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Design of speculative artifacts: Integrating generative artificial intelligence, biomaterials, and digital fabrication in co-creative and participatory design

Guilherme Giantini[1]*, Lígia Lopes[1,2], and Jorge Lino Alves[2,3,4]

[1]Department of Design, Faculty of Fine Arts, University of Porto, Porto, Portugal

[2]Course Director of the Master's in Product and Industrial Design, University of Porto, Porto, Portugal

[3]Department of Mechanical Engineering, Faculty of Engineering, University of Porto, Porto, Portugal

[4]Department of Mechanical Engineering, Institute of Science and Innovation in Mechanical and Industrial Engineering, Porto, Portugal

Abstract

This study explores artificial intelligence (AI)-mediated participatory design integrating biomaterials and digital fabrication to co-create speculative artifacts grounded in lived experiences. The present study involves experimentation with biomaterials, exploring the intersection of image-based generative AI, participatory, and co-creative methodologies within a design framework that reimagines lived experiences shaped by identity-based exclusionary processes. Rather than pursuing AI-driven discovery of new materials, this study positions design as a mediating process among human experience, critical reflection, biomaterial exploration, and digital fabrication. The research introduces a three-stage workflow (co-creation, fabrication, and materialization) that employs AI as a mediating tool between subjective narratives and tangible speculative artifacts. During the co-creation stage, participants shared their personal experiences through open-ended surveys, text-to-image generative AI visualization, and algorithmic three-dimensional (3D) modeling. This process enabled participants to speculatively reimagine lived experiences of social exclusion, demonstrating how AI can support new modes of participatory and social engagement. During the fabrication stage, digital models were translated into physical counter-molds through 3D printing and subsequently cast in silicon, reaffirming the reciprocal relationship between digital and craft-based production. The materialization stage explored biomaterial compositions informed by participants' narratives and materialities, incorporating hair, wood ash, and plastic waste into biomaterial compositions grounded in circular economy principles. The resulting artifacts function as speculative objects that incite interpretation beyond fixed symbolic representation. This study contributes to ongoing discussions in digital fabrication, material design, and critical craft by demonstrating how AI-mediated participatory co-creation can foster ethically conscious, socially engaged, and materially grounded design practices. Future work may extend this approach to larger collective settings and further explore the integration of biomaterials and AI within ecological and inclusive design frameworks.

Keywords: Artificial intelligence; Biomaterials; Co-creative design; Participatory design; Three-dimensional printing; Artifact-based design research

***Corresponding author:**
Guilherme Giantini
(up202002299@edu.fba.up.pt)

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1. Introduction

The increasing role of artificial intelligence (AI) in data management and community interaction is shaping practice-based applications in material exploration and design, broadening opportunities for developing artifacts at the intersection of craft, digital fabrication, and material agency. While materials science research frequently focuses on AI-powered discovery, optimization, and prediction, design may extend that to esthetic exploration, analysis of experience, and contextual meaning.

AI has increasingly been used to support both the prediction of material behavior and the optimization of processing methods in material development. Yet, these advances often prioritize functional performance while overlooking the exploratory and embodied engagement with materials, which is central to craft and design practices and addresses issues of meaning-making and social context. When undertaken with participatory and co-creative design methods, generative AI can unlock new opportunities for agency, transparency, and meaning in human–machine collaboration.

Emerging research indicates that generative systems enhance craft by mediating gesture-driven fabrication, supporting speculative practice, and enabling participants to actively co-create. Within this setting, generative AI tools help mediate relationships among participants, tools, materials, and artifacts, transforming the digital–craft interface into a speculative space where lived experience, biomaterial engagement, and digital fabrication blend to create new material meanings.

This study uses a three-stage workflow of co-creation, fabrication, and materialization to bridge design gaps involving participatory/co-creative methods, generative AI tools, biomaterials or craft processes, and meaning derived from lived experience. By engaging participants in a co-creative process mediated by generative AI, which explores biomaterials and digital fabrication, this study introduces, as a novelty, the creation of three artifacts that reflect participants' agency over their lived experiences as a unique way of expressing subjective meaning. This study contributes to interdisciplinary debates on digital fabrication, craft, AI, and design by foregrounding participation, material agency, and subjectivity at a time when technological progress often outpaces attention to human experience and social justice. It argues for reconnecting design technologies with lived narratives, critical reflection, and speculative imagination, underscoring the continued value of these dimensions amid rapid technological change.

1.1. State of the art

The intersection of AI, data management, and community interaction has increasingly converged into practice-based applications,[1] such as in material exploration and design practice, thereby opening new possibilities for the conception and production of artifacts at the threshold of craft, digital fabrication, and material agency.

While most materials science literature highlights AI-driven discovery of new materials, task optimization, and faster prediction, many design-focused approaches emphasize different aims (esthetic exploration, experience, and situated meaning) than purely functional optimization.[2] This study contributes to the latter aspect by exploring the mediation of subjective lived experience and speculative materialization through a process combining biomaterial exploration, participatory/co-creative design, and generative AI tools.

In materials science, AI and machine learning are widely used to predict relationships between structure and properties and to optimize processing methods, thereby enhancing the development of new materials. These technological advances indicate significant changes in how material systems are understood and conceived,[3,4] shifting from trial-and-error methods to data-driven, algorithm-supported processes.[5] Although these advances are important, they often focus on functional improvement and tend to overlook the more contextual and exploratory interactions with materials through craft and design-led methods. In research related to design and craft, digital technology has been demonstrated to change how creators interact with materials and tools, where digital tools risk disconnecting the hand from the craft process, thereby challenging traditional human–material–tool dynamics.[6]

At the same time, participatory and co-creative design approaches emphasize involving users, especially marginalized ones in the context of this study, in the design process, granting them agency and voice in shaping outcomes.[7] When these approaches are combined with generative AI tools, new possibilities and tensions emerge: participants may engage with generative systems, interact with AI-driven suggestions or visualizations, and thereby become co-creators and active agents, rather than passive recipients of design outcomes. Research on AI and participatory design highlights the need to attend to power, agency, transparency, and meaning in the human–machine collaboration.[8] Within the fields of craft and digital fabrication, recent work has examined how AI and generative tools can support craft practices rather than replace them, for example, by enabling new forms of gesture-driven digital fabrication or by integrating AI-augmented workflows into human–machine collaborative processes.[9,10] This highlights AI as a tool of mediation and collaboration for technology-driven processes within craft practice[11] rather than an autonomous creator. This also emphasizes AI as a potential tool for encouraging reflection, critical thinking, and speculative imaginaries, especially when technology is employed as a generative tool for learning or co-creative and participatory processes.[12,13]

While much of the AI–materials literature focuses on high performance, particularly for functional biomaterials used in medicine,[14] craft- and design-led practices often take a more exploratory approach, engaging with material affordances, identity, subjectivity, and the politics of material form. By working with biomaterials, the designer or maker may encourage a more contextually grounded exploration of materials that resist purely techno-functional instrumentalization. In this context, the use of generative AI tools in design aids to mediate the relationships among participants, tools, materials, and artifacts. The digital–craft interface becomes a site of speculative meaning-making, where generative AI supports the exploration of form, structure, and fabrication possibilities. Participants bring their lived experiential knowledge (especially within identity-based exclusionary contexts), and the materialization through digital fabrication and biomaterial engagement anchors the artifact in the tangible world.

Although there is a growing body of work on AI-driven materials discovery and separate research on participatory or co-creative design with digital tools, this study advances relatively few studies that combine: (i) participatory/co-creative design methods, (ii) generative AI tools as mediators of form exploration, (iii) biomaterial or craft-oriented fabrication processes, and (iv) the agency of participants bringing identity-based lived experience. This research gap is addressed in this study by engaging participants in a co-creative process mediated by generative AI, which explores biomaterials, digital fabrication, and craft-inspired engagement to materialize artifacts that reflect their subjective ownership and lived experience. Rather than generating novel material for performance-driven design, the participatory and co-creative outcomes explore esthetic experimentation with biomaterials as a unique way of expressing subjective meaning. In particular, this paper emphasizes how generative AI can enable non-designer participants to engage materially and experientially with design processes and fabrication, rather than leaving it exclusively to design or engineering experts.

1.2. Project-based academic context

This approach was undertaken as part of a practical design project within a master's thesis in the Product and Industrial Design course at the University of Porto, Portugal, between 2023 and 2024. This Master's program fosters a project-based learning environment,[15-20] in which students are encouraged to work on real design problems, prototype their ideas, and critically analyze their creative processes. The program is primarily grounded in multidisciplinary collaboration across academic institutions, jointly managed by the Faculty of Fine Arts and the Faculty of Engineering at the University of Porto. This convergence between design and engineering education[19] fosters a strong connection with industry, leading to partnerships between the Master's course program and local industrial firms, enabling students to work on real briefs, constraints, and opportunities. The program also features a research-oriented approach, including a dedicated teaching unit on research methodology and the option for a scientific research dissertation or project.

2. Methodology

Within this background and project-based academic context, the practical development of this project, described in the following sections, adopted a methodological approach comprising human–AI collaboration[21] that undertakes participation and co-creation methods to actively engage participants in the design process[22-24] and grant them interactive agency over design decisions,[25-27] respectively. Contributing to the expansion of the intersection between participatory and co-creative design approaches,[28] this methodology was undertaken with three individuals whose subject experiences were consistently shaped by identity-based exclusionary processes (i.e., racialization, LGBT-phobia and transphobia, misogyny, xenophobia, and ableism, among others). For ethical reasons, the identities of the participants, who willingly agreed to respond to the survey, were anonymized. The objective of this study is to enable participants to express creative and subjective agency of their lived experiences by reimagining them through the materialization of a design artifact conceptualized with generative AI tools and produced through digital fabrication techniques.

During the co-creation phase, participants had full decision-making agency regarding the narrative elements included in their narratives, as well as the selection of images derived from them. In the participatory phases (including material base definition, material experiments, and artifact production), they actively engaged in design decisions that ultimately influenced the final outcome. This blend of co-creative and participatory phases enabled the focus on the participants' creative and decision-making agency while maintaining the realization of technical aspects of the design process (such as AI prompts and image generation, merging of images, conversion of two-dimensional files to 3D, and the 3D printing of both counter-molds and final molds) for the designer. This design process was undertaken in three stages: co-creation, digital fabrication, and materialization (Figure 1).

2.1. Co-creation

The objective of this stage was to design a 3D digital object based on each participant's interpretation of a lived experience relating to social exclusion. To this end, a co-creation methodology was developed (Figure 2), comprising three subsequent processes.

2.1.1. Memory to text: Data collection and surveys

The participants were asked to complete an open-ended survey centered on their social context and a significant object from their lived experience of discrimination, which they were invited to share. The aim was to collect words, expressions, and nuances of meaning that could help qualify the participants' experiential accounts in response to three questions. Question one referred to the object that was most relevant to the shared memory, requiring participants to disclose its main features or qualities and explain how that object could be used to address an experience of discrimination. Question two explored the context in which the discrimination experience took place, asking participants to describe the physical environment, the inner feelings caused by the aggressor, and their feelings toward the aggressor. The final question focused on the materiality of the experience, asking participants to identify the type of waste that was most relevant in such a context. The survey was also structured in a way that the output responses' syntactic morphology would relate to the typical syntax of a text-to-image generative AI art prompt.[29] Following the conventional order of subject, verb, and predicate, this prompt structure loosely framed the data collected from each participant's narrative. The data provided by participants are summarized in Table 1.

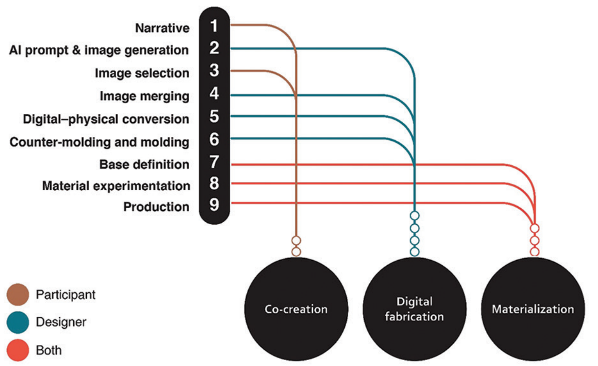

Figure 1. Map of the design process comprising methodological stages of co-creation, digital fabrication, and materialization
Abbreviation: AI: Artificial intelligence.

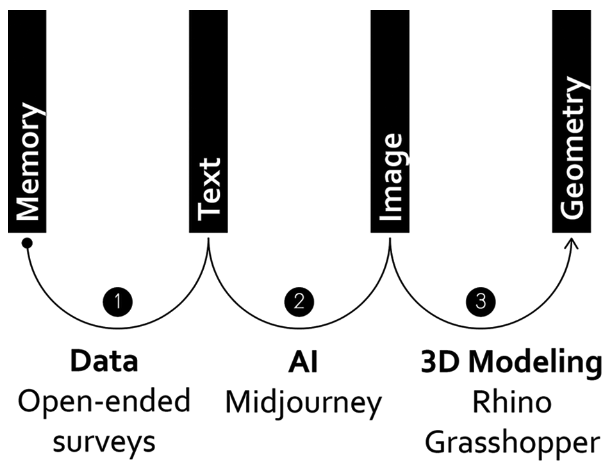

Figure 2. Methodology of the co-creation process
Abbreviations: 3D: Three-dimensional; AI: Artificial intelligence.

2.1.2. Text to image: Meaning beyond representation

After collecting and organizing data on each participant's experience, a series of prompts was created to visually translate these experiential narratives. This was undertaken in the Midjourney text-to-image generative AI model (version 5), which also allows for specifying a representational style as input data. In this case, however, such stylistic specification was intentionally excluded to avoid visually biasing the graphical results. In addition, Midjourney also allows for the insertion of descriptive prompt modifiers, such as "4K" or "16K," to simulate high fidelity or fine detail, as well as the customization of parameters, such as "--v" for version control, "--ar" for aspect ratio, and "—s," where "s" stands for lower and higher values to control how faithful to the prompt the AI tool will process the information. For each participant's narrative, the prompt was iteratively modified. The following example shows one of these prompt iterations: "A black transgender sentient, delicate being feeling rage, anger, shame, repulsion, and abjection when destroying a burning wooden pulpit, 8K --v 5 --ar 9:16 --s 100."

The objective of using AI in this creative exploration was to leverage the generative potential of AI techniques and tools, understood here in the Heideggerian sense of technology.[30,31] This concept originates from the field of philosophy, critiquing the common and current use of technology as framed by a modern mindset of resource optimization and control. When not enframed, technology may act as a form of poetic bringing-forth or an art-like revelation that cooperates with the world by uncovering processes and meanings beyond utility.

(a) Image creation and selection

A comprehensive set of images was produced for each experience, after which participants were requested to select the images that most accurately represented their own narrative, as illustrated by Figures 3-5. The number of images was a variable parameter, and its resulting numeric value depended on each participant's personal decision.

(b) Image merging
The image merging stage was designed to, on one hand, integrate each set into a single composite abstract image, and on the other hand, to minimize any representational characteristics that might suggest a fixed meaning, thereby moving away from symbolic signification. To achieve this, the Photomerge technique in Adobe Photoshop version 14 was applied to integrate overlapping regions across the images. Figure 6 displays the process of merging the images for each participant, where similar features among images within each set are identified and seamlessly joined. This process resulted in three composite images, as shown in Figure 7.

2.1.3. Image to geometry: Digital conversion

Once the images from each set were merged, the next step involved assigning them a third dimension. This two-dimensional-to-3D conversion was performed in Rhinoceros version 7 using algorithmic modeling with the Grasshopper 3D plug-in (version 1.0.007), employing a simple algorithmic definition, that is, a visual script made from connecting parameters and components (patches of code) to generate and manipulate geometry parametrically without traditional code scripting (Figure 8).First, the algorithmic definition was used to define an 800 × 450 mm^2 mesh, of which normal vectors were extracted for each patch. The normal vector's amplitude of each patch was equated to the merged images from the participants using the "Image Sampler" component. This component is capable of identifying color or brightness values from any given image and applying them to control design parameters. Given the mesh size and subdivision, the vector's amplitude was mapped to the corresponding brightness-scale control values of each image to define the final mesh topology across different displacement heights. With displacement intervals of 50 mm within a domain of 50 to 350 mm, and a maximum height of 30 mm, brightness values of 0 produced minimal Z-displacement (50 mm),

Table 1. Summary of participants' data collected in surveys

Parameters	Predicate				
	Verb	**Object**	**Object's features**	**Social context**	**Emotional response**
Participant A	Release/loosen	Hair	Curly and coiled	Racism on a school bus route	Confusion, rage, hatred, revolt
Participant B	Burn	Pulpit	Tall, aggressive, dark, and slender	Transphobia at a Pentecostal Evangelical Church	Shame, humiliation, dishonor, smallness, anger, rage, disgust, repulsion
Participant C	Crush and discard	Plastic bag	Rigid	Xenophobia in a supermarket	Inferiority, rejection, exclusion, injustice, displeasure, sadness

Figure 3. Participant A. Each panel of the figure shows a generated iteration output that was selected by the participant as the most representative of their experience.

Figure 4. Participant B. Each panel of the figure shows a generated iteration output that was selected by the participant as the most representative of their experience.

Figure 5. Participant C. Each panel of the figure shows a generated iteration output that was selected by the participant as the most representative of their experience.

whereas values of 100 produced maximum displacement (350 mm). This process generated a mesh morphology whose geometric topography directly corresponded to each input image (Figure 9). From this process, three digital artifacts were obtained, each corresponding to the narrative of a participant, as shown in Figure 10.

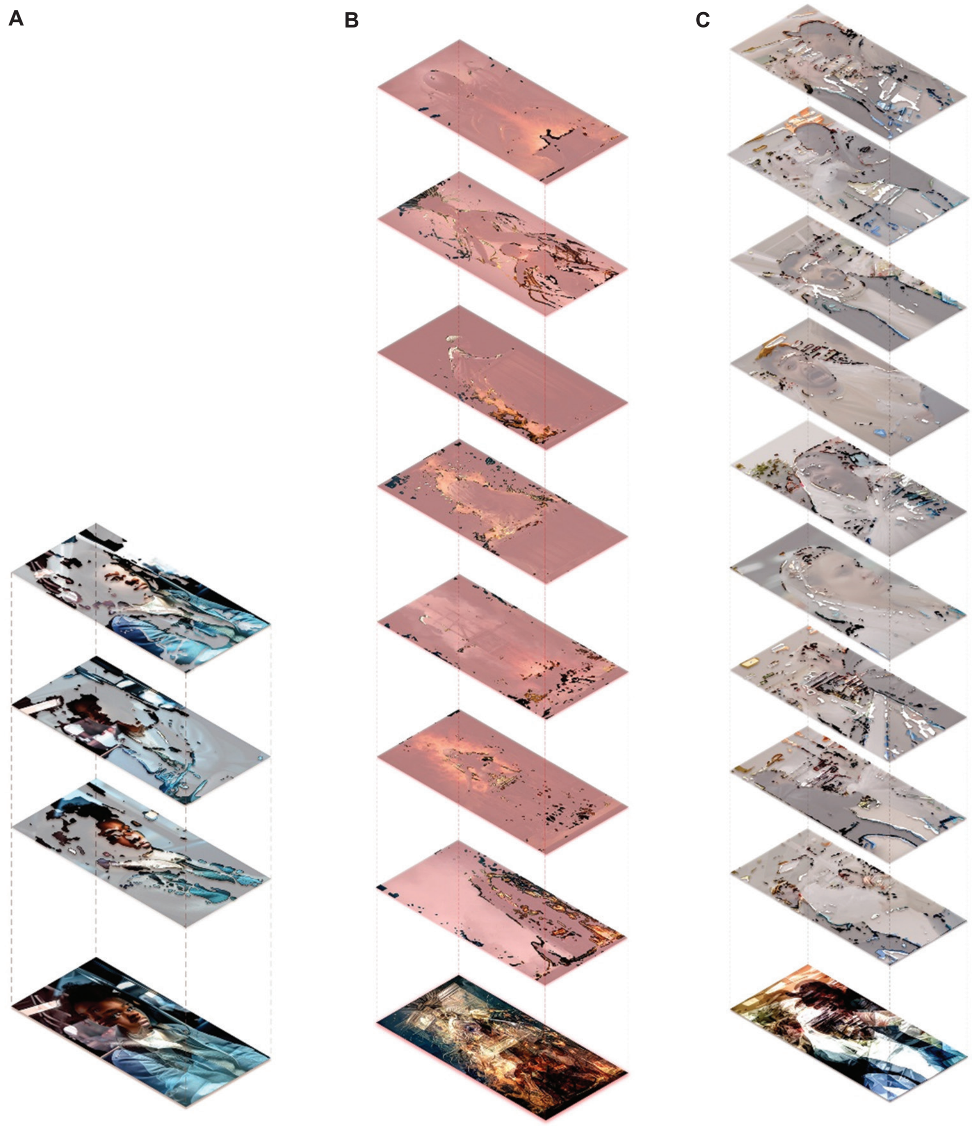

Figure 6. Merging images for each participant's selected images, accounting for overlapping regions. Images of (A) participant A, (B) participant B, and (C) participant C.

2.2. Digital fabrication

The production workflow comprised two main stages. In the fabrication stage, counter-molds were produced through 3D printing, from which silicon molds were created to enable an easier extraction of the final pieces. In the materialization stage, materials were selected, binding compositions were tested and refined, and the three narratives were ultimately materialized as artifacts. The production strategy is illustrated in Figure 11.

2.2.1. Mold fabrication

Once the 3D files of the artifacts were acquired, the next step involved creating molds to facilitate materialization.

The counter-molds were produced considering the maximum build volume of the Prusa i3 MK3S+ printer (Czech Republic) (250 × 210 × 210 mm) at the Product and Service Development Laboratory, Faculty of Engineering, University of Porto. Each digital artifact was segmented into 12 parts (200 × 150 × 30 mm each) (Figure 12) and converted into.STL files for 3D printing using the Prusa Slicer software (version 2.8.1) (Figure 13). The 3D printing process was conducted in a polylactic acid thermoplastic polymer widely used in 3D printing.[32] A 1.75 mm red filament (Tucab, Portugal) was used; the filament color was selected for practical reasons and did not influence the results. The other parameters were a layer height of 0.15 mm, an extrusion temperature of

Figure 7. Result of image merging. Images of (A) participant A, (B) participant B, and (C) participant C.

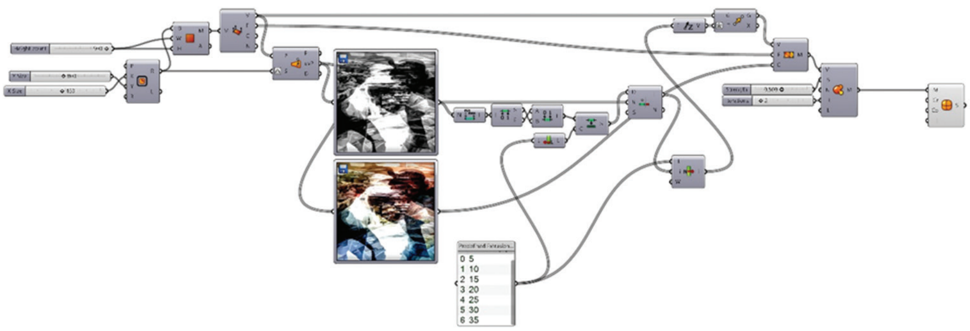

Figure 8. Algorithmic definition for three-dimensional image conversion

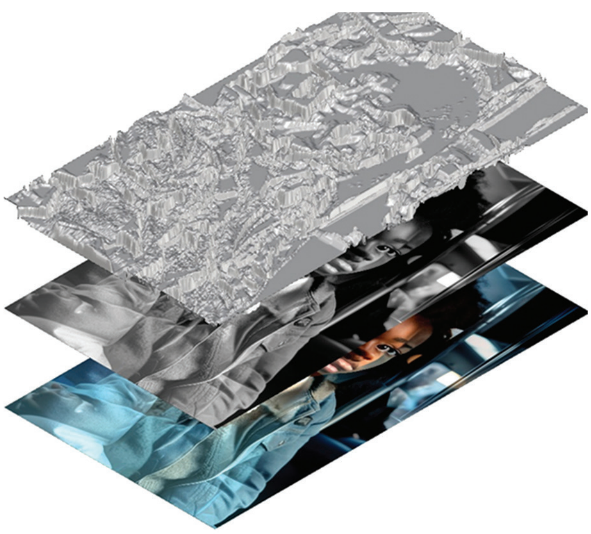

Figure 9. Outcome of the Image Sampler component applied to mesh deformation

approximately 210°C, a print speed of 60 mm/s, and an infill of 20%. These parameters were selected according to a performance criterion that balanced low weight, adequate resolution, and reduced fabrication time. Figure 14 shows the 3D printing of each of the 12 parts comprising one artifact.

For the production of the silicon molds, each set of 12 counter-mold parts was arranged on a wooden base measuring 1,030 × 680 × 25 mm, fitted within a frame of 1,080 × 730 × 45 mm to contain the silicon. Following the sequence defined in the design, each module was bonded to the base and to adjacent parts using a drop of cyanoacrylate, a fast-acting adhesive. To cover the counter-molds, an adequate amount of XIAMETER® RTV-4234-T4 (Dow Silicones Corporation, USA) industrial silicon was mechanically mixed and degassed in a vacuum chamber (Protoclick, Portugal)[33] with a catalyst before being poured over the assembly (Figure 15).[34]

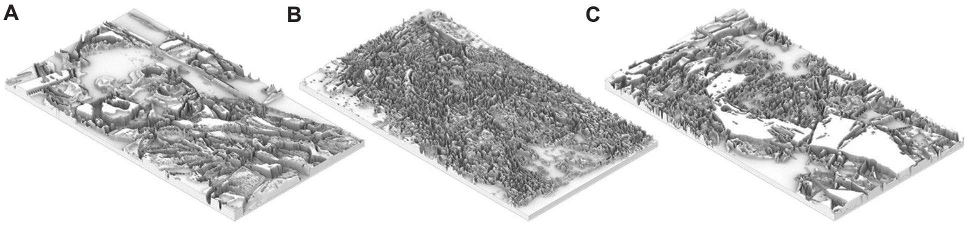

Figure 10. Outcome of three-dimensional mesh deformation. Outcomes of (A) participant A, (B) participant B, and (C) participant C

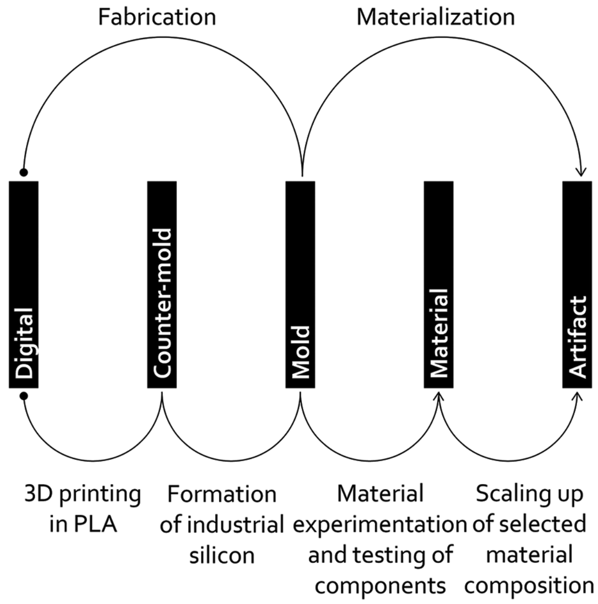

Figure 11. Methodology of the fabrication process
Abbreviations: 3D: Three-dimensional; PLA: Polylactic acid.

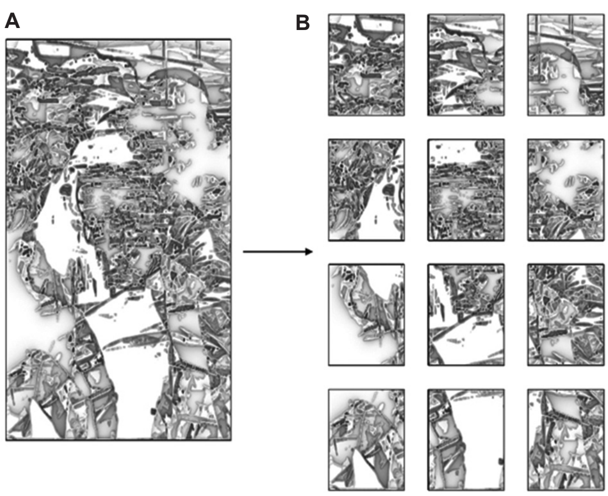

Figure 12. Segmentation of the digital model. (A) The full digital model before segmentation. (B) The same digital model segmented into 12 parts.

Figure 16 illustrates the silicon mold after it has dried and been removed from the wooden base. Each mold had an approximate weight of 13 kg.

2.3. Materialization

The materialization of the artifacts involved the preliminary development of biomaterials whose primary constituents were directly related to the materials of each object identified in the participant interviews. Following the co-creative agency of the methodology undertaken, the criteria for selecting these materials were left to the participants, guided by the final survey question about materiality. They were hair strands, wood ash, and plastic bags, as summarized in Table 1. Drawing on principles from emerging material disciplines, such as biodesign, biomaterials, and design for a circular economy, preliminary studies were conducted to develop biomaterial pastes with varying compositions, building on prior work. Following the material design guidelines explored in the Master's program on Industrial and Product Design at the University of Porto, which focused on waste materials for the circular economy,[18] the materialization process of the artifacts discussed in this paper was inspired by a preceding biomaterial experimentation. The methodological development of such experimentation assessed a wide range of base materials (such as used coffee grounds, vegetable peels, and eggshells), leading to the development of a circular tote bag made from garlic husks.[35] Characterization and evaluation of the biomaterial pastes enabled the development of a versatile composition capable of incorporating the three specified materials while meeting criteria such as dimensional stability, resistance to mildew, and resistance to mechanical impact. Each composition was poured into the corresponding mold, thereby assuming the 3D form equivalent to the previously conceived virtual image.

2.3.1. Biomaterial experiments

To develop a single composition capable of binding all the materials used, experimentation began with wood ashes, which were readily available during the development of the experiences. Drawing on compositions sourced from platforms such as Materiom and the Rhode Island School of Design Nature Lab, and scientific dissemination platforms including ResearchGate and MDPI, Composition 1 (Table 2) was prepared using plastic molds measuring 230 × 140 × 30 mm, greased with petroleum jelly to facilitate demolding.

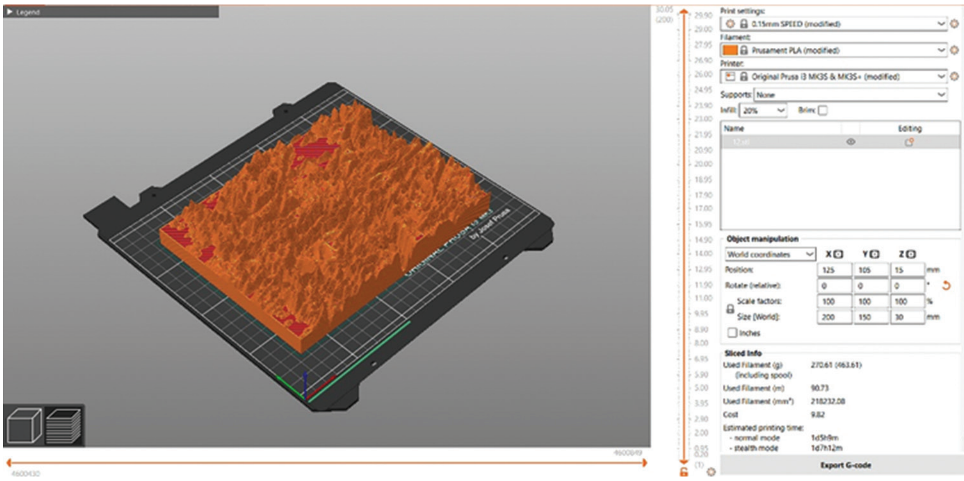

Figure 13. Preparation of the three-dimensional printing process of each counter-mold using the Prusa Slicer software

Table 2. Substances used in making the compositions

Composition	Substance	Amount
Composition 1	Water	300 mL
	Sodium alginate	45 g
	Wood ashes	60 g
	Glycerin	6 mL
	Gelatin	15 g
Composition 2	Water	150 mL
	Sodium bicarbonate	4 g
	Sugar	8 g
	Wood ashes	60 g
	Gelatin	60 g
Composition 3	Water	100 mL
	Glycerin	12 mL
	Sodium bicarbonate	4 g
	Wood ashes	120 g
	Gelatin	30 g

The liquid substances were combined in a container, while the solid substances were aggregated in a separate one. Both were then combined, without fusing, using heat, and poured into a single container to be air-dried. Figure 17 displays the result of the experiment using Composition 1, where the material's fragility and prolonged drying time rendered it unsuitable for the project.

Composition 2 was also inspired by the sources cited above and developed accordingly (Table 2). The preparation process followed the same procedure as before, in which liquid and solid substances were combined separately before mixing. However, in this and the subsequent compositions, heat fusion was applied using a FLAMA (Portugal) 8170FL gas stove for 270 s at an approximate power of 6,800 W. Figure 18 presents the result of the experiment using Composition 2. The material was considered unsuitable for large-scale applications due to its dimensional and shape instability.

The third test composition differs from the previous one by omitting sugar and by adjusting the quantities of the other binding agents (Table 2). Figure 19 shows the result of Composition 3. The resulting material demonstrated relative dimensional stability, mechanical and mold resistance, reduced drying time, and ease of demolding, making it suitable for replication with the other substances identified in Table 1, "object" column. It is also relevant to highlight the role of each component: gelatin as a thickening agent, cornstarch as a material commonly used in the production of gums and bioplastics, glycerin as a plasticizer, and sodium bicarbonate as a fungicidal agent. Accordingly, Composition 3 was used in the following experiments, considering substance replacement. Therefore, the following experiment replaced wood ashes with an equivalent amount of shredded plastic bags, while the subsequent experiment utilized hair as the primary substance. Respectively, Figures 20 and 21 present the results of an experiment that exhibited consistent characteristics when compared to the preceding experiment, undertaken with wood ashes.

This multivalent composition, adaptable across different materials, was therefore deemed suitable for large-scale application in the materialization of the artifacts. Table 3 offers a summary of the experiments conducted until arriving at the multivalent formula.

2.3.2. Biomaterial to artifact

Scaling the composition was necessary to achieve an adequate volume for producing the final artifacts. This

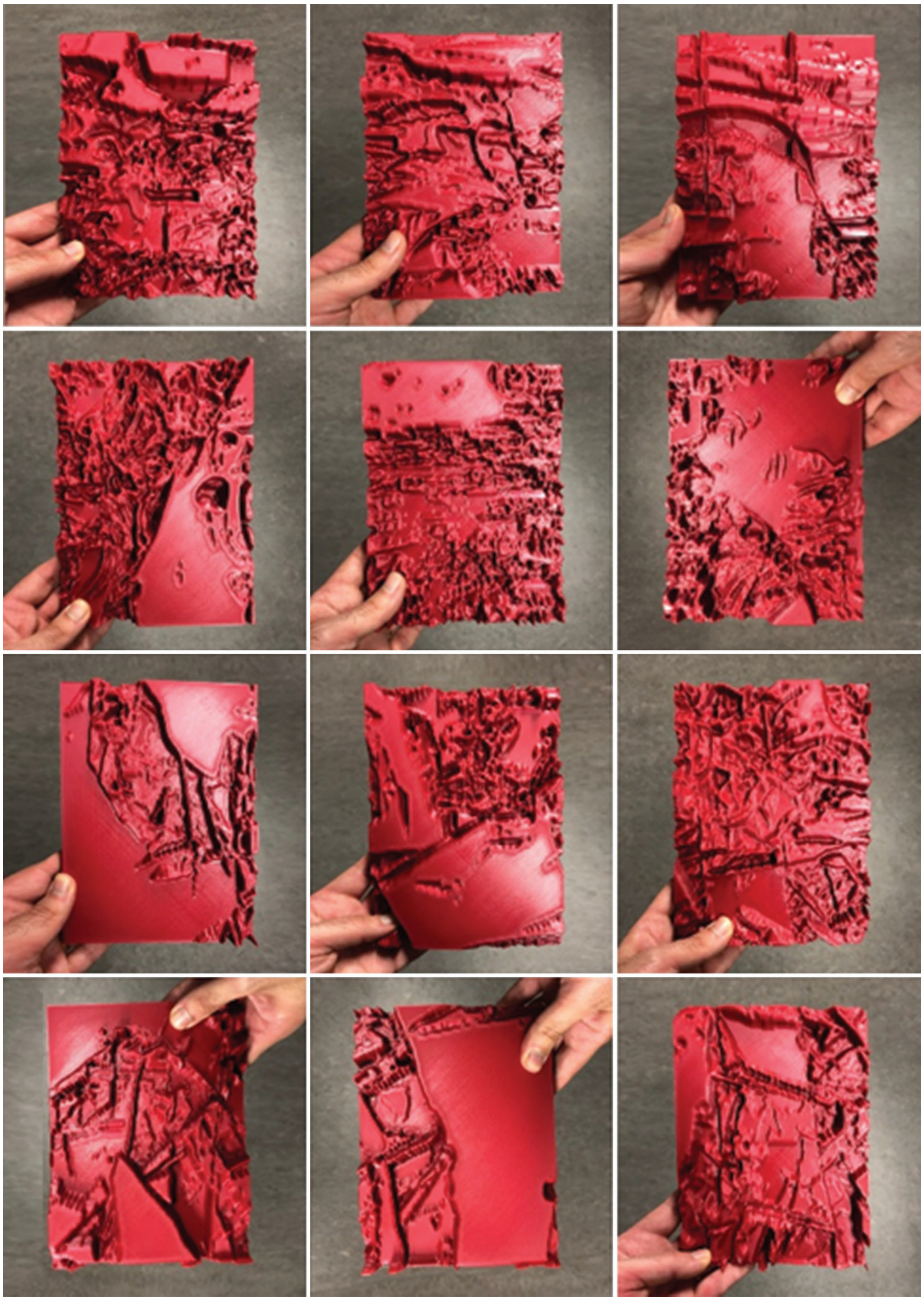

Figure 14. Set of 12 counter-mold parts produced through three-dimensional printing being poured over the assembly (Figure 15).[34]

was carried out in direct proportion to the volume of the artifacts, with quantities calculated in the Rhinoceros 3D modeling software (version 7). Using the amount of water as the reference parameter for scale-up, the volume of each artifact was set at approximately 2,000 mL, corresponding to a 20-fold increase in compositional scale. Table 4 shows the formulation.

Following this scaling procedure, the three artifacts were produced by casting the pastes into the molds, allowing them to cure for 12 h before demolding.

3. Results and discussion

Figure 22 presents the results of the materialization of narratives from participants A, B, and C into design artifacts.

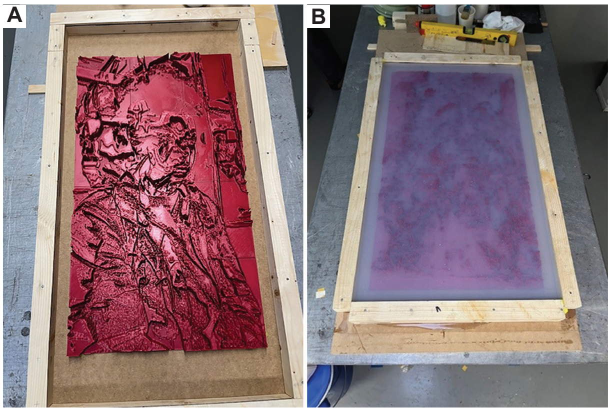

Figure 15. Silicon mold production. (A) The positioning of artifact components on a wooden base. (B) The industrial silicon pouring process

Figure 16. Prepared silicon molds ready for use

Figure 17. Experiment using composition 1

The artifacts developed in the presented project aim to evoke viewers' own modes of perception of the artworks co-created with the participants through the semiotic potential of the intersection of material, form, and image in a de-representative esthetics. In doing so,

Figure 18. Experiment using composition 2

Figure 19. Experiment using composition 3

Figure 20. Experiment using shredded plastic bags in composition 3

Figure 21. Experiment using hair in composition 3

they avoid symbolic signification or the fixed meanings of signs imposed by established representational systems. The artifacts thus propose, at least from a philosophical standpoint, a poetic provocation to symbolic signification in the loss of fixed meaning within the subject–object domain. This is achieved by evoking a form of affect that is unconditioned by the established sets of symbols familiar to our common form of world perception.[36,37] Within this process, combined with biomaterial exploration and participatory co-creative methodologies, AI is not intended to be employed as an instrumental tool, but rather as a mode of revealing something, in line with a

Figure 22. Biomaterial design artifacts. Outcomes of (A) participant A, (B) participant B, and (C) participant C

Table 3. Summary of biomaterial experiences until arriving at the multivalent formula

Substances	Composition		
	1	2	3
Base substance			
Wood ashes, shredded plastic bags, or hair			
Base solvent			
Water (mL)	300	150	100
Thickener agents			
Sodium alginate (g)	45	-	-
Gelatin (g)	15	60	30
Cornstarch (g)	-	30	15
Sugar (g)	-	8	-
Plasticizer			
Glycerin (mL)	6	-	12
Antifungal agent			
Sodium bicarbonate (g)	-	4	4

Table 4. Scaled composition of composition 3

Substance	Amount
Water	2,000 mL
Base substance	2,400 g
Glycerin	240 mL
Sodium bicarbonate	80 g
Gelatin	600 g
Cornstarch	300 g

Heideggerian sense of technology. Accordingly, the act of poetic creation at the intersection of critical thinking, social concerns, and technology becomes a space for exploring perception, stretching beyond the limits of representation. In such an endeavor, apprehension may potentially move beyond signification toward another mode of meaning-making grounded in experience, wherein the intensity of what is felt by the participant provokes a direct affect in the viewer.

4. Conclusion

This study explored the intersection of generative AI, biomaterial experimentation, and participatory and co-creative methodologies in a practical design project, providing a tangible way to reimagine lived experiences shaped by identity-based exclusionary processes. Instead of focusing on the AI-driven discovery and design of new technological materials, this study highlighted design as a mediating process among human experience, critical thinking, biomaterial exploration, craft practice, and digital fabrication processes. Through the integration of co-creation, fabrication, and materialization, the study used AI as a critical collaborator/mediator between subjective narratives and tangible speculative artifacts.

During the co-creation stage, participants expressed their critical perspectives on personal experiences as visually reimagined scenarios. This was achieved through a process that included data collection through open-ended surveys, visualization with text-to-image generative AI, and the conversion of these into digital objects using algorithmic 3D modeling. This process granted participants speculative agency in critically shaping alternative imaginaries of their lived experiences, showing how generative AI can potentially enable new forms of social engagement when aligned with participatory and co-creative design methodologies. The digital fabrication stage converted digital objects into physical counter-molds using 3D printing. Subsequently, silicon casting from these counter-molds was employed to facilitate an easier removal of the final molds, reinforcing the reciprocal relationship between digital and artisanal creation in contemporary craft and design. Finally, the materialization stage established a direct link between biomaterials and participants' critical narratives by incorporating symbolically charged substances (hair, wood ash, and plastic bags) into exploratory biomaterial compositions. Grounded in principles of biodesign and circular economy, these compositions demonstrated the expressive and affective potential of biomaterials as carriers of identity, memory, and speculative critique.

The resulting artifacts encourage the viewer to engage with meaning by inciting a singular interpretation rather than relying on fixed symbolic representation, using AI not as a mere tool but as a mode of revealing, which aligns with Heidegger's critique of technology. By integrating generative AI into a co-creative and participatory design process exploring biomaterials, the project demonstrates how technological mediation can be used, both critically and artistically, to support socially engaged, embodied, and ethically conscious practices of creation.

This study thus contributes to the ongoing interdisciplinary discussion on digital fabrication, craft making, AI, and design practices, highlighting the importance of participation, material agency, and subjectivity at a time when technological progress continues to be prioritized over human experience and social justice, rather than ethically developed alongside them. This study emphasizes that, despite the era of prominent technological advancements, there remains significant value in reconnecting design technologies with lived narratives, meaning-making, critical thinking, and speculative imagination. Future work may involve enhancing the methodological approach by further increasing participants' engagement and extending this approach to wider collective settings, integrating additional forms of biological or waste materials, and further investigating how generative AI can enhance co-creative authorship and biomaterial exploration within ecologically oriented and socially engaged design contexts.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Guilherme Giantini
Data curation: Guilherme Giantini
Investigation: All authors
Methodology: All authors
Project administration: All authors
Resources: Lígia Lopes, Jorge Lino Alves
Supervision: Lígia Lopes, Jorge Lino Alves
Validation: Lígia Lopes
Visualization: Guilherme Giantini
Writing–original draft: All authors
Writing–review & editing: All authors

Ethics approval and consent to participate

No specific ethical approval was required for this study, as the master's committee responsible for reviewing the original research determined that the survey's statement would sufficiently cover participants' consent. Permission was obtained from participants in written format. By participating in the anonymized survey, participants agreed to provide and grant permission for the use of their shared data. These data are limited to subjective information (i.e., subjective perceptions, opinions, and claims).

Consent for publication

By participating in the anonymized survey, the participants granted their permission for the use of their shared subjective data, which includes publication for scientific and artistic purposes.

Availability of data

The original data presented in this study are openly accessible in *Repositório Aberto da Universidade do Porto* at https://hdl.handle.net/10216/164287.

Further disclosure

This is the first English-language version of this work. The research underpinning this paper was originally presented in a Portuguese-language master's level thesis (December 2024), which is available at https://hdl.handle.net/10216/164287.

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