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Co-designing the future in complex systems

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Abstract: The face-to-face co-design workshop has been the default mode for designers to collaborate with stakeholder groups to solve complex challenges. However, the disruption associated with COVID-19 led to practitioners exploring alternative modes of collaboration that opened an array of new possibilities. The aim of this paper is to present the case study of Reboot STEMM, a distributed co-design process that combined live and asynchronous modes of contribution, and explored how digital technologies could be used to scale-up co-design processes, while also prioritising accessibility, and promoting empowerment. The case demonstrates the success of using an augmented version of the Multi-Level Perspective as a facilitation tool for co-designing complex systems, and of using a digital platform as an ongoing and interactive record of project data alongside traditional reporting practices.

Keywords: Co-design; Future visioning; Systems design; Design for Transitions

1. Introduction

Co-design is a methodology that is often called upon to engage complex groups of stakeholders in solving difficult challenges, and to work toward solutions to wicked problems (Sanders & Stappers, 2012). The success of these approaches is often reliant on bringing together different knowledge sets and working through dialogic rather than dialectic collaborative processes (Sennett, 2010). Until recently, the tradition of the face-to-face co-design workshop has been a preferred way of working, but public activity restrictions associated with the outbreak of COVID-19 forced, or at least accelerated, experimentation in new ways of working (Langley et al., 2021).

This paper shares insights from a co-design process that was used to facilitate a national conversation on diversity, discrimination, disability, recognition and reward in academic careers in STEMM, in Australia. It begins by introducing some key theoretical underpinnings of the approaches used in the paper, before presenting and critically analysing the case study project. The discussion provides insights into the 'blended assemblages of co-design' method (Davis et al., 2021) as well as a framework applying Wallace's (2021) adaptation of

Geels' (2002) Multi-Level Perspective (MLP) in a complex co-design approach aimed at transitioning multiple fields of study from their current states to other more inclusive states.

The purpose of this paper is to share learnings, as well as to illustrate the ways in which new ways of thinking about how we co-design might be applied to a range of complex systemic change projects. The authors introduce new tools into co-design with the intent to not only meet the aims and objectives of the project, but to also broaden the possibilities for co-design as a research method and a process. The reflective process undertaken through this paper examines these tools and the potential they hold for future research and practice-based applications.

2. Background

The co-design workshop has been synonymous with co-design practice for many years but is understood in multiple ways that differ across cultural contexts. In this work the authors define the co-design workshop in line with the work of Sanders and Stappers (2012) where co-design is described as a mindset, method, tool or technique, and the workshop provides space where generative processes can unfold. The challenges in delivering meaningful and broadly accessible engagement through formal workshop sessions have been documented since at least the 1960s (Arnstein, 1969). However, the tipping point brought by COVID-19 related restrictions forced co-design practitioners to adopt different ways of co-designing with communities. In 2020-2021, various levels of public activity restrictions around the world meant co-design practitioners were forced to rapidly transition their practices away from the face-to-face workshop (Beresford et al., 2021). Although the initial shift to a digital version of the face-to-face co-design workshop seemed logical to many, it became evident that the digital environment excludes many opportunities, from physical making, to building and interacting with analogue prototypes, and forming strong social connections (Langley et al., 2021).

A model based on a spatiotemporal mapping of the co-design process by Davis et al. (2021) allows for the consideration of not only whether people are interacting virtually or physically, but also whether this is happening synchronously or asynchronously. Further, a 'blended assemblages' approach which prioritises a needs-driven rather than convenience approach to the challenge added depth to an engagement strategy (Davis et al., 2021).

The notion of using distributed methods of investigation is not new, and tools such as cultural probes (Gaver et al., 1999) have long been used as a way of engaging beyond the boundaries of a co-design workshop (Sanders & Stappers, 2014). Similarly, the importance of conceiving co-design as a process rather than an event has been recognised (Manzini & Rizzo, 2011). The shortcomings of the event-based workshop have also been identified in discussions on democratic design processes (Binder et al., 2015) and the need to work with power dynamics in complex systems and transitions is also relevant here (Hyysalo et al., 2002; Avelino, 2017).

Moreover, there are a range of debates about directing change in complex systems, often focused on sociotechnical systems, particularly in recent times as they relate to transitions in response to the climate crisis. There are a number of key threads that can be drawn between these approaches and co-design. The inclusion of plural perspectives plays a significant role in both. This is particularly relevant in the context of this paper, given the understanding that transitions demand collaborative approaches, and any failure to empower systemic actors through inclusive, open processes and distributed decision-making power can challenge the traction of a transition. This is in no small part due to a system's inherent power dynamics, which are complex and often also plural in nature (Avelino, 2011). The systems we seek to change are typically stable by nature and feature dominant power structures that are easily maintained, despite the co-existence of plural types of power. Without increased inclusivity and participatory co-design approaches, a transition can (even if unintentionally) reinforce the oppressive power structures it potentially seeks to overcome. The processes of involvement described in this paper offer actor-specific perspectives that draw on Avelino's (2011) work. The approach we outline here aims to be attentive to the many roles and types of power in systems and seeks to empower the actors within these systems to co-create possible transition pathways. This understanding of human interactions within systems is underpinned by Social Practice Theory (Hargreaves et al., 2012; Schatzki, 1996; Shove et al., 2012) and the Multi-Level Perspective (Geels, 2002; Wallace, 2021) and draws on Assemblage Theory as a cross cutting theme in developing the co-design approach. These theories are outlined below.

2.1 Social Practices

Approaches based on theories of Social Practice, including the work of Schatzki (1996) and more recently Shove et al. (2012) have emphasised the relationship between the individual, perceptions and beliefs held by their community or communities, and objects in their environment, or between skills, meanings and materials (Shove et al., 2012). This shift between the horizontal view of everyday activity and the vertical view of systemic structures in sociotechnical systems is particularly useful when working within complex systems because it allows for the consideration of social and organisational, as well as physical or environmental resilience (Hargreaves et al., 2012; Stevenson, Baborska-Narozny & Chatterton, 2016).

When using co-design processes as part of deliberate and directed programs of change, there is of course an inherent risk of engaging as a form of therapy to 'teach' participants the 'correct' way to think, feel and act (Arnstein, 1969). However, this can often be overcome through careful structuring of these approaches using frameworks such as Critical Pragmatism (Forester, 2013). Remaining cognisant of the power dynamics in co-design processes and inviting participation that is open and generative can hold space for emergent social practices. This application of social practice theory is contextualised by and works in conjunction with the multi-level perspective in transitions (Geels, 2002; 2010; 2018).

2.2 The Multi-Level Perspective (MLP)

In Transition Studies, the Multi-Level Perspective (Geels, 2002; 2010; 2018) provides a heuristic model for understanding the nature of transitions in socio-technical systems. In his initial articulation of the Multi-Level Perspective (MLP), Geels (2002) describes these systems using 3 levels: the landscape (macro level), the regime (the meso level), and the niche (micro level). These levels can also be understood as scales of activity where different types of socio-technical activity occur in a nested holarchy which views each scale as a part of and whole in its own right (Irwin at al., 2015; Wallace, 2021). Wallace's (2021) adaptation of the MLP presents a framework for mapping the complexity of these scales in relation to systemic problems to explore their evolution, current condition and possible futures. This adaptation includes two additional contexts — people and place — thereby adding two additional levels to the MLP and increasing the complexity that is mapped using the framework. The first addition, the mentalitè, maps the ideologies, mindsets, values and beliefs of people in systems, and the second addition, ecology, provides the largest scale which maps interactions across the living system in which the socio-technical system exists (Figure 1).

Figure 1. The MLP framework with the addition of Mentalité and Ecology levels, highlighted for ease of identification.

The addition of these two levels helps to connect the MLP which was developed as a tool for understanding the diffusion of technological innovations, with socio-technically-oriented theories based on Social Practice. It applies the vertical-horizontal explorations of the MLP and social practice theory drawn from Hargreaves et al., (2012) and maps the way structural change is intertwined with everyday practices (Irwin et al., 2015). Accounting for the

intersections of everyday life with systemic change through these observations of social practices and systemic structures together also enables greater interaction with the complexity brought by people in systems. In the context of this paper, the levels have been rearticulated as scales of activity within STEMM disciplines (see Figure 1 for more detail) and these scales provided participants with a framework to scaffold their conversations.

2.3 Assemblage theory

The approach presented in this paper was co-designed by the authors as a 'blended assemblage of co-design', comprising of multiple interrelated processes aimed at maximising access and participation. In their initial theorisation of assemblages, Deleuze & Guattari (1987) describe an assemblage as a basic structure that is comprised of an abstract machine (the condition), concrete assemblage (the elements), and personae (the agents). Assemblages are arranged according to four political types, territorial, statist, capitalist and nomadic, each with their own ordering and have constantly changing states that are relative/absolute positive/negative. DeLanda (2006) argues that Assemblage Theory is incomplete as a theory and proposes his own 'neo-assemblage theory' in response, however Nail (2017) argues for the completeness of DeLeuze & Guattari's work. It is evident through Puar (2012), Ghoddousi and Page (2020), and Russell et al., (2011) that Assemblage Theory is political. The completeness of the theory is not being argued in this paper which instead describes how the theory has been applied as a politic within a co-design context.

3. Methodology

This paper aims to provide insights into the opportunities presented by applying the various frameworks introduced above into a case study of a complex systems change project. To this end, the paper uses the case study method (Yin, 2009) to document the process and outcomes of a large multi-stage co-design project that was focused on catalysing bottom-up as well as top-down initiatives for change in a highly complex system using synchronous and asynchronous co-design strategies and the adapted MLP framework. Two key elements of the co-design process were specifically targeted for exploration through this project: (1) the use of digital technologies to reduce power differentials and hierarchies between participants, and (2) the expansion of the collaborative experience beyond the event-based collaboration (Davis et al., 2021).

The case study method allows for the explication, and documentation of processes as well as outcomes, as well as for critical reflexivity from the authors about their own experiences of the process (Yin, 2009). The data presented has been gathered from a range of sources, including the presentation of documentary evidence, contributions from co-design participants, and reflections from the process facilitators. This triangulation is used to help ensure the internal validity of the data reported (Yin, 2009), and principles from Grounded Theory (Strauss & Corbin, 1990) are used in the formation and extrapolation of theoretical constructs. Anonymous reflections on the process were gathered from participants at the

end of the workshop session using the Mentimeter platform. These were then coded using an inductive thematic analysis process (Braun & Clarke, 2012).

Human research ethics approval was granted by the Human Research Ethics Committee of the University of South Australia, protocol number 203814. Participants were all early or mid-career researchers at Australian higher education or research institutions, and were recruited by the Australian Academy of Sciences through academic and research institution mailing lists, and through a snowballing recruitment process.

4. Case study context

In many parts of the world, the disciplines of Science, Technology, Engineering, Mathematics and Medicine (STEMM) struggle with questions of recognising and rewarding diverse models of success and promoting inclusion in the sciences (Room For Everybody's Talent, 2019). Reliance upon quantitative metrics such as the h-index has hindered the progress and contributions of academics who can be overlooked by the existing structures in place in these fields of study (Brock, 2021). This exclusion can relate to many complex factors but is most obvious in visible dimensions including cultural background (Price et al., 2010), gender (Rees, 2011), and disability (Yerbury & Yerbury, 2021). In an effort to begin to address these issues, The Australian Academy of Science provided funding for a national forum of early and mid-career researchers in the STEMM disciplines. The authors were brought into the project to help co-design the approach that would be taken, as well as to facilitate the process.

All participants were employed at Australian higher education or research organisations. The nature of their employment facilitated their access to digital technologies to participate in the project. However, additional support to enable participation was offered to all participants, including supplying technology, child minding, and communication support. A small number of participants (n=5) utilised these supports, with four requesting support for caring responsibilities and one requesting closed captioning.

5. Results

The results of this project are presented as a chronological narrative to provide practitioners with insights into the process as well as reporting on the outcomes that were achieved. The project was facilitated across three main stages that were broadly aligned with the Design Council's Double Diamond model (Figure 2).
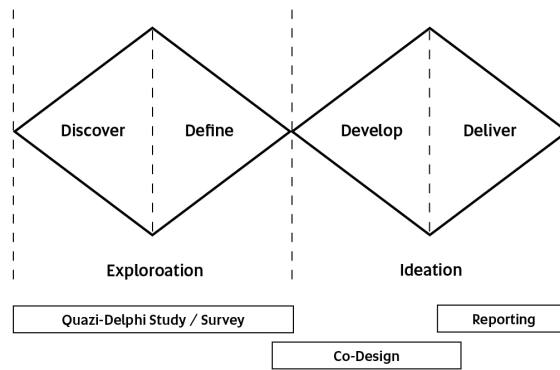
Figure 2. The project process aligned with the Double Diamond Design Process (Design Council, 2015)

5.1 Agenda setting exercises

The decision was made to use a modified form of a Delphi study (Linstone & Turoff, 1975) for the early stages of the project rather than a live discussion because the project was entering into a well-established (although perhaps not saturated), field and seeking to build upon existing knowledge in the area. To this end, the researchers carried out a two-stage process, using a series of prompts that asked participants to reflect on their experiences of being an early or mid-career researcher in the STEMM disciplines, and to identify a list of key issues through an online form.

The Qualtrics online platform was used to gather these contributions. Rather than focusing on collecting data through a survey, the 'agenda setting exercises' were designed to feel like a piece of communication, and an invitation to make contributions to an asynchronous conversation. Hierarchies of information, the customization of the visual identity of the platform to match the project branding, and oversized open text response fields were used to suggest that this was not a survey, but an iterative exercise (Figure 3).
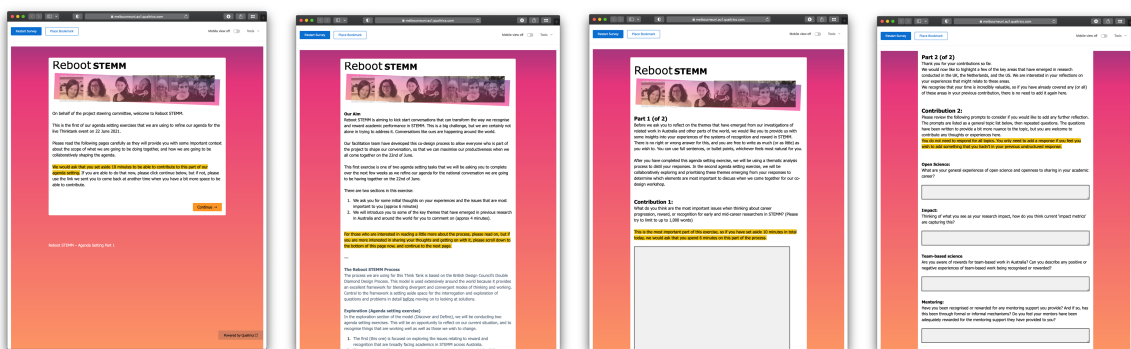

Figure 3. Example screenshots from the Agenda Setting Exercises

After asking participants to share their experiences in general terms, they were introduced to some of the key themes that had been identified in previous work in this area and were asked to add any further stories, comments or experiences triggered by these prompts. After a period of two weeks, the data from the first part of the exercise was coded using an

inductive thematic analysis process (Braun & Clarke, 2012), then analysed against the categories established in previous projects to identify if there were any emergent themes that should be added to the workshop agenda.

Somewhat unexpectedly, over 33,000 words of contributions from 228 participants across Australia were received in the first part of this process, making the inductive analysis a longer and more complex process than planned. Contributions related to all of the six high-level themes identified in previous work, but also identified an additional high-level theme that related to the diversification of career paths.

In the second stage of the Agenda Setting exercise, participants were presented with and asked to reflect on the inductive coding. They were then asked to assign importance to the existing and emergent themes. 208 participants completed this stage (175 who completed the first stage and 33 who did not).

In total, seven broad themes were defined through this process:

- Open Science
- Diversification of Careers (appreciating that there is no 'one-size fits all' in academic careers and that there needs to be a focus towards more holistic and equitable evaluation process) (Emergent theme)
- Team Science (including work closely with colleagues from many different disciplines, countries and sector)
- Mentoring
- The Future Australian Research Landscape (incorporating concepts around inclusivity, career stability, metrics of research success, cultural attitudes, public engagement, increased collaboration and national funding)
- Career Breaks and Disruptions, and
- Impact.

The rankings of themes, as well as an indication of how many themes the participants wanted to contribute to was used to determine the agenda for the live event (Figure 4). Almost all participants indicated that they wished to be part of two or three theme conversations, and we were able to ensure all participants that completed the agenda setting exercises were allocated to their top three preferences. In preparation for the live event, the project steering committee put together a summary of key videos, reports, academic articles, and other media that was then sent to participants in advance of the live event. Participants were also provided with training materials on the use of the MLP framework (an overview of the theory and how it would be applied), Miro (an interactive training video), and the opportunity to attend drop-in sessions to ask any questions. Importantly, participants were provided with an individually tailored agenda for the day based on their contributions in the agenda setting exercises, but also reminded that they were free to move between sessions as they wished. Participants who did not take part in

the agenda setting exercises were allocated to sessions that reflected the most popular topics, but also told that they were free to navigate the sessions as they wished.
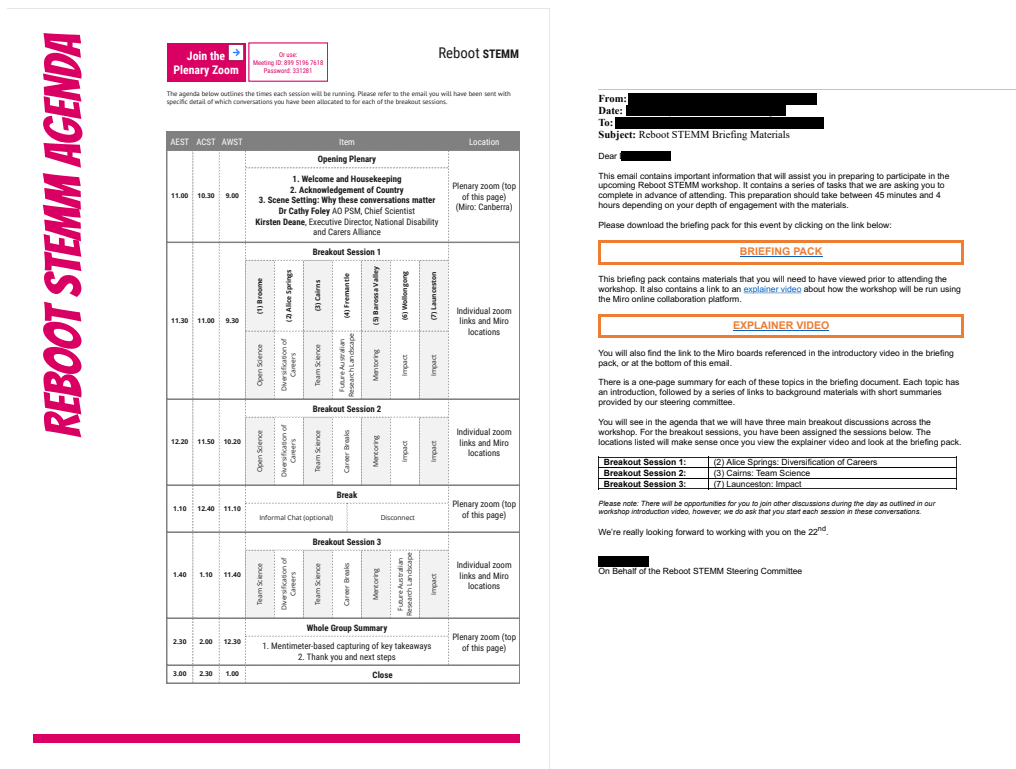

Figure 4. The overall agenda, and an example of an individual participant agenda

5.2 Stage 2: Live co-design workshop

The live co-design process was facilitated using two main tools: Zoom Meetings for the video conference and a Miro Board as an online collaborative whiteboard space. Despite the risk of unintended interruptions or unmuting, Zoom Meetings rather than Webinars were used across all sessions to switch participants from being in a 'passive' position to a more 'active' position. Similarly, a single Miro Board was used to create a single open, transparent, and shared space for documenting the event rather than separating out into individual working spaces.

The live event had 283 participants from across Australia and was facilitated from a hub in Adelaide. The agenda was set to ensure the focus of the day was on participation, with 3.5 of 4 hours devoted to participation and dialogue. The first 30 minutes of the event was didactic to enable housekeeping, an acknowledgement of the Traditional Owners of country, and a very brief scene setting presentation from Australia's chief scientist, but participants were quickly engaged in interactive sessions thereafter.

Participants were given either two or three main pathways for navigating and contributing to each part of the process. These were designed to support different communication styles and different levels of technical competence and experience. A simplified version of the considerations for how the event was designed and facilitated is presented in Table 1 below.

The multiple forms of interaction were developed and tested with the project steering committee (including a person with muscular dystrophy) to simulate both low and high access to and understanding of technology, as well as some key accessibility criteria.

Table 1   Event design considerations to enable different forms of participation

Participation	Option 1	Option 2	Option 3
Access to Zoom meeting, Miro, breakout session or switch between sessions	Via direct link in personalised agenda email	Via link embedded in Miro	Via link embedded in briefing pack
View contributions of others	Via facilitator screen-sharing (Zoom)	Access on Miro	
Follow rapid conversations	Live (AI-based) closed captioning available in all sessions	Facilitator documenting summaries on Miro (shared screen)	Facilitator trained to summarise and repeat-back where required
Time to speak / discuss	Small group breakout sessions	Option to switch to another discussion	Zoom link to talk 1:1 with project leader if required
Contribute	Verbally in zoom (documented live by facilitator)	Add anonymously in Miro	Type in zoom chat (transferred to Miro by facilitator)
Connect or build upon ideas	Verbally in zoom	Add comments or connections in Miro	Type into zoom chat (transferred to Miro by facilitator)
Disagree or contend	Verbally in zoom (moderated)	Anonymously via Miro	Type into zoom chat (transferred to Miro by facilitator)
Summarise and establish take outs	Via Mentimeter in final shared session	Via Miro	Via email

For the majority of participants, Miro was the main navigation structure used throughout the day. We used the visual analogy of a map, in this instance of Australia, to encourage participants to zoom in and out and to travel to distinct locations via the Miro board (Figure 5). This allowed each conversation area to have a discrete zone of the Miro Board that could be worked on, and also encouraged the metaphor of travelling between places and switching between conversations. Further, the use of a map rather than numbered or

lettered spaces helped to remove the hierarchy of the sessions and encourage participants to contribute to the topics that were most important to them rather than perceived as most important because of where they had been listed. The place names for the lands of Aboriginal and Torres Strait Islander Peoples were used alongside colonial settlement names to recognise the custodians of Traditional Knowledges in Australia and to prompt the consideration of these groups in discussions.
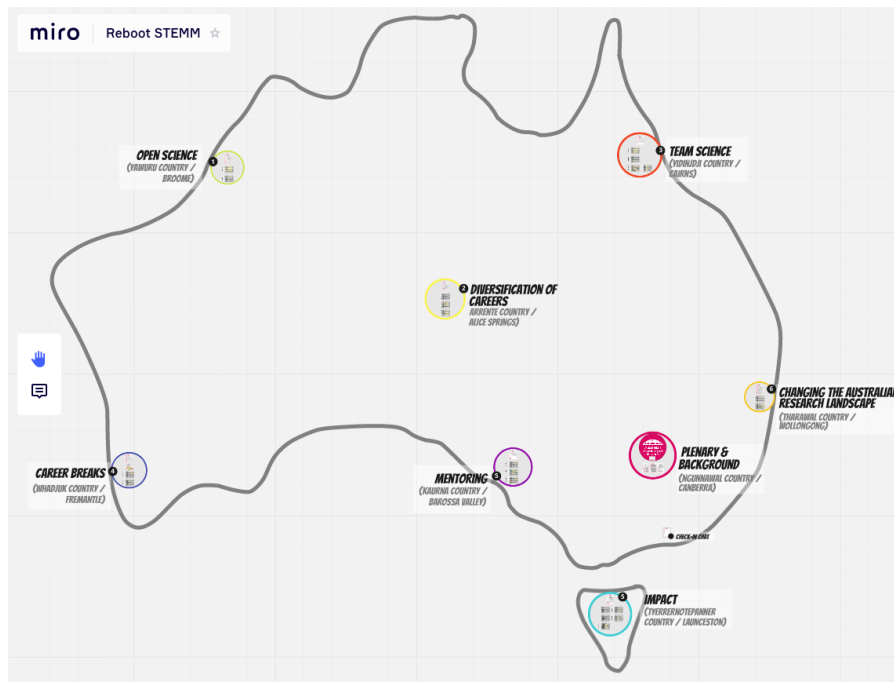

*Figure 5. The Miro board prepared with topic spaces laid out on a map to facilitate non-hierarchical navigation (*https://miro.com/app/board/o9J_lMBfUFk=/*)*

To join a session, participants were encouraged to zoom in on the location then use the embedded link to join the discussion and access further resources and links of interest. Each session was hosted by a facilitator as well as an academic 'subject matter' expert for the topic. Each started with a blank template of the MLP framework, but the previous groups' discussions were left visible. In some instances, a summary of the previous discussions was provided by the facilitator, alternatively, participants independently read and built upon previous contributions.

The final part of the live event was facilitated as a whole-of-event conversation using Mentimeter, a live digital tool that compiles participant responses for immediate sharing at the event. Participants were asked to reflect on: how they would describe the experience; what they enjoyed most; the best idea they heard across the day; and the changes they would most like to see at the niche, then regime, and then landscape level. Mentimeter allowed the responses to appear live on a shared screen. Live commentary and analysis was provided through this process, and participants were also encouraged to engage and build

upon others' ideas during each question. Emergent themes identified in participant feedback included:

- Connecting with others
- Personal Learning and Development
- Positivity About the Future
- Social Learning
- The Workshop Experience
- Ideas
- Career Breaks
- Changing the Australian Research Landscape
- Diversification of Career Paths
- Impact
- Mentoring
- Open Science

The feedback provided by participants spanned these themes and the value of participation was reflected in 327 comments from participants that described their experiences of the process alongside their expressions of desirable outcomes. Nine negative comments related to the experience being 'overwhelming', 'overstimulating', 'busy', and 'exhausting', reflecting both the complexity of the content and the nature of the online workshop processes.

Highlights from the positive feedback include the immersive nature of the conversations; feeling heard alongside the opportunity to hear others' voices and insights; feeling connected/a sense of community; feeling solidarity in frustrations with the current state of STEMM; recognising the need for increased diversity; a strong shared desire for change; catalysing collective action; and feeling a sense of hope for change in the future.

5.3 Stage 3: Results dissemination

The contributions and live co-analysis with participants provided the foundation for a quick summary of outcomes that was shared with participants approximately 2 weeks after the event. A more detailed analysis was then prepared for the final project report.

In addition to these traditional forms of reporting, the Miro board has been turned into a durable record of the conversations with the contributions from the event. This is currently 'locked', but further contributions will be enabled through the 'comment' feature of Miro alongside the official launch of the project report by the Academy of Sciences. This is intended to serve two purposes: to capture and showcase the richness and variety of contributions to the co-design process, and to encourage ongoing dialogue and engagement with the content.

6. Discussion

This project demonstrates the value of taking a critically pragmatic (Forester, 2013) approach to designing a blended assemblage co-design process. By starting with the preferences and needs of potential participants and using a spatiotemporal framework for co-design (Davis et al., 2021), the project is believed to have engaged with a wider range of people than if it were designed through the default of the face-to-face co-design workshop (Langley et al., 2021).

This 'blended assemblage' approach was originally theorised by the authors in their research exploring low-contact co-design in response to the pandemic (Davis et al., 2021; Langley et al., 2021) and this paper expands on this original work through its presentation as a case study. This project demonstrates the increased capacity for deeper engagement through blended assemblages and reveals the value of continuing these approaches once social restrictions are lifted by explicitly increasing the inclusivity of co-design, workshops and the processes facilitated within these spaces. Further investigation may continue to develop this idea in line with Nail's (2017) description of the 'nomadic assemblage', where processes are continually developed and evolved in response to the changing needs, conditions or intent of the agents without establishing specific hierarchies between approaches.

The quazi-delphi process used in the first stage of the project enabled the gathering, sharing, and discussion of contributions through an asynchronous platform. This enabled participants to take part at times that suited them, and to contribute to the overall agenda of the live event. Having given the option of participating in just the agenda setting exercises, just the live co-design event, or both, the researchers were surprised to receive over 33,000 words of contributions from 228 participants in this stage. This made the inductive analysis a longer and more complex process than planned. However, the value of enabling participants to share their experiences, and see them reflected back in the summaries that were presented in advance of the live co-design event was seen as an opportunity for participants to "get things off of their chests" so that the discussions could focus on co-designing a collective vision for the future rather than on recounting the past. The danger of using the terminology of Dephi is that it suggests a consensus seeking method that is aligned with dialectic rather than dialogic processes (Sennett, 2012).

The unique opportunity to run an experimental digital large-scale simultaneous co-design process using live digital collaboration technologies allowed the researchers to investigate the role these types of collaborations may have in co-design practice. The event attracted participants from across Australia, including in regional and remote areas, as well as people from culturally and linguistically diverse backgrounds, and those with physical, cognitive, emotional, or circumstantial conditions that can challenge/limit their participation in a face-to-face workshop setting. In particular, and somewhat counterintuitively, the facilitation of the event through a virtual platform helped to flatten hierarchies and maximised the opportunities for participation. This was likely aided by the nature of the participants'

employment in academia, which is reliant on digital tools and platforms, particularly post-pandemic.

The combination of facilitated conversations through Zoom, and distributed documentation and recording through Miro supported participants to be continuously encouraged. Participants were able to contribute their thoughts, views, experiences, and insights to the collective space even when not having the opportunity to contribute verbally. We see this as an expanded bandwidth of conversation by allowing multiple streams of conversation to occur through different communication channels without the queuing associated with taking turns to speak aloud.

Reflecting on their roles as facilitators, the authors noted the conversations were deep and engaged and participants were building on each other's ideas. Participants actively added written notes into collaborative board while others spoke, developing a rich conversation while also helping surface the voices of participants who were not confident or able to speak aloud. The live recording of any outputs typically biases the longer lasting session outcomes, where the focus remains on those who talked the longest (or loudest). In our approach this bias shifted towards insights that were shared and documented through the collaborative Miro board. While this presents an entirely different experience of the face-to-face workshop, we are confident there is a significant value in these types of co-design processes, though we remain challenged in describing this eloquently. In an earlier description of the value of the face-to-face we argued

> it is the tacit and somewhat invisible aspects of interaction in this space that contribute to the popularity of the workshop format. Face-to-face interactions, the relations between people who share their multiple perspectives, and the energetic exchange that occurs creates a dynamic primary experience that becomes tangible as it is documented (Langley et al., 2021, p. 126).

Further research is required into how tacit real-time multi-participant interactions in collaborative digital spaces is understood and valued. For example, the experience of seeing multiple cursors move around the screen at the same time or sticky notes being written and placed on a shared page are forms of digital interaction that are still unfamiliar to most people.

While some of the success in shifting toward future looking conversations and contributions in the live event can be linked with the agenda setting process, the authors attributed a great deal of the success to the modified MLP framework (Wallace, 2021), which was used to structure conversations and contributions. The basic premise of MLP (Geels, 2002) helped participants to draw links between themselves (the niche), their organisations (the regime), and the wider research community (the landscape) while the addition of mentalité and ecology as scales expanded the social dimensions of the discussions, adding richer contexts for exploration. In particular, the idea of an explicit link between attitudes and beliefs, and structural and material elements can be linked with frameworks such as Social Practice

Theory (Shove et al., 2012). This helped participants to capture and inhabit the inherent complexity of the problem space being explored.

6.1 Future research directions

The reporting and dissemination process is currently underway. However, better mechanisms are required for the translation of energy from live co-design events into tangible actions that can preserve momentum when working on big-picture challenge such as this. There may be opportunities to further engage with the spatiotemporal mapping of co-design approaches to investigate a more immediate continuation of conversations through an ongoing asynchronous process rather than waiting until releasing a final project report before enabling these ongoing contributions.

The report findings and layout mirrored the MLP framework, capturing and reporting on contributions and opportunities at all scales. While this is relevant and accessible for researchers that work within our, or a similar, methodological framing, further research is required to explore disciplinary expectations and understandings around how information from the process should be most effectively analysed and presented. While the 'traditional' report format provides a baseline for presenting major themes, or a 'snapshot' of the day, it does not allow for the richness of the experience and sheer extent of the material that was collected on the day. Reserving the final live session for a rapid summarising of the workshop by all participants was successful in identifying key highlights and themes from the day, but more detailed and rich reporting is still required. Others have been investigating opportunities for sharing data in rich ways, including UWE Bristol's documentation and sharing of projects such as Forum Theatre through video and audio in addition to text-based reporting (https://www.youtube.com/watch?v=QWHAb3Y2eKM).

The approach of making the Miro board from the workshop an open and public record of the event is in keeping with the principles of openness, and distributed documentation and interpretation. Although editing has been disabled, users can still actively comment on the results from the workshop and read the thousands of comments provided by participants. Having direct access to this 'raw data' potentially negates issues around interpretation and analysis, allowing the reader to focus on areas and details which are of importance to them, and while the insights gained from the process were still especially relevant and recent for participants.

7. Conclusion

The Reboot STEMM project demonstrates how a blended assemblage of co-design can facilitate engagement that goes beyond 'the workshop crowd' and can engage with a highly diverse stakeholder group. It also demonstrates the success of the augmented model of MLP used in facilitating the live co-design event, connecting individuals with local, national and global systems, and helping to connect the socio-political nature of systems with physical

and technical structures. This suggests this framework may be a useful process and tool for other projects that are addressing complex systemic change.

Though the framework shows promise in the context of complex systemic change, the potential for this project to catalyse the change that is being demanded within STEMM relies on its next steps. Continuing discussions are exploring how the live, 'on the day' momentum could be directed in ways that generate the energy required for a movement to emerge within STEMM fields, alongside further dissemination and distribution of the reported findings from the overall process.

The project is significant for co-design practitioners because it demonstrates the relevance of a blended assemblage approach and the success of blending synchronous and asynchronous work. As a case study the project offers guidance on establishing collaborative approaches when working in complex systems. The processes and approaches used in the presented case appear to show promise in bringing together the kinds of complex groups of stakeholders required for addressing change in complex systems. As our and others' work in this space continues, further refinement and development of these processes can help to bring clarity to how assemblages of co-design processes can help facilitate processes aimed at systemic change.

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