands" the materials and what made it seem like it did or did not understand, students used their own understanding of the physical materials to evaluate the extent to which GenAI understood. If GenAI generated answers that included specific details that were relevant to the materials such as key safety information, it indicated to the students that it understood. One student found the AI did not "understand" which LEGOs they had at their disposal, but that it "did 'understand' the basic nature of LEGOs, which is that they can be reconfigured easily and have lots of potential for customization" (P16). One student highlighted that although the AI generated reasonable ideas for mug decorations it could make out of Play-Doh, it was not taking full advantage of the opportunities afforded by the materials.

When asked if there was a table with materials that GenAI would be better at brainstorming with, most students (27/31) understood that the type of materials had some level of influence on the output the AI generated. A few students (3/31) mentioned materials that have many finished projects documented online. A handful of others (5/31) similarly pointed to materials the AI was “more familiar with”. Only four of these students used language that explicitly refers to the data the GenAI was trained on.

The most common responses referred to the physical properties of materials (18/31). The properties mentioned included versatility (7/18), ease of physical connections (2/18), and uniformity or simplicity (3/18). Students who mentioned versatility thought that materials with fewer constraints would reduce the likelihood of GenAI to generate nonsensical answers. Students' preference for uniform or simple materials was because unique shapes such as 3D printed scraps were harder for the human to describe compared to simple shapes like uniform wooden planks. Interestingly, two students mentioned that weird or unique shapes would actually be preferable: “I think that sometimes the more absurd the request, the better the AI will respond to it since it doesn't register that it's a weird request the way that we as humans do.”

4.4.2. Comparing Human and AI Approaches to Physical Creative Processes

The activity was designed to prompt students to reflect on their own creative building processes and draw attention to how ideas evolve, and how physical play can spark ideas. We investigated whether the aspects of the human physical creative process that students noticed were similar to what they hoped GenAI would be able to do.

When asked how they knew what to do with the building materials, students brought up a number of human strategies and processes. More than half of the students mentioned something about the physical materials (20/28). Specifically, some said they drew on past experiences with the materials (16/28), some had past experiences with building in general (7/28), and some (6/28) brought up being able to physically touch the materials. Out of these 20 students who mentioned materiality as part of their own creative process, just over half (13/20) also mentioned material properties when asked what data they would include when training GenAI for the task.

Students compared themselves and GenAI. One stated, "I think the most important difference between AI and me is that I have sentiments and creativity that does not only come from the feeded [sic] materials exposed before, but also my unique personal experience. In contrast, AI is unable to have the latter sentiments.” Another noted that their hands-on experience is "something the AI couldn't quite grasp". Yet another states "I can understand their physics by playing with them and using my hands. The dimensional perspective for that experience is something that counts for a lot and AI doesn't have that ability."

5. Discussion

Results showed that our activity created opportunities for students to consider tensions and synergies between the physical world of playful discovery and GenAI's digital domain of abstractions and data. Students found different ways to incorporate GenAI in their process, as a consultant or as a co-contributor and at different stages. They drew on playful strategies to make sense of physical materials and considered how GenAI could be improved to be more fully embedded in those processes. Key aspects of the activity were starting with physical materials, prompting reflection on the dynamics of human-human collaboration, and using GenAI for a task that it was likely not going to be very good at.

5.1. Role of GenAI in Creative Processes with Physical Materials

Our results highlight a tension when considering how to train AI for co-creativity with physical materials. When students were asked what type of data to include to train GenAI for similar tasks, responses varied. Some said examples of similar finished products, aligning with how GenAI is traditionally trained, while others mentioned data about the physical traits and uses of the building materials. These approaches reflect different perspectives on how GenAI could complement human creativity. Training GenAI on finished products is technically feasible and consistent with current training methods, but risks constraining human creativity by emphasizing pre-defined outputs over exploration. In contrast, training on material properties aligns more closely with the activity's goal of fostering material exploration and collaboration. This tension presents an opportunity for deeper student reflection and discussion. It invites exploration into the limitations of GenAI's reasoning about physical materials, the kinds of data it can effectively leverage, and the trade-offs involved in optimizing GenAI for specific tasks.

5.2. GenAI as a Playful Design Material

One of the key differences between student groups was how some took a linear approach to GenAI, asking it to generate something and then directly adopting its output, while others had more back and forth, iterating on what they were asking, and transforming the output in different ways. This points to an opportunity for the design of co-creative systems, which is to ensure that the user can approach GenAI in a playful manner. This might entail encouraging a playful disposition, letting the user discover what GenAI can and cannot do on their own rather than telling them, and letting GenAI have ambiguous results that the user can appropriate towards their own goals. Opportunities for interacting with AI as a playful material like this are in line with researchers who cite the importance of human creative agency in co-creation [2, 1].

Iterating and playing with GenAI does, however, come at an environmental cost. Environmentally conscious students may be more hesitant to play and discover with GenAI given the frivolity of the activity may not seem to be worth the cost to them. This is also an opportunity to discuss what constitutes a co-creative relationship and the value of learning how to explore and discover GenAI in a playful dialogue.

6. Conclusion

We explored the relationship between GenAI and material play through an activity that used physical materials to prompt critical reflection on the role of GenAI in the creative process. Our results show the activity offered a rich bed students to reflect on both their creative process and the role of GenAI. This suggests promise in pursuing the broader goal of creating opportunities for students in an introductory course see GenAI as a creative material.

References

[1] R. Watkins, E. Barak-Medina, Ai's influence on human creative agency, Creativity Research Journal (2024) 1–13.

[2] A. H.-C. Hwang, Too late to be creative? ai-empowered tools in creative processes, in: CHI conference on human factors in computing systems extended abstracts, 2022, pp. 1–9.

[3] Q. Gu, Y. Wang, X. Hu, O. Shaer, Exploring the impact of human-ai collaboration on college students' tangible creation: Building poetic scenes with lego bricks., in: IUI Workshops, 2024.

[4] M. M. Jensen, R. Rädle, C. N. Klokmose, S. Bodker, Remediating a design tool: implications of digitizing sticky notes, in: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, 2018, pp. 1–12.

[5] L. Zenk, N. Hynek, S. A. Krawinkler, M. F. Peschl, G. Schreder, Supporting innovation processes using material artefacts: Comparing the use of lego bricks and moderation cards as boundary objects, Creativity and Innovation Management 30 (2021) 845–859.

[6] D. Gauntlett, The lego system as a tool for thinking, creativity, and changing the world, in: Lego studies, Routledge, 2014, pp. 189–205.

[7] B. Sutton-Smith, The ambiguity of play, Harvard University Press, 2001.

[8] O. Shaer, A. Cooper, O. Mokryn, A. L. Kun, H. Ben Shoshan, Ai-augmented brainwriting: Investigating the use of llms in group ideation, in: Proceedings of the CHI Conference on Human Factors in Computing Systems, 2024, pp. 1–17.

[9] M. P. Verheijden, M. Funk, Collaborative diffusion: Boosting designerly co-creation with generative ai, in: Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems, CHI EA '23, Association for Computing Machinery, New York, NY, USA, 2023. URL: https://doi.org/10.1145/3544549.3585680. doi:10.1145/3544549.3585680.

[10] J. Tholander, M. Jonsson, Design ideation with ai - sketching, thinking and talking with generative machine learning models, in: Proceedings of the 2023 ACM Designing Interactive Systems Conference, DIS '23, Association for Computing Machinery, New York, NY, USA, 2023, p. 1930–1940. URL: https://doi.org/10.1145/3563657.3596014. doi:10.1145/3563657.3596014.

[11] J. Kim, M. L. Maher, The effect of ai-based inspiration on human design ideation, International Journal of Design Creativity and Innovation 11 (2023) 81–98. URL: https://doi.org/10.1080/21650349.2023.2167124. doi:10.1080/21650349.2023.2167124. arXiv:https://doi.org/10.1080/21650349.2023.2167124.

[12] J. He, S. Houde, G. E. Gonzalez, D. A. Silva Moran, S. I. Ross, M. Muller, J. D. Weisz, Ai and the future of collaborative work: Group ideation with an llm in a virtual canvas, in: Proceedings of the 3rd Annual Meeting of the Symposium on Human-Computer Interaction for Work, CHIWORK '24, Association for Computing Machinery, New York, NY, USA, 2024. URL: https://doi.org/10.1145/3663384.3663398. doi:10.1145/3663384.3663398.

[13] Y. Shi, T. Gao, X. Jiao, N. Cao, Understanding design collaboration between designers and artificial intelligence: a systematic literature review, Proceedings of the ACM on Human-Computer Interaction 7 (2023) 1–35.

[14] T. Goel, O. Shaer, C. Delcourt, Q. Gu, A. Cooper, Preparing future designers for human-ai

collaboration in persona creation, in: Proceedings of the 2nd Annual Meeting of the Symposium on Human-Computer Interaction for Work, 2023, pp. 1–14.
[15] K. Han, K. Tang, M. Wang, Tangible diffusion: Exploring artwork generation via tangible elements and ai generative models in arts and design education, in: Proceedings of the Eighteenth International Conference on Tangible, Embedded, and Embodied Interaction, 2024, pp. 1–13.
[16] H. Zhang, P. Chen, X. Xie, C. Lin, L. Liu, Z. Li, W. You, L. Sun, Protodreamer: A mixed-prototype tool combining physical model and generative ai to support conceptual design, in: Proceedings of the 37th Annual ACM Symposium on User Interface Software and Technology, 2024, pp. 1–18.
[17] S. R. Elran, A. R. Zoran, Probabilistic craft-materialization of generated images using digital and traditional craft, Proceedings of the ACM on Computer Graphics and Interactive Techniques 7 (2024) 1–10.
[18] A. Guo, S. Sathyanarayanan, L. Wang, J. Heer, A. Zhang, From pen to prompt: How creative writers integrate ai into their writing practice, arXiv preprint arXiv:2411.03137 (2024).
[19] M. Muller, S. Houde, G. Gonzalez, K. Brimijoin, S. I. Ross, D. A. S. Moran, J. D. Weisz, Group brainstorming with an ai agent: Creating and selecting ideas, in: International Conference on Computational Creativity, 2024.
[20] R. Yilmaz, F. G. K. Yilmaz, The effect of generative artificial intelligence (ai)-based tool use on students' computational thinking skills, programming self-efficacy and motivation, Computers and Education: Artificial Intelligence 4 (2023) 100147.
[21] G. Dove, K. Halskov, J. Forlizzi, J. Zimmerman, Ux design innovation: Challenges for working with machine learning as a design material, in: Proceedings of the 2017 chi conference on human factors in computing systems, 2017, pp. 278–288.
[22] Cs110: Sociotechnical computing in the age of ai, ???? URL: https://cs.wellesley.edu/~cs110/.
[23] AI4All, Ai drawing, 2024. URL: https://ai-4-all.org/resources/ai-drawing/.
[24] E. E. R. Rosenbaum, Explorations in musical tinkering, Ph.D. thesis, Massachusetts Institute of Technology, 2015.

A. Data Analysis Details

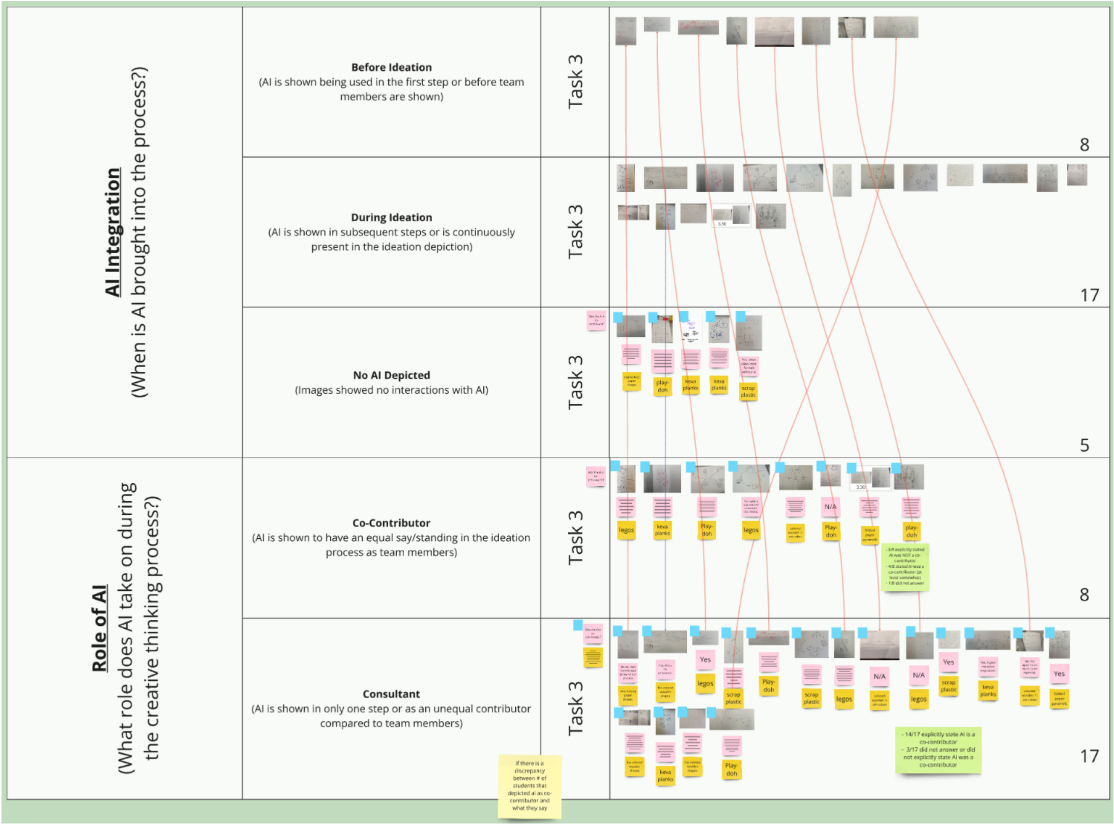

Figure 6: Data analysis of analyzing student diagrams from the AI task

Theme	Code	Student	Quote
Influential	Research	1	"We decided to use AI after we had a rough idea in our heads. Working with AI previously in internships, I found it more useful to guide the research process once I have a concept in mind so that the work tends to be more original and AI is just used to help with the research process and summarize market activity."
	Ideation	12	"It helped us develop ideas to incorporate into our mug, while we focused more on design and certain simple elements."
	Directions	3	"Yes we used it as a building block for ideas on how to combine that materials"
	Design	7	"Yes, I used the ai ideas to create certain features of my mug like a flip top"
Not Influential	Did not understand materials	23	"The ideas AI gave us are quite basic and not very specifically customized for the materials we have. And it keeps asking as to use materials we do not have, like glue and stickers."
	Unhelpful/ Unoriginal	9	"I felt as if the AI's ideas were more basic and textbook and not very 'novel'."

Table 2
Question 1: Did the output from the AI influence the ideas you built?

Theme	Code	Task	# Students
Emphasis What aspects of the creative process are most prominent in the depiction?	**Material** Diagram depicts a focus on the specific materials available with no final product depicted.	1	7
		2	7
		3	6
	Artifact Diagram focuses more on output or a final product constructed out of given materials.	1	8
		2	17
		3	10
	Both Diagram depicts both a final product and the materials used to construct it.	1	15
		2	5
		3	11
Process Structure How is the creative thinking process depicted?	**Iterative** The thinking process is depicted as circular or repeated multiple times.	1	10
		2	7
		3	9
	Linear The thinking process is depicted as straightforward with a clear start and finish.	1	12
		2	11
		3	13
Main Activity What step of the thinking process is emphasized the most in the diagram?	**Ideation** Diagram depicts a process that focuses on how the group brainstormed ideas (emphasis on people).	1	12
		2	16
		3	17
	Artifact Design Diagram depicts a process that focuses on how materials are combined or the various prototypes created.	1	8
		2	8
		3	8
	Both Diagram depicts people or a team ideating as well as the materials and prototypes created in the design process.	1	6
		2	6
		3	5

Figure 7: Results of analyzing student sketched diagrams for the three tasks

Theme	Code	Student	Quote
Yes	Ideation	15	"Since it did provide ideas and various possibilities, it should be counted as a co-contributor since the item was not produced by organic human thought."
	Starting Point	13	"It was the main contributor, we gave it input it told us what to [do] and we followed"
No	Unhelpful	14	"I think it was more of a sounding board than a co-contributor. It didn't do much other than suggest, and often went on to suggest aesthetic options I probably would've already had in mind if prioritizing aesthetics was possible with my materials."
	Inadequate contribution	25	"It contributed to the idea creation process, but not to the creation of the prototype, so no."

Table 3
Question 2: Was the AI a co-contributor?

Theme	Code	Student	Quote
Yes	Practical	4	"Yes. It gave ideas that are practical to implement into the design."
	Somewhat	30	"Partially, but many of the ideas were either unachievable or required additional materials which we didn't list."
No	Did not understand limitations	15	"I think the AI would need to understand the materials we had at hand to better produce results that are viable or at the least make sense."
	Uncreative	17	"It didn't quite stick to the parameters I gave it and couldn't get that creative. I was stuck trying to interpret its abstract ideas into reality."
	Repetitive	7	"Not exactly, the legos I had were more limited than what AI thought of, and the ideas given were frequently repetitive with just different wording"

Table 4
Question 3: Did the AI suggest ideas that were reasonable given the materials you were working with?

Theme	Code	Student	Quote
Yes	Creative Insights	6	"They were helpful in getting us to think creatively about design."
	Helpful Suggestions	11	"Specifically, it gave us some ideas of placing the blocks in geometric patterns to make the mug look unique. It also suggested using the foam to insulate the mug which I feel would be an interesting idea to try out."
	Ideation Assistance	8	"I think the AI was simply helpful by giving us unique ideas, while our team decided if these ideas were compatible with our vision and materials."
	Perspective	29	"The ideas helped me to have another perspective on what I was creating."
	Reassurance	14	"It was nice to have reassurance during the process, like I wasn't stupid to think to arrange the blocks in a way where they wouldn't easily fall over, as the AI also suggested."
	Provided Starting Point	12	"They helped us come up with new ideas and start our creative process."
	Provided Inspiration	23	"they are helpful in the sense that they inspire us to consider both practicality and aesthetics."
No	Unhelpful	10	"I did not find them particularly helpful since we'd already had the thought of trying to use container-esque materials we had at the table."
		16	"The unreasonable ideas generated by the AI were not helpful because they involved the use of specialized bricks, not interesting ideas or building patterns I could adapt."

Table 5
Question 4: If not, were the ideas the AI suggested helpful in a different way?

Theme	Code	Student	Quote
Types of Data	Variety/ Diverse Data	7	"I would include more innovations and a wider range of data in product development so that AI could have more data to work with when suggestions ideas."
	Material Properties and Uses	22	"The texture and quality of wood sticks; Texture and quality of a coffee mug; Different types of vessels."
Relevant Examples	Similar Failed Products	19	"Probability of use, so maybe specific items that are not ideal or examples of prototypes that are."
	Human Design Processes/Building Processes	3	"I would include data on people's design process so the AI could generate doable ideas ."
	Similar Products	8	"I would include data of what can be done with sticky notes or similar materials and styles of art, such as origami."
	Projects with Limitations	14	"I would include limitations in the scenario. Like what other materials are present, how long I have to create the model, etc."

Table 6
Question 5: If you were to build a dataset to train a new AI to be really good at this specific task, what data would you include?

Theme	Code	Student	Quote
Using Prior Knowledge	Past Experiences with Materials	6	"We have all used play-doh in the past and know how to manipulate it to create different forms."
	Innate Creativity	22	"It's something that is intuitive/already wired into our brains ever since we were young. Creativity is something that can be naturally found in humans."
	Past Experience with Building/Creating	31	"I knew what to do with the materials due to prior knowledge. Play doh is a material that children experiment with in school and at home. I knew what to do with the material due to this, and also because I have taken many art classes, which have equipped me with further knowledge on what to do with clay-like materials."
Physical ("in-person") Abilities	Experimentation/ Trail and Error	4	"Experimenting with the materials multiple times and making small prototypes to test possible designs."
	Ability to Physically Touch Materials	29	"Because I have the ability to touch them and see them from a perspective that an AI cannot. I can understand their physics by playing with them and using my hands. The dimensional perspective for that experience is something that counts for a lot and AI doesn't have that ability."
	Collaboration with Other People	7	"I used previous knowledge and the ability to generate new ideas to think of what to do. I also collaborated with other people which allowed us to share ideas and suggestions."
Used AI	Decisions were AI Informed	3	"We used the AI suggestions as a launching point, then we knew what to do with the materials due to the instructions AI gave us."

Table 7
Question 8: How did you (as a human) know what to do with the building materials at your table?