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Kuchner, Ulrike; Nasser, Mona; Steyaert, Pieter; Maranan, Diego S.; Birsel, Zeynep; Haines, Agatha; Peeters, Ann; Vermeulen, Angelo C.J.

Important note
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Biomodd: The integration of art into transdisciplinary research practices

Biomodd is an artistic project with the potential for supporting transdisciplinary practices in blended virtual and in-person environments. After describing the project components, we discuss the collaborative process of idea generation and participant engagement.

Ulrike Kuchner (iD), Mona Nasser (iD), Pieter Steyaert (iD), Diego S. Maranan (iD), Zeynep Birsel (iD), Agatha Haines (iD), Ann Peeters, Angelo C. J. Vermeulen (iD)

Abstract

In this paper, we argue for the integration of collaborative art practice in transdisciplinary (TD) research to generate ideas and engage researchers and non-academic stakeholders. We draw on the virtual and in-person (hybrid) participation of members of the TD collective *Space Ecologies Art and Design (SEADS)* during *Biomodd,* an art installation that addresses global challenges in ecology, humanity, technology, and technological waste. Using survey responses, diaries, and meeting minutes, we reflect on the process, methods and ideation during *Biomodd* and map them to the concept of the "idea journey" discussed by Jill E. Perry-Smith and Pier Vittorio Mannucci. We find that while in-person ideation was driven by utility, materiality, and emergence, the hybrid mode provided favorable conditions for a feedback loop of expansive, individual experimentation and online sharing.

Keywords

art-science collaborations, co-creation, community art, e-waste, hybrid creation, idea generation, innovation, transdisciplinary sustainability research

Partnering art and science

Transdisciplinary (TD) collaboration is central to sustainability research, employing interactive, community-based, or participatory approaches. Simultaneously, working across disciplines is also the most common challenge for sustainability researchers (Aminpour et al. 2020). Numerous challenges stem from the plurality of TD ontologies and methods, imbalances in teams, and lack of integration (Wiek 2007, Lang et al. 2012). *Biomodd* focuses on engaging diverse researchers and practitioners across art and science in creative ways, independent of problem-solving, for critical reflections on topics of societal and environmental concern and relevance. We argue that this quality of *Biomodd* has the potential to enrich TD methodology.

Collaborations that bring together art and science are a rapidly evolving feature in applied research and innovation – as evident from, for example, the European *S+T+ARTS* initiative[1], the June 2020 *Science, Technology and Industry Policy Paper* of the Organization for Economic Cooperation and Development (OECD 2020) and a plethora of output in art production, art theory, and arts-based research, which employs creative expression and artistic knowing as a primary mode of inquiry (McNiff 2012, Catts and Zurr 2018, Schnugg 2019, Kuchner 2022). Birsel et al. (forthcoming) recently defined the growing art-science-technology landscape as situated at the intersection of art-based research, transdisciplinarity, and collaborative art. The *SHAPE-ID* project[2] has provided recommendations for the integration of arts, human-

Ulrike Kuchner, PhD, MFA (corresponding author) | University of Nottingham | School of Physics and Astronomy | Nottingham | UK | ulrike@seads.network

Prof. Mona Nasser, DDS, MSc, PhD | University of Plymouth | Dental School | Plymouth | UK | mona@seads.network

Pieter Steyaert, MFA | University of Antwerp | Department of Training and Education Sciences | Antwerp | BE | pieter@seads.network

Assoc. Prof. Diego S. Maranan, PhD | University of the Philippines | Open University | Faculty of Information and Communication Studies | Laguna | PH | diego@seads.network

Zeynep Birsel, MA | Erasmus University | Erasmus School of History, Culture and Communication | Rotterdam | NL | zeynep@waag.org

Agatha Haines, PhD | University of the Arts London | Central St Martins | London | UK *and* University of London | Goldsmiths | Department of Design | London | UK | agi@seads.network

Ann Peeters, MA | Erasmus Brussels University of Applied Sciences and Arts | Department of Design & Technology | Brussels | BE | ann@seads.network
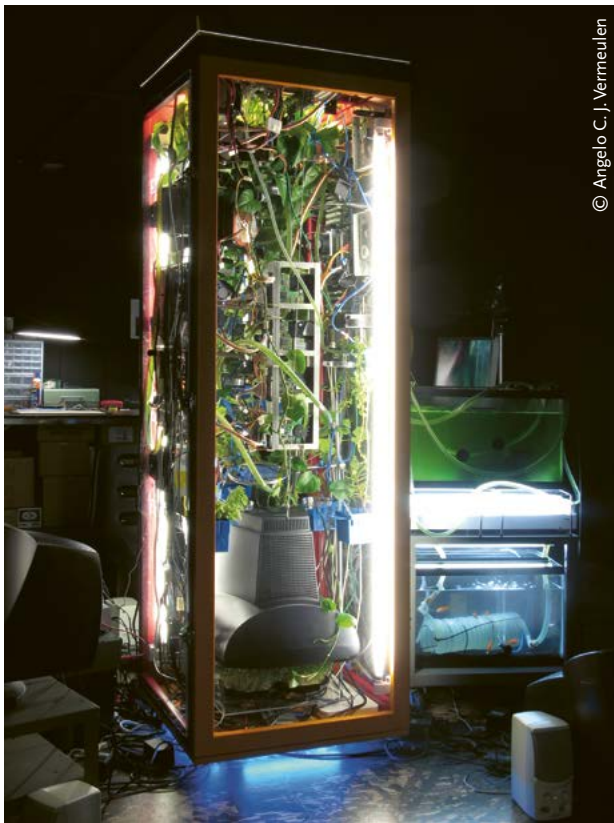
Angelo C. J. Vermeulen, PhD | Delft University of Technology | Faculty of Technology, Policy and Management | Delft | NL | angelo@seads.network

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BOX 1: The *Biomodd* project

Biomodd art installations reimagine the relationship among nature, technology, and people. They are overseen by the open TD collective *SEADS (Space Ecologies Art and Design)* and are developed together with local communities. Over the past 15 years, 33 independent *Biomodd* installations have been created worldwide with the help of hundreds of people (figure 1). While no two *Biomodd* installations are exactly alike, a typical *Biomodd* installation has novel features such as those listed below:

- integrating living ecosystems with electronic waste components reassembling functioning computers;
- computer-generated waste heat repurposed to create microclimates for sustaining organisms such as plants and tropical fish;
- liquid cooling of computers through living cultures of microalgae;

- aquaponic systems of warm algae heating fish tanks that boost the fish's metabolism, thereby increasing nutrients in a hydroponic plant growth system;
- an open-source multiplayer game that can be played by audiences;
- organisms and humans become participating agents in the virtual world;
- reiterating the same concept in different cultures with different needs, thereby resulting in different outcomes and interpretations.

While we have written about *Biomodd* as an educational experience (Librero et al. 2011, Maranan and Librero 2014) and, thus, a potential learning platform for real-world experiments (Singer-Brodowski et al. 2018, Krütli et al. 2018) and in a university setting (Thieme and Fry 2023, in this issue), in this paper, we examine *Biomodd* as a participatory artistic project and generator for ideas.

FIGURE 1: *Biomodd [ATH[1]]*, the first *Biomodd* installation in Athens, OH, US in 2007.

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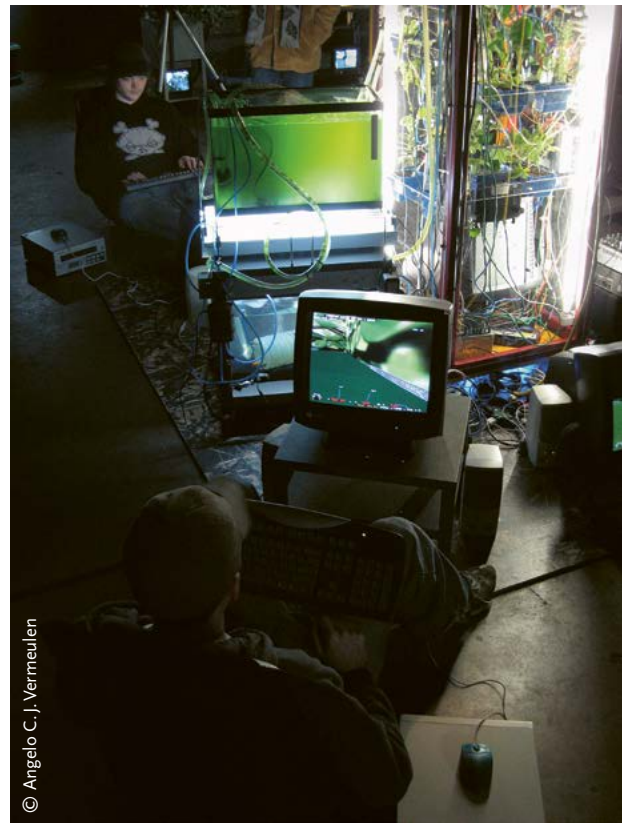
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ities, and social sciences with science and technology partners (Vienni-Baptista et al. 2019). A purposeful integration of socially engaged collaborative art practices and arts-based pedagogies into sustainability research creates a prominent space for ideation. *Biomodd* establishes such a space.

The *Biomodd* project and *Biomodd [BRG[13]]*

Biomodd[3] is an ongoing series of temporary art installations referencing ecology, progress, consumer culture, and technological waste (box 1). In this paper, we offer a critical reflection of *Biomodd* as a case example for a long-term TD project situated in

the realm of sustainability that produces art (e. g., van Eck and Lamers 2013, Maranan and Vermeulen 2015). Transdisciplinarity can be understood as the system of thought that brings out a more holistic understanding of a complex world, of which one of the imperatives is the "overarching unity of knowledge" (Nicolescu 2010, p. 22), thereby advocating in favor of maintaining diverse views on conceptualizing TD. *Biomodd's* collaborative re-

1 *https://starts.eu*
2 *Shaping Interdisciplinary Practices in Europe, www.shapeid.eu*
3 *https://seads.network/hyperproject/biomodd*

search and creation approach follows this logic in the sense that the imperative to solve a predefined problem is not central to its research and co-creation ambition, as is the case for the Mode-2 view (Nowotny et al. 2001). The *Biomodd* project itself builds the scaffolding that outlines the general context, structure, and main tools; however, participants of each version of the series uniquely define their own rules for interaction, questions, and ideas to pursue by virtue of co-creation. This approach promotes joint problem-framing (Pearce and Ejderyan 2020) and rapid collaboration and experimentation amongst all stakeholders while critically addressing assumptions regarding interactions among natural, technological, and social systems.

One of the goals of *Biomodd* is to enable stakeholders envisage a range of alternative futures for the addressed themes and their associated system drivers, including emotions and information that may identify triggers and criteria for possible pathways. Outcomes have included artwork, research papers, integration and exchange of knowledge, and the generation of new ideas, propositions, and procedures. Thus, the *Biomodd* project has evolved within a wider change in the role of the arts from "a primarily solitary practice involved with its own internal dialogue to one actively seeking a larger discourse" (Gilbert and Cox 2018, p. 4). The project belongs to a vibrant movement of creative practitioners that utilize arts-based research and practice for sustainability (other examples include Macklin and Macklin 2019, *Salikhain Kolektib*[4], *Ethics – Durability – Ecology – Nature [EDEN]*[5]) that support the creation of differentiated bridges between science and practice (Grunwald et al. 2020).

In 2020, we were invited by Musea Brugge in Bruges, BE, to build a new version of *Biomodd*. For the remainder of this paper, our discussion of *Biomodd* will focus on this version, which is called *Biomodd [BRG13]*. Borne out of necessity during the COVID-19 pandemic, the participatory practice of *Biomodd* was shifted to a blended process of online (i.e., virtual) and offline (i.e., in-person) aspects of participation, which we refer to as "hybrid" throughout this paper. The recent increase in hybrid collaborations has fundamentally transformed research and resembles today's mode of TD (Schulte-Römer and Giesing forthcoming). However, hybrid work comes with drawbacks and concerns of limiting engagement and creativity (Babapour Chafi et al. 2021). For example, Brucks and Levav (2022) reported experimental evidence that online videoconferencing inhibits the generation of ideas, which they attribute to a narrowing of the cognitive focus (i.e., arising thoughts and associations). Nonetheless, they found that selecting which idea to pursue works well while collaborating virtually. We add to this discourse by investigating how the hybrid art practice of *Biomodd [BRG13]* reflected on idea generation and participant agency. In doing so, we suggest that the integration of art in TD research and practice could enrich hybrid TD research by providing tools for engagement and ideation.

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4 *www.salikhainkolektib.com*
5 https://starts-prize.aec.at/en/eden
6 Data available at https://seads.network/project/biomodd-participation-survey.

Understanding where ideas come from

For our analysis, we apply the concept of the "idea journey" given by Perry-Smith and Mannucci (2017, 2019) and Mannucci and Perry-Smith (2022) to *Biomodd [BRG13]* to examine whether and how *Biomodd [BRG13]* facilitated participant agency and activated idea generations in its collaborators. Perry-Smith and Mannucci (2017) defined the journey of ideas in four stages from conception to completion: *idea generation, elaboration, championing,* and *implementation.*

The first phase of the journey, *idea generation,* is defined as the process of forming and relating different creative and unpredictable ideas and (self-)selecting the most promising one(s). This could be the core idea for a research paper, a new product, or art piece. Perry-Smith and Mannucci (2017) found experimental evidence that in this phase, activating weak ties in networks – that is, distant people with diverse approaches, opinions, and knowledge leads to exposure of unusually stimulating viewpoints and perspectives, thereby inspiring novel ideas. We argue that this setting resembles the environment of *Biomodd [BRG13]*. In the second phase, *idea elaboration,* novel ideas are developed through experimentation, prototyping, and discussion, and then internally evaluated with the project's vision in mind. During this phase, creators require emotional support and feedback to reduce uncertainty and to expand ideas. This could be the development of a draft, lab tests, or prototypes to probe the viability and feasibility of the idea. This resembles the core practice of *Biomodd [BRG13]*. In the third phase, *idea championing,* ideas are promoted so that they may be accepted and implemented. This phase requires social influence and legitimacy. This could be the submission of a paper to a journal or presentation of the elaborated concept or product. The final phase, *idea implementation,* is determined by production, where ideas are turned into something tangible, like a finished product, artwork, service, or process. In this paper, *implementation* refers to ideas that became part of *Biomodd [BRG13]*'s art installation.

A *Biomodd* installation is an amalgam of ideas generated at different moments in time and implemented at different speeds (figure 2). Therefore, *Biomodd* creations are characterized by flexible, interconnected, and iterative phases that call into question the linear phases of the "idea journey" concept. Thus, we revisit the concept in order to investigate the ideation process during *Biomodd [BRG13]*.

Data and methods

This article is based on available data[6] that was collected as part of an internal evaluation of *SEADS* collective members on the process during *Biomodd*.

Online survey of *Biomodd* participants

We surveyed participants of *Biomodd [BRG13]* and previous *Biomodd* versions to gauge past and current *Biomodd* processes. An email was sent with the online survey information and link on
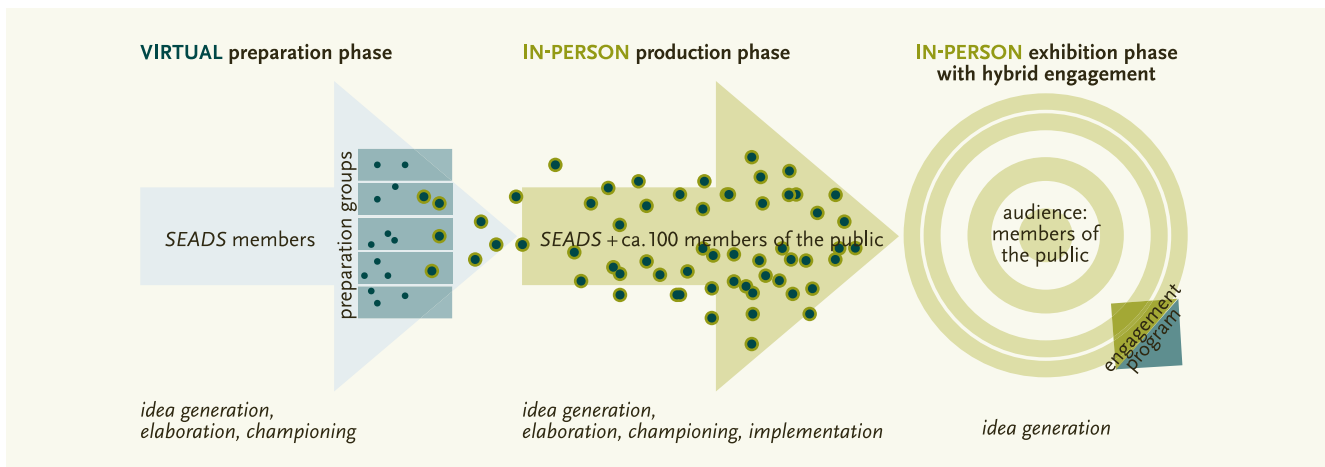
FIGURE 2: Schematic overview of the components of the *Biomodd [BRG¹³]* art installation, folding in the "idea journey" concept from Perry-Smith and Mannucci (2017). **Dark green** denotes virtual, and *light green* denotes in-person participation. Five preparation groups of *Space Ecologies Art and Design (SEADS)* collective members from a variety of disciplines met online for six months to generate, elaborate, and champion ideas that were prototyped in the individuals' environments. Several *SEADS* members participated in the in-person production phase of the installation. They were joined by approximately 100 members of the public. Finally, the audience experienced and interacted with the installation to generate their own ideas.

April 20, 2021. Follow-up emails were sent after two weeks and again before closing the survey. We received responses from 23 members, yielding a response rate of 16%. The participant group included, amongst others, academic researchers, art and design practitioners, engineers, and technologists from Europe, South America, and Southeast Asia. The survey consisted of nine open-ended questions that addressed the following four general areas:

- capturing past and present contributions of the participant to *Biomodd;*
- *Biomodd's* effect and impact on the participant;
- process and experience of co-creation, bottom-up design, and shared authorship;
- *Biomodd's* impact on participants' inquiries related to sustainability.

Additional data is drawn from diaries, chats, posts, meeting minutes, conversations, and personal reflections and observations of the authors. Participants used online documentation and a dedicated *Discord* server – an instant messaging and digital distribution platform – to track, communicate, record, and store ideas, sketches, and experimental prototyping. We chose *Discord* because it allows for a "work-out-loud" approach (Aten et al. 2016) where ideas can grow in parallel through dedicated channels, while offering "virtual visits" to the installation site through its video channel to create a shared sense of presence.

Further, to investigate the *Biomodd [BRG¹³]* creation process, we used an adapted approach from Gale et al. (2013), which describes the use of the *framework method* (Ritchie and Lewis 2003) for the analysis of qualitative data. Specifically, we mapped the data from interviews, notes, and observations across the existing framework of the "idea journey" concept given by Perry-Smith and Mannucci (2017, see above). We highlight and explain

any findings that diverge from the concept and use quotations from participants to more clearly demonstrate the discussed issues or themes. Finally, we highlight the journey of two specific ideas novel to *Biomodd [BRG¹³]:* Winogradsky columns incorporated into a multiplayer game and virtual and augmented reality for hybrid audience participation (box 2).

Creating and facilitating community building, participation, and making during *Biomodd [BRG¹³]*

We summarize the setup of *Biomodd [BRG¹³]* in figure 2 and describe it in this section. Six months before the exhibition, approximately 50 members of *SEADS* collective split into five preparation teams that regularly met online. Each team was focused on a different aspect of the project, related to key guiding questions that stem from artistic or conceptual principles of *Biomodd:* biotechnological integration of microorganisms, a custom-built interactive multiplayer game, nonconventional interfaces to interact with the virtual world and with living organisms, and engagement of the public. Each online team was led by one or   >

BOX 2: Winogradsky columns, virtual and augmented reality

Winogradsky columns are model microbial ecosystems that are set up from pond sediment in a clear cylinder with a carbon source, such as newspaper, and incubated with light. It is a classic experiment to demonstrate the role of microorganisms in environmental processes.

Virtual reality (VR) is a computer-generated simulation of a three-dimensional environment that enables users to interact with it in a seemingly real or physical manner.

Augmented reality (AR) is a technology that overlays computer-generated images onto a user's view of the physical world. This enhances the user's perception of reality and provides an enriched experience.

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FIGURE 3: Final installation view of *Biomodd [BRG¹³]* at the Saint John's Hospital in Bruges, BE.

two *SEADS* members. The physical installation of *Biomodd [BRG¹³]* was created without a specific a priori design concept (emergence) in the historical site of the Saint John's Hospital in Bruges, Belgium (figure 3). Approximately 100 members of the public joined voluntarily on site for the production phase, which lasted for four weeks. A few participants were actively invited to join based on their skills or knowledge. However, the majority followed a call-out campaign, which led to a diverse group of community representatives with no or partial understanding of *Biomodd* and its themes. The exhibition was opened to the public from June 26, 2021 to August 29, 2021.

Biomodd's methodology is based on co-creation, emergence, and experimentation. Within the context of *Biomodd,* co-creation has been defined as "a cross-boundary collaboration where people are invited to transcend their self-defined professional expertise and work on different aspects of the project" (Vermeulen et al. 2018, p. 173). Participatory workshops like the e-waste recycling workshop (figure 4) are central to community-building in *Biomodd*. Salvaged electronic components were re-assembled into an operational local network connected to the Internet and to a light and sound system. This was used to run a custom-designed multiplayer computer game, which was played by the exhibition audience (figure 5). Gamers (i.e., engaged citizens) virtually influenced the environment of living plants that were

part of the art installation. Real-time measurements of changes in the plants were fed back into the game. *Biomodd's* emphasis on experimentation and emergence invites collaborators to think through art and design, as described in Frayling's (1993) seminal paper *Research in Art and Design*. This refers to a means of approaching problems that involve the use of creative, artistic, and design principles to come up with new solutions.

Findings and discussion

We summarize our findings regarding participation and the idea journey in figure 6 (p. 150), which presents a conceptual framework of practice and ideation during *Biomodd [BRG¹³]*.

Practice: Participation and engagement during *Biomodd [BRG¹³]*

Participants joined the project for a variety of reasons, including curiosity, the promise of exploring questions of the co-existence of nature and technology, the opportunity to craft an inventive vision of the future, personal development and social bonding, or for professional advancement. Varied experiences, new ways of learning, and being part of a diverse community was highlighted by several participants, including those who commented

in the survey that "the project has infused me with the principle of harmonious and productive coexistence", and that the *Biomodd* environment "brought me comfort". Other participants were motivated by *Biomodd* providing "the kind of knowledge that I know I wouldn't get anywhere else" and "to translate climate anxiety into creative output". When asked about their experience of co-creation during *Biomodd,* participants responded with comments

FIGURE 4: Community members from the city of Bruges, BE, join *Biomodd [BRG¹³]* during the in-person building of the installation. This includes workshops in which participants are guided in the repurposing of salvaged electronic components (top, center) and reconstituted computers (bottom).
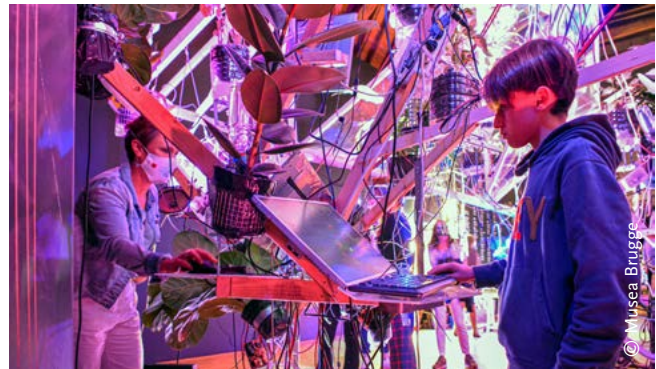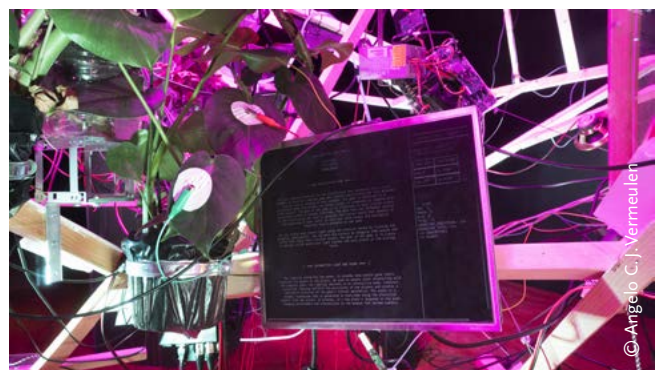

FIGURE 5: Detail of the installation displaying the Winogradsky columns (top) with plant sensors collecting data as input (center) for the multi-player game played by visitors of the installation (bottom).

related to social trust and liberation. *Biomodd's* co-creation approach successfully enabled "often overlooked voices to come to the fore" while improving awareness of the participants' position in the group as well as their perspectives and learned behaviors. Being part of a wide TD collaboration was challenging for a few, particularly when they found themselves distant from their core discipline. However, at the same time, this approach allowed for "eye-opening inputs". For the participants, the outcomes bore "the thumb-mark" of each collaborator, thereby alluding to a co-creation that retains individual characteristics.

Several fundamental characteristics of previous in-person-only *Biomodd* instances (left-hand side of figure 6) were main-

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tained in a hybrid mode through an index of "work-out-loud" tools, regular meetings, and live feeds. These aspects facilitated the sharing of information and created a level of intimacy. The tools encompassed the narration of the work as it happened (*Discord, WhatsApp,* and live streams) and also allowed for meeting points of skill circles (*Zoom* and *Jitsi* meetings, *Google Docs*). This supported the building of social, creative, and scientific relationships. The right-hand side of figure 6 compares virtual (dark green) and in-person (light green) interactions, where the volume of the two shapes evolves depending on the intensity of the relevant mode. The virtual preparation phase dominated the type, level, and volume of interaction. It included virtual conceptualizing, in-person individual experimentation, and virtual reporting. This sequence of isolation and diversity is favorable in collaborative networks (Barkoczi and Galesic 2016) and led to a feedback loop of generation and elaboration of ideas.
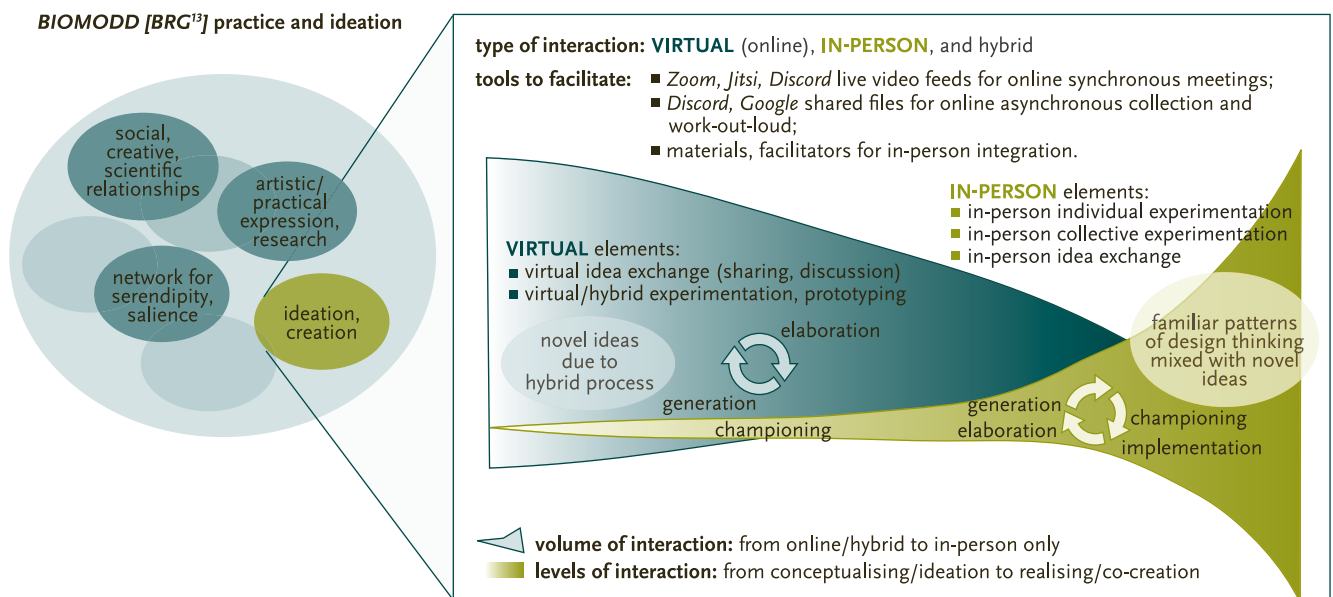
Ideation: **Mapping the idea journey onto *Biomodd [BRG¹³]***
Participants explored a range of topics, including waste as circular systems, how waste is situated and repurposed, its relation to production and consumption, and creative future scenarios for waste reduction and repurpose. One online preparation team explored ideas around the use of Winogradsky columns through arts-based research (box 2 and figure 5). The team decided to use the columns as data input for the multiplayer game and generated ideas to amplify the weak signal from the electric current produced by the microorganisms inside the columns. A different online preparation team generated ideas related to digital interactions for audiences. This included the use of virtual reality (VR) and augmented reality (AR). The aim was for visitors to experience a mix of virtual and real elements to evaluate their current situation, where lives are lived both online and offline.

During the online idea elaboration phase, experiments were set up in homes, lab spaces, or studios (e. g., figure 7) and instantaneous discussions took place on *Discord* and during regular online meetings. While the isolated experimentation introduced limitations, the long elaboration phase over six months provided opportunities for individual exploration alongside the growth of the collective understanding. Members of the relevant preparation team that pursued the idea of Winogradsky columns conceived several custom sensors for their measurements (figure 5 top) and elaborated on ideas for further applications of the collected data, including creative visualizations and soundscapes, which led to educational videos, and custom-built plotters from electronic waste. The elaboration of the Winogradsky columns evoked excitement and generated discussion across all preparation groups, which was essential for the network to support the idea. On the other hand, the elaborations around VR and AR were largely shared and discussed within the specific preparation group. The team further devised questions and drafted texts related to whether a digital recreation of "affective fields" during problem solving – emotional experience, moods, and feelings that typically require bodily responses – is possible (Schindler and Bakker 2020).

Perry-Smith and Mannucci (2017) note that championing an idea requires influence to convince the network to protect ideas from criticism, eliminate obstacles, and persuade decision-makers. We found evidence that this influence depends on the type of participation. In-person participation was fundamental for effectively championing and implementing ideas even amongst participants with a similar experience. Most implementations traveled along the entire idea journey during the short in-person-only production phase. In this phase, participants were seen to fall back into patterns that mimic earlier versions of the *Biomodd*

FIGURE 6: Characteristics and engagement during the collaborative process of *Biomodd [BRG¹³]*, highlighting virtual *(dark green)* and in-person *(light green)* aspects of ideation and creation, tools of facilitation, and idea journey phases.

BIOMODD [BRG¹³] practice and ideation

social, creative, scientific relationships

artistic/ practical expression, research

network for serendipity, salience

ideation, creation

type of interaction: **VIRTUAL** (online), **IN-PERSON**, and hybrid
tools to facilitate:
- *Zoom, Jitsi, Discord* live video feeds for online synchronous meetings;
- *Discord, Google* shared files for online asynchronous collection and work-out-loud;
- materials, facilitators for in-person integration.

IN-PERSON elements:
- in-person individual experimentation
- in-person collective experimentation
- in-person idea exchange

VIRTUAL elements:
- virtual idea exchange (sharing, discussion)
- virtual/hybrid experimentation, prototyping

novel ideas due to hybrid process

elaboration

generation

championing

familiar patterns of design thinking mixed with novel ideas

generation elaboration

championing implementation

volume of interaction: from online/hybrid to in-person only
levels of interaction: from conceptualising/ideation to realising/co-creation

project, in which ideas were anchored in materiality, feasibility, utility, and impact. Online-created ideas were only implemented if they were accepted by the entire group and fully supported by in-person decision-makers. The utility-driven example related to Winogradsky columns was successfully championed and implemented in the final installation. However, ideas related to AR and VR experiences were not implemented. Their promoters were not physically present, and they were not sufficiently championed to be picked up by in-person members.

Lessons from *Biomodd [BRG13]* for hybrid sustainability research

Sustainability research heavily relies on ideas created by interdisciplinary and TD collaborations. Therefore, methods for developing and guiding collaboration and co-creation are becoming increasingly relevant (Turvey 2015). Simultaneously, collaborative work today is often performed as a blend of online and offline (hybrid) work, which comes with additional challenges related to creative ideation, participation, and engagement. Through our empirical research around *Biomodd [BRG13]*, we reflect on the values of integrating hybrid art practices into collaborative research.

The diverse expertise in the online *Biomodd* groups was useful for jointly framing a problem, formulating, and defining a model as well as for generating and elaborating on new ideas. However, *Biomodd* does not focus on solving problems. *Biomodd's* "disciplinary crowd-sourcing" and collaborative practice supports the understanding of disciplines and professional practices and provides experience in community engagement. Further, it provides a framework for engaging collaborations in "thinking through art and design" along with cultivating a fluid mindset for applications and implementations. We highlight *Biomodd's* multiplayer gaming platform to be considered as a form of communication, participation, and interaction amongst stakeholders that does not rely on verbal behaviors. Playing the game created an exaggerated non-verbal presence in a social context rather than the more common content-first verbal communication. The gaming context and other audiovisual interaction platforms that were explored during *Biomodd [BRG13]* invite inquiry and multisensory interaction with complex problems that can be complementary to traditional methods of investigation.

We suggest that a creative process in *Biomodd* that combines online conversations, individual prototyping, creative workshops, gaming, and collaborative art may be beneficial for supporting the facilitation of TD and trans-sector participation. The *Biomodd* project creates an open remote-first space that is loosely framed by a set of topics and applications of knowledge work, and creative practice to ascertain what is important, train improvisation, and understand the collective interest and priorities. We have seen that this process works well for joint reflection, training in communication skills, and co-creation of ideas. Therefore, we suggest that the inclusion of the arts and creative practices in hybrid work can benefit TD research teams with a variety of goals. We argue it can support the guidance of members in articulat-
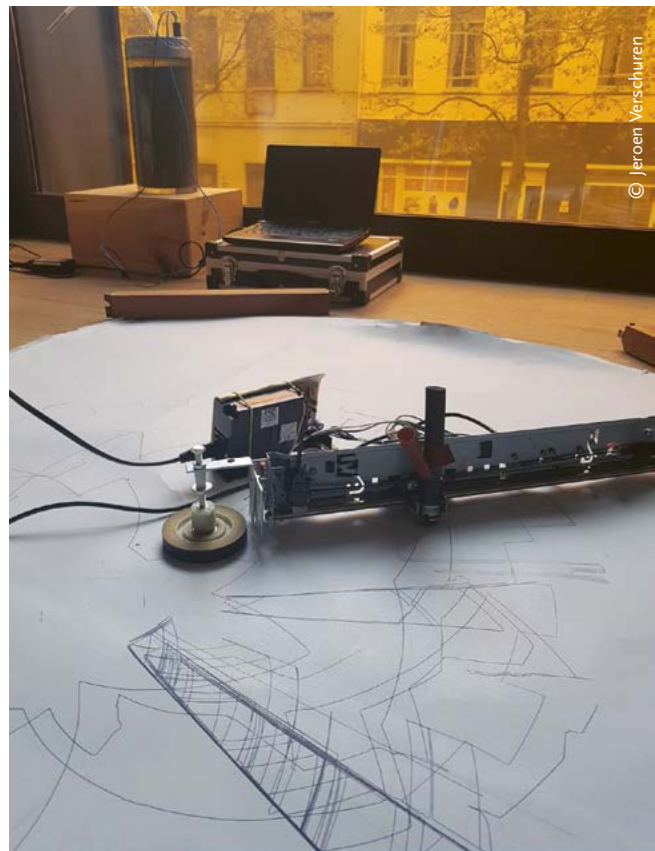

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FIGURE 7: At-home experimental setup for a creative visualization of the voltage output of a Winogradsky column.

ing why they think the problem under investigation exists and development of values, framings, or system models for the idea, problem, or topic under investigation. All these aspects are required to successfully develop and guide TD teams (Bergmann 2012).

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Ulrike Kuchner
Studies in astrophysics and extragalactic astronomy (BSc, MSc, PhD, University of Vienna, AT, University of Sydney, AU); studies in fine arts (studio arts) in paintings (BFA/MFA, University of Applied Arts Vienna, AT). Post-doctoral research fellow in large-scale galaxy environments at the University of Nottingham, UK. *SEADS (Space Ecologies Art and Design)* collective member and coordinator, artist, creative producer, and curator. Research interests: art-science collaborations for integrated research processes; collective thinking; inter- and transdisciplinarity for fundamental science; co-evolution of galaxies and the large-scale structure of the universe.

Diego S. Maranan
Studies in computing science, multimedia, and contemporary dance (BSc), and digital anthropology, perceptual psychology, and user interface design (MA) (Simon Fraser University, Burnaby, BC, CA); art, media, and cognitive science (PhD, University of Plymouth, UK, with *CogNovo*, an EU Marie Skłodowska Curie initiative). Associate professor at the Faculty of Information and Communication Studies at the University of the Philippines Open University, Laguna, PH. Co-founder of the transdisciplinary collective *SEADS (Space Ecologies Art and Design)*. Research interests: somatic practice; embodied cognition; art-science collaboration; creative industries; sustainable development; new media art; social innovation.

Ann Peeters
Studies in theatre (MA, Vrije Universiteit Brussels, BE). Research affiliate of the Erasmus Brussels University of Applied Sciences and Arts, BE; lecturer of Interaction Design and Physical Computing. *SEADS (Space Ecologies Art and Design)* collective member. Research interests: crossroads between technology and human interactions at all levels and learning.

Angelo C. J. Vermeulen
Studies in biology (PhD, Katholieke Universiteit Leuven, BE). Contemporary art studies at Higher Institute of Fine Arts (HISK), Antwerp, BE, and photography studies at SLAC Academy of Fine Arts, Leuven. Co-founder of the transdisciplinary collective *SEADS (Space Ecologies Art and Design)*. Currently space systems researcher at Delft University of Technology, NL, and artist. Research interests: complex system science; principles of self-organisation, emergence and evolution; co-creation and collective intelligence; transdisciplinary research.

Mona Nasser
Studies in dental surgery (doctoral degree, DDS, Shahid Beheshti Medical University, Teheran, IR), dental public health (MSc, University of London, UK), and clinical education, PgCert, and health services research (PhD, University of Plymouth, UK). Professor in Clinical Epidemiology and Oral Health Research at the University of Plymouth, leader of *MetaFuturism Lab*. Interdisciplinary researcher, *SEADS (Space Ecologies Art and Design)* collective member and coordinator, artist. Research interests: meta-research on approaches to conducting research priority setting exercises; art-science collaborations; speculative futures; haptic simulation.

Pieter Steyaert
Studies in fine arts (MFA, KU Leuven association LUCA Gent, BE). Co-founder of the transdisciplinary collective *SEADS (Space Ecologies Art and Design)*. Transdisciplinary PhD researcher in the *CHAMELEON* innovative training network at the University of Antwerp, BE, and the University of Copenhagen, DK, and artist. Research interests: transdisciplinary research; exoplanets and protoplanetary disks; ArtScience; STEAM education.

Zeynep Birsel
Studies in English language and literature (BA, Istanbul University, TR), and mass communications (MA, California State University, CA, US). PhD Researcher in arts and culture studies, transdisciplinary collaborations in art-science and technology at Erasmus University, Rotterdam, NL. Concept and project developer at Waag Future Labs, Amsterdam, NL; lecturer. *SEADS (Space Ecologies Art and Design)* collective member. Research interests: art-science-technology collaborations; post-disciplinary co-creation practices; arts-based research; boundary objects in creative research; systemic change; collective thinking and performance.

Agatha Haines
Studies in graphic design (BA, Kingston University, London, UK) and design interactions (MA, Royal College of Art, London, UK) and art, media, and cognitive science (PhD, University of Plymouth, UK). Lecturer of Material Futures at Central Saint Martins, University of the Arts London, and Design at Goldsmiths, University of London, and *SEADS (Space Ecologies Art and Design)* collective member. Research interests: speculative design; scientific imaginaries; roles of design; transdisciplinary collaboration; biomedical and healthcare representation.