

Sensemaking-As-Trace in Researcher-Led Synthesis of Co-Design Materials

Julia Bugler,^{1*} Ryna Cilliers,¹ Veronica Barnes¹

¹Cape Peninsula University of Technology, Department of Applied Design, PO Box 652, Cape Town, 8000, South Africa

*Corresponding author: julia.bugler1998@gmail.com

ABSTRACT

Co-design scholarship stresses connecting participant contributions to research outcomes but gives limited attention to the common practice of researcher-led synthesis after participation ends. This study asks how researcher-led sensemaking unfolded through synthesis actions and how connections to participant contributions were retained or restored. An instrumental case study examined a digital whiteboard workspace and reflective walkthrough transcript from a practice-based co-design project. The transcript was process-coded inductively and categorised deductively using design synthesis categories; workspace configurations were examined alongside it throughout both analytical passes. Sensemaking unfolded through making and revising representations, narrowing material and forming connections. Five mechanisms described how origins, sources, relationships and earlier states remained available, and how the researcher returned to participant material: provenance encoding, source linking, relationship marking, versioning and retracing. *Sensemaking-as-trace* brings practices dispersed across design, provenance and documentation research into design synthesis by asking whether interpretations remain connected or can be connected back to participant contributions.

Keywords: Co-design; co-creation; design synthesis; sensemaking; traceability; provenance.

Received: January 2026. **Accepted:** August 2026.

INTRODUCTION

After direct participation ends, researchers often transform co-design materials into findings through researcher-led synthesis. As cards, drawings, maps and photographs are selected, transcribed, moved, grouped and abstracted, the path from a participant contribution to a later claim can become difficult to follow. This creates a methodological problem with ethical implications: interpretive authority becomes concentrated among researchers, who remain responsible for explaining how participant material informed their claims. Johnson et al. (2017) describe the challenge as moving “from the post-it note to the final report.”

This interpretive work is common in design and co-design research, yet it is rarely described with the methodological detail given to procedures such as coding and thematic analysis (Saldaña, 2013; Braun & Clarke, 2006). Published accounts often present illustrative fragments of a method or tool rather than examine synthesis as a practice in its own right (Johnson et al., 2017). This study asks: How did researcher-led sensemaking unfold through synthesis actions, and how were connections to participant contributions retained or restored?

An instrumental case study examined a digital whiteboard workspace in which photographed workshop cards were developed into codes and themes, together with a reflective walkthrough transcript. The study’s central contribution is *sensemaking-as-trace*.

Empirically, it describes the synthesis actions and identifies five mechanisms showing what remained available and how the researcher returned to participant material. Together, the five mechanisms bring practices discussed separately across design, provenance and documentation literature into one account. Conceptually, *sensemaking-as-trace* extends the analysis of design synthesis by asking whether developing interpretations remain connected, or can be connected back, to participant contributions.

RESEARCHER-LED SENSEMAKING IN CO-DESIGN SYNTHESIS

Co-design involves designers and people not trained in design working creatively together, with participants contributing knowledge grounded in their experiences (Sanders & Stappers, 2008). Participation in generating material does not necessarily extend to its analysis, when researchers may take primary responsibility for selecting, organising and interpreting contributions. Johnson et al. (2017) identify the movement from workshop material to a final account as an under-described part of co-design methodology. Recent co-design reviews identify a broader reporting problem, with labels standing in for process descriptions and methodological transparency remaining uneven (Masterson et al., 2024; Vargas et al., 2025).



Sensemaking is the continuing work of developing and revising an understanding of uncertain or complex material (Klein et al., 2006; Weick et al., 2005). Design synthesis gives this process a material form (Kolko, 2010b). Kolko (2010a) describes how designers externalise, manipulate, organise, filter and prune material while prioritising possibilities, judging their fit and forging connections. These actions overlap rather than forming a fixed sequence. External representations make material visible and movable so that emerging interpretations can be compared and revised. In this study, researcher-led synthesis refers to this work as performed by a researcher interpreting material generated through co-design.

The practices this paper draws together under *trace* are dispersed across several fields. Provenance research characterises the origins and history of analytic elements and distinguishes types of provenance (Ragan et al., 2016). Artefact-evolution research records how design artefacts relate to the decisions, contributors, rationale and earlier versions behind them (Gutierrez Lopez et al., 2018). Reflective design documentation retains selected process records to support later analysis (Dalsgaard & Halskov, 2012), and curated research threads let readers retrace the development of a research contribution (Rogers et al., 2026). Across these strands, sources, relationships, rationale and earlier states can be retained, but each addresses a different purpose, and the strands are rarely brought into contact with one another.

Some provenance and artefact-evolution research examines purpose-built systems in which origins, changes or rationale are captured as designed features (Ragan et al., 2016; Gutierrez Lopez et al., 2018). Researcher-led co-design synthesis often takes place on more general-purpose media, such as physical research walls, sticky notes or shared digital canvases. These media support moving, grouping and connecting material, but do not by themselves maintain provenance or transformation history within the analytic arrangement.

Maintaining these connections is important in co-design for reasons specific to its participatory and ethical commitments. Interpretive authority concentrates at exactly the stage where participants are least present, giving retained connections between interpretations and participant material particular weight. Involving participants in the analysis is one response, supported by tools designed for participant-led analysis (Wood et al., 2025), but it is frequently constrained by time and resources and is not always possible (Cashman et al., 2008), so researcher-led synthesis remains common.

Within co-design, Claisse et al. (2019) come closest to this concern, showing how synthesis artefacts can form a chain of thought between participant contributions and outcomes while stressing the researcher's responsibility for maintaining those connections. One established analogue outside co-design is the qualitative audit trail, a record that lets readers trace a researcher's decisions and reasoning to judge the dependability and confirmability

of an account (Lincoln & Guba, 1985; Carcary, 2009). Audit trails primarily support later scrutiny of decisions and reasoning, whereas *sensemaking-as-trace* focuses on connections used during interpretation to return to participant material.

Kolko's design synthesis concepts help explain how researchers make material workable and develop interpretations, but not what those actions leave available afterwards. Here, a trace refers to a retained mark, relation or configuration that points back to prior material, activity or an earlier state. *Sensemaking-as-trace* adds the question of whether and how connections between those interpretations and participant contributions remain available or are re-established during that work. Retaining or restoring such connections does not make synthesis ethical or validate an interpretation, but it can make researcher judgement more open to explanation, reconsideration and questioning.

METHOD AND DATA

An instrumental case study (Stake, 1995) examined researcher-led synthesis within a practice-based co-design project with eight young adults in Cape Town, South Africa. In a co-design workshop, participants produced issue cards, a persona, a day-in-the-life map and an as-is scenario map. The issue cards supplied the main material for thematic analysis; the other artefacts provided context. This article examines how these materials were synthesised rather than the wider project's substantive findings (Figure 1). The project received institutional ethical approval, and participant identifiers were anonymised.

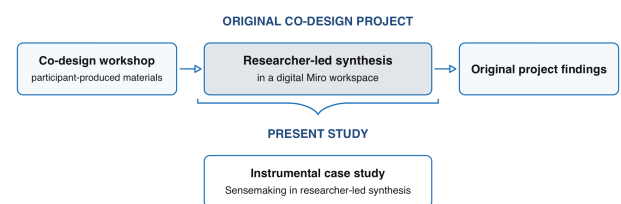


Fig. 1. Relationship between the original co-design project and the present instrumental case study.

Case materials and reflective walkthrough transcript

The case used two connected sources: the retained Miro workspace and the reflective walkthrough transcript. During a recorded Microsoft Teams session lasting approximately 90 minutes, the first author, who had conducted the original synthesis in the Miro workspace, shared their screen and explained actions, decisions, uncertainty and changes of direction. The second and third authors questioned the sequence, terminology and interpretation of the account while referring to the visible workspace. The session was

transcribed, and the second author coded the transcript while repeatedly revisiting the recording and workspace. The transcript provided a retrospective account of the synthesis; the workspace provided evidence of retained arrangements, identifiers, source relationships and earlier states. The workspace did not record every analytic step.

Analysis

Analysis combined inductive and deductive coding in a first analytical pass (Figure 2). The analytic unit was an action, with transcript quotations serving as coding segments; a quotation could contain multiple actions and receive multiple codes. The second author used ATLAS.ti to apply inductive, gerund-based Process Coding (Saldaña, 2013). Data-near codes included transcribing, returning to source and reconsidering placement. The process codes were then categorised deductively using Kolko's (2010a) material and spatial operations and interpretive synthesis activities (Figure 2). Inductive contextual codes for affect, affordances and constraints, and analytic redirection were developed alongside this categorisation. Throughout both analytical passes, relevant workspace configurations were examined

alongside transcript quotations and codes. Table 1 provides an illustrative example.

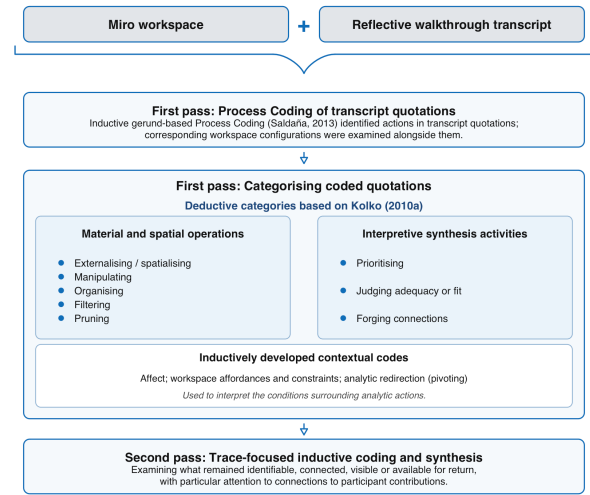


Fig. 2. Two-pass analytical procedure. Workspace configurations were examined throughout both passes.

Table 1. Illustrative example of the analytical procedure.

Transcript evidence	Corresponding workspace evidence	Process coding	Deductive and contextual categorisation	Second-pass trace-focused coding
[00:54:51; 00:55:48; 00:56:24] "That context came back in and you're like, actually, no, this might fit better here. Physically having to ... manually take the quote from here and put it here, [that] process helped my brain ... go through the understanding of it. ... Going to trace it back to the direct code quote, and then copying it and pasting it and cutting out a bit that's relevant."	The workspace retains source cards, an interim code-linked arrangement, participant-marked category lists and later thematic tables. It does not record the movement sequence or its reported cognitive effect.	Adjusting placement; manually relocating; tracing back; copying, pasting and cutting relevant material	Kolko-derived: organising; judging fit; manipulating. Contextual: manual movement as an affordance supporting understanding.	Retracing; source linking

Note. Timestamps refer to the session recording. Quotations have been lightly punctuated; ellipses omit fillers, repeated wording and brief intervening prompts. The workspace provided evidence of retained configurations; actions, sequence, judgements and reported cognitive effects came from the transcript.

A second, inductive trace-focused pass examined the coded transcript alongside the workspace to identify what remained identifiable, connected, visible or available for return, with particular attention to connections to participant contributions. It identified five mechanisms. Selected board configurations were linked to relevant transcript passages.

RESULTS

Results are reported at two analytical levels. The board shows retained configurations and relationships; the transcript explains actions, sequence and rationale.

How researcher-led sensemaking unfolded

The first level reports two deductive groups derived from Kolko (2010a). Although presented separately, quotations could receive codes from both. Taken together, these actions show sensemaking unfolding through making and revising representations, narrowing material and forming connections (Table 2).

Table 2. Kolko-derived synthesis categories and their enactment in the case.

Synthesis category	Enactment in this case
Material and spatial operations	
<i>Externalising / spatialising</i>	Photographing and transcribing cards; rebuilding graphics; adding labels and participant identifiers.
<i>Manipulating</i>	Moving and splitting items; copying arrangements; extracting and relocating quotations.
<i>Organising</i>	Sorting by participant and similarity; arranging codes into themes using frames, headings, tables and domain groupings.
<i>Filtering</i>	Comparing repetition and frequency; using context to judge fit; selecting quotations.
<i>Pruning</i>	Parking lower-frequency themes; setting aside early notes; ceasing to develop unhelpful representations.
Interpretive synthesis activities	
<i>Prioritising</i>	Applying a participation threshold; carrying forward higher-frequency themes; selecting quotations.
<i>Judging adequacy and fit</i>	Assessing representations, groupings and placements; redirecting or relocating material.
<i>Forging connections</i>	Linking codes to participant quotations; marking overlaps and cross-artefact connections.

Making material workable

An early operation was to translate heterogeneous workshop material into forms that could be handled together. The researcher described taking photographs of the issue cards and retyping their content so that the material was available digitally [00:05:17]. Keeping each photograph beside its transcription created a movable unit while an image of the original artefact remained visible (Figure 3). Other graphical outputs were rebuilt in simpler layouts. Participant identifiers and headings were added as material was moved, separated and regrouped by participant, similarity and emerging theme.

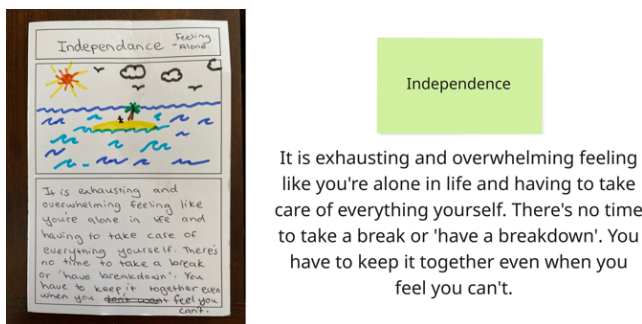


Fig. 3. An artefact photograph and its digital transcription retained together.

These arrangements were provisional and were revised or abandoned when they no longer supported the analysis. The mind map in Figure 4 was one such attempt: codes were arranged around domains to explore possible relationships, but the configuration was later abandoned.

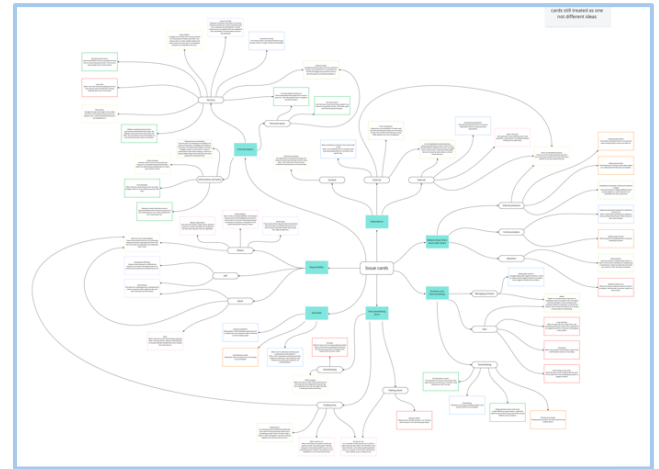


Fig. 4. A mind-map arrangement used to explore possible relationships and later abandoned.

Filtering compared repeated or similar codes and their contextual fit. *Pruning* set aside material no longer under active consideration. Lower-frequency themes and early notes were parked rather than deleted, so *pruning* included ceasing to elaborate material rather than removing it from the workspace.

Developing interpretations

Prioritising set the scope of the developing analysis. Themes identified by “at least five or more of the eight participants” were carried forward [00:21:14]. Three or four quotations that could “encapsulate the theme” were then selected for each theme [01:06:47]. Figure 5 shows one consolidated theme, its description, participant identifiers and a selected quotation.

Category	Keywords
Internal feelings with secondary links to environmental demands and interpersonal misunderstanding	Difficulty focusing, distract: one thought or focus when there are a lot of people around the area I'm trying to self-monitoring stress, pin-distracted unless I put headphones in; difficulties, mental restles: developed an inability to sit still and concentrate, I get fidgety and restless in 10 restlessness, chronic fatigue is I take longer to do work, I struggle to watch a movie and it's a cause of anxiety self-care, lack of mental d studying, I need to be doing multiple things at the same time and some people pace mismatch, multitask "sat" for multitasking I when everyone is giving me a lot of instructions at once, I feel confused and I do"

Fig. 5. A consolidated theme description with participant identifiers and a selected quotation.

Judging occurred throughout this narrowing. The researcher moved away from participant-made categories and “reset that and analyse it ... through a different lens” [00:07:33; 00:19:45]. Returning to a fuller quotation could narrow the possible fit of a code or prompt its relocation. These judgements concerned the adequacy of representations, groupings and placements rather than a single final assessment.

The first author described this as an iterative process:

[It] is more like intuition. It's a lot of going back and forth and experimenting with different ways of organising data, some which work, some which didn't. ... I backtracked, and I categorised everything I did before it worked as me coming to terms with the data [00:25:07].

Connections were formed in two directions. Codes and themes were linked to participant quotations so the analysis could show “exactly what the participants said” [00:51:46]. Themes were also related across workshop artefacts. The first author described the issue cards as showing what participants experienced, while the daily-routine map, persona and scenario showed how and when those issues arose [01:11:09–01:14:43]. They marked where the issue-card themes appeared in those other materials; Figure 6 retains one such cross-artefact mapping.

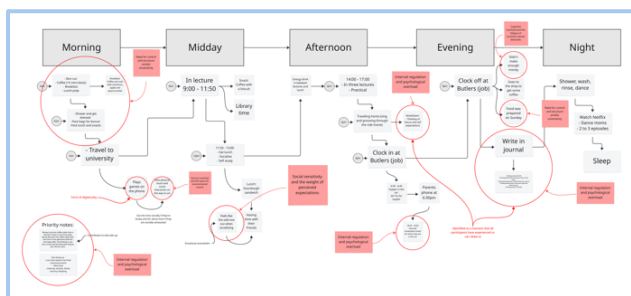


Fig. 6. Issue-card themes overlaid on a journey map, making a cross-artefact connection explicit.

What the synthesis left available

The second, trace-focused pass asked what remained available and how it was used. Four mechanisms concern what the synthesis retained. Retracing concerns how the researcher used what remained available to return to participant material (Table 3).

Table 3. Trace mechanisms and their roles in the analysis.

Trace mechanism	Observed practice or feature	Analytic role
<i>Provenance encoding</i>	Participant colours, card numbers and identifiers retained across analytic materials.	Origins remained identifiable; material was moved and reorganised.
<i>Source linking</i>	Source images, fuller quotations and quotation-to-code or theme links.	Fuller participant material, or a route to it, remained accessible.
<i>Relationship marking</i>	Visual markers and annotations linking analytic elements and artefacts.	Relationships among analytic elements remained explicit rather than inferred from proximity.
<i>Versioning</i>	Frames or tables deliberately duplicated before further change.	An earlier state or backup remained available beside later work.
<i>Retracing</i>	The researcher returned to fuller participant material when fit or meaning was uncertain.	Source context was restored and an interpretation could be reconsidered.

Identifiable origins and accessible sources

Provenance encoding kept origins identifiable; source linking kept fuller material accessible. The first author explained that “each colour is a different participant” and that each participant’s cards were numbered, meaning that “at any point I could trace these back to the original card” [00:35:49–00:36:55]. Participant colours, card numbers and stable identifiers remained visible across frames (Figure 7). Photographs remained beside transcriptions (Figure 3), while quotations remained associated with codes or themes elsewhere in the workspace.

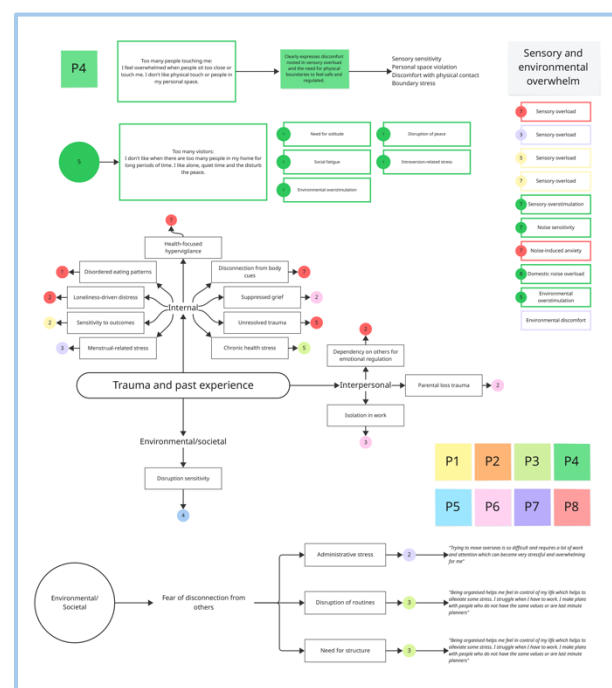


Fig. 7. Composite view of participant labels, colour codes and legends retained across the workspace.

Visible relationships and earlier states. Visual markers and annotations kept overlaps, hierarchies and cross-artefact connections explicit. Figure 6 shows one example: issue-card themes were linked to the journey-map material rather than merely placed nearby. Versioning used the digital workspace’s capacity for non-destructive iteration: configurations could be copied forward and developed without overwriting selected earlier or intermediary states. A code-sorting frame was copied before further annotation [00:21:59], and a theme table was duplicated “in case something went wrong” [01:05:07]. The passively retained mind map was treated as persistence rather than versioning.

Returning to participant material. *Retracing* occurred when the researcher used what remained available to return to participant material. It was most evident when thematic fit or meaning was uncertain:

I had a lot of self doubt that I was getting it wrong at points ... at times, you do actually misinterpret the context of the code, and that's why there was a bit of adjusting ... because that context came back in and you're like, actually, no, this might fit better here. [00:54:51]

Going to trace it back to the direct code quote, and then copying it and pasting it and cutting out a bit that's relevant ... [was] when I started really understanding it. [00:56:24]

The first author described reconnecting a code to its card as bringing “weight” back into it [00:37:00], later clarifying that the value of codes came from their connection to direct quotations [00:51:48]. The retained materials made return possible. The transcript shows that the researcher followed these routes and sometimes changed a quotation's placement after restoring its context. Retracing therefore involved both return and reconsideration.

DISCUSSION AND CONCLUSIONS

Material and interpretive work were intertwined rather than sequential. *Judging* was closely tied to *organising*; *prioritising* appeared through *filtering* and *pruning* decisions about what to carry forward; and *forging connections* depended on arranging materials so that sources and relationships could be compared. This coupling is consistent with Kolko's (2010a) account of overlapping synthesis actions.

What sensemaking-as-trace adds to design synthesis

An action could matter at both analytical levels. Numbering and colour-coding externalised and organised material; when those identifiers continued to show where an item came from, they also encoded provenance. Duplicating a working arrangement manipulated the material; retaining both arrangements also preserved an earlier version. Returning to a quotation involved *filtering* and *judging fit*; using that return to restore participant context constituted *retracing*. Kolko's concepts describe what these actions did within synthesis. The trace-focused mechanisms describe what they left identifiable, connected, visible or available for return. Not every synthesis action necessarily creates such a connection. *Sensemaking-as-trace* therefore adds a second analytical question to design synthesis rather than replacing its existing account of interpretive action. In this case, traceability was not designed into a dedicated analytic system but enacted through ordinary synthesis actions within a general-purpose workspace.

The component practices are established across design synthesis, provenance and documentation research (Claisse et al., 2019; Ragan et al., 2016; Dalsgaard & Halskov, 2012; Gutierrez Lopez et al., 2018; Rogers et

al., 2026; Mahajan, 2025). This case shows how they operated together during researcher-led interpretation. Uncertainty prompted the researcher to return to fuller quotations, restoring context and sometimes changing placement. Retained connections therefore supported ongoing judgement, not only later documentation or reader scrutiny.

This distinction matters in co-design because interpretive authority shifts towards researchers. This extends accounts of how workshop material becomes research claims (Johnson et al., 2017; Claisse et al., 2019): transformations can develop interpretations while preserving different connections to their sources.

Partial traces and interpretive responsibility

Persistence enabled the analysis but was not the paper's principal contribution. Neither source contained the whole process. Documentation is necessarily selective (Dalsgaard & Halskov, 2012), and traces require contextual explanation (Gutierrez Lopez et al., 2018; Rogers et al., 2026). Other environments may retain different relations; this case does not establish the digital whiteboard as superior.

Making traces visible should not be equated with transparency or accountability. Ananny and Crawford (2018) caution that making a system visible does not by itself make it understandable or governable. A persistent workspace can preserve careful interpretation, biased interpretation or both. The traces in this case did not demonstrate that the analysis was correct, complete or participant-endorsed, and they did not redistribute interpretive authority. Their more modest value was to support the researcher's responsibility for explaining and reconsidering how participant material became a research claim. Participant validation or co-analysis would remain necessary where shared judgement or authority is intended.

Used prospectively, *sensemaking-as-trace* invites researchers to ask whether an analytic unit's origin remains identifiable, whether fuller participant material can still be reached, whether relationships and earlier states remain visible, and whether source context can be revisited when meaning or fit becomes uncertain.

Contribution

The study answered its two-part question in two ways. Researcher-led sensemaking unfolded through overlapping material and interpretive synthesis actions. Five trace mechanisms described what remained available and how the researcher returned to participant material. The contribution is both empirical and conceptual. Empirically, the study provides a detailed account of a common but under-described stage of co-design analysis. Organised by the five mechanisms, the account shows how synthesis actions leave connections available and how the researcher returns to them. Conceptually, *sensemaking-as-trace* extends the analysis

of design synthesis by asking not only how interpretations develop, but what those actions leave available for connecting interpretations back to participant material. For co-creation research, it draws attention to the interpretive work that continues after direct participation ends.

Limitations and future research

This study examined one instrumental case and relied on a retrospective, insider account. Although the second and third authors questioned and clarified that account while referring to the retained workspace, participants were not involved in the retrospective analysis. The five mechanisms should therefore be treated as a case-based account rather than an exhaustive account.

These limitations suggest three directions for empirical research. Prospective studies could follow synthesis as it occurs, reducing reliance on retrospective reconstruction. Comparative studies could examine physical walls, qualitative-analysis software and collaborative digital workspaces to establish which connections each environment retains, obscures or makes recoverable. Studies could also compare researcher-only synthesis with participant validation or co-analysis to examine how retained traces are used when interpretive authority is shared differently.

ACKNOWLEDGEMENTS

The authors thank the participants in the co-design project for sharing their experiences and insights. During manuscript preparation, generative artificial intelligence supported editing, clarity and iterative refinement. The authors remain fully responsible for the analysis and content of the article.

SUPPLEMENTARY MATERIALS

Supplementary File S1 provides a cleaned export of the retained Miro workspace from the original co-design project. Supplementary File S2 provides working definitions of the analytical categories and trace mechanisms used in this article, together with additional illustrative coding examples.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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