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# Affordances of Decision-Support Software in Group Decision-Making

**Isabella M. Lami**[1] · **Elena Todella**[2]

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**Abstract**
Decision-making in complex, contested settings increasingly relies on decision-support software that shapes how groups compare trade-offs and stabilise collective judgements. This study examines a specific software, Multi-Values Appraisal Methodology, integrating the Strategic Choice Approach and the Analytic Hierarchy Process, through eight workshops in four European countries on urban transformation cases. Inductive analysis of participants' reports and surveys distinguishes software affordances from outcomes. Findings show that shared visualisation, traceability and staged transitions support consensus building and dissent management, contributing to a "Plural Subject", while the workflow alternates collective modelling with individual scoring to enable iterative and more transparent decisions. The paper clarifies how socio-technical affordances are perceived and actualised in workshop practice.

**Keywords** Problem structuring methods · Decision-support software · Affordance · Multi-criteria decision analysis · Group dynamics

## 1 Introduction

Problem situations today involve complexity, conflict, and uncertainty, the same conditions that led Operational Research (OR) to move beyond optimisation toward facilitated, interactive inquiry. Early practitioners used group discussions not to refine

✉ Elena Todella
elena.todella@unipr.it

Isabella M. Lami
isabella.lami@polito.it

[1] Politecnico di Torino, Turin, Italy

[2] Università degli studi di Parma, Parma, Italy

algorithms but to challenge the view of decision support as purely technical, giving rise to Problem Structuring Methods (PSMs) that help groups build shared meaning and commitment (Rosenhead 1996; Rosenhead and Mingers 2001).

While this question remains, the medium has evolved. Digital artefacts now visualise options, record argumentation, and reveal trade-offs in real time. Much research has examined fully online collaboration (Aubert et al. 2024; Gimpel et al. 2024; Burger et al. 2019), but less is known about screen-mediated, co-present settings, neither traditional facilitation nor fully virtual interaction.

To address this gap, the study examines MuVAM, or Multi-Values Appraisal Methodology. Based on the theory outlined by Lami and Todella (2023), it combines the logic of the Strategic Choice Approach, SCA (Friend and Hickling 1987, 2005) with the Analytical Hierarchy Process, AHP (Saaty 1980, 1990), to connect facts and values within a single software environment. By projecting a shared model, MuVAM synchronises deliberation and documents trade-offs transparently.

The focus is not the software per se but the affordances it creates as both technical artefact and social mediator. In this sense, affordances are understood as software-enabled possibilities for action. The research question is therefore: *Which affordances emerge from the use of decision-support software in group dynamics?* More specifically, we investigate how these affordances are perceived by participants and how they are actualised during interaction, giving rise to specific outcomes and related group dynamics. Eight workshops were analysed using an inductive, participant-centred approach to explore how specific features of the software influence interaction and outcomes.

Building on this, the work advances the situated understanding of OR practice (Franco and Greiffenhagen 2018) by identifying how PSMs' processes and structural features influence workshop outcomes (Lami and Tavella 2019) and how models support group dynamics. By focusing on participants' perceptions rather than real-time observation, it highlights that perceived and functional affordances vary by role and experience (Wang et al. 2018).

Accordingly, the paper offers two main contributions. First, it advances an affordance-based account of decision-support software in PSM workshops by distinguishing software affordances (software-enabled possibilities for action) from outcomes (the effects produced when those possibilities are enacted), and by showing how shared visualisation, traceability and stage-gated transitions contribute to consensus building and dissent management, supporting the emergence of a "Plural Subject" through joint commitment (Gilbert 2014). Second, it clarifies the technical and procedural implications of MuVAM's workflow by analysing how the platform alternates collective modelling with individual reflection, scoring and aggregation, thereby structuring iterative decision-making while foregrounding trade-offs related to self-facilitation and time structuring.

## 2 Softwares' Affordances

Models are central to PSMs' facilitated interventions (Franco and Montibeller 2010; Franco 2013). They foster shared understanding (Franco 2006) and commitment through visualization (Pidd 2003; Nakagawa et al. 2010; Fregonese et al. 2020), shape negotiation and knowledge creation (Rosenhead and Mingers 2001; Cunha and Morais 2019) and help build commitment to action (Yearworth 2024). Codeveloped models surface multiple facets of problems, supporting communication, consensus, and learning (Franco and Rouwette 2022), and reshaping problem conceptualization (Franco 2014), through an interactive process by which models are jointly developed and used, mainly in a workshop environment (Tavella and Franco 2015).

*Affordances* are features of material artefacts that enable action (Gibson 1986), rooted in the ecological approach to perception (Gibson 1979) and adopted in Soft OR to explain how models and artefacts enable or constrain behaviour and interaction (Norman 1999; Durugbo 2020; Chidambaram et al. 2021).

Norman (1988) introduced the notion of *perceived affordances* in design, distinguishing what an object suggests from what it actually enables. Affordances may remain unused, yet if not perceived, they are not actionable (Ruttkay and op den Akker 2008; Blewett and Hugo 2016). While Gibson (1986) stresses usefulness, Norman (1988) focuses on usability.

Later studies frame affordances within a sociotechnical view that bridges technological determinism and social constructivism, emphasizing their relational nature and the coupling of artefacts and social actors, both for physical and digital artefacts (Wang et al. 2018; Leonardi 2011). OR has long recognized this sociotechnical complexity (Eden 1989; Keys 1998; Ormerod 1996; White et al. 2016), though only recently have detailed studies of group dynamics in PSMs expanded, paving the way affordance-based theorizing (Tavella et al. 2020; Ackermann et al. 2016, 2018; Burger et al. 2018).

Affordances shape negotiation and knowledge creation (Lami and Franco 2016), enabling progression toward shared understanding, commitment, and agreed action (Burger 2020).

This study extends that line by unpacking the situated practice of OR (Franco and Greiffenhagen 2018): it identifies which structural features influence workshop outcomes, focusing on how models support group dynamics. The analysis centres on participants' perceptions, acknowledging the emerging *functional affordances* (Markus and Silver 2008) that can arise from a structure-actor relationship. Affordances are not features of artefacts per se, but relational possibilities for action (Hutchby 2001) that emerge when specific structures become actionable for particular users in a given setting, are meant as relationships between a technical object and a specified user (individual or group) and as possibilities for goal-oriented action. In this sense, affordances are connected with immediate concrete outcomes that actors experience, as consequences associated with actualising the affordance (Strong et al. 2014), that is how it is used by those who engage with it (Franco and Greiffenhagen 2021). Through observation and interviews, it is then possible to trace back from observable outcomes to the affordances that made them possible, such as how an arte-

fact enabled certain actions and what it actually made possible in practice (Volkoff and Strong 2013).

### 2.1 Multi-Values Appraisal Methodology (MuVAM)

Over time, digital support tools have evolved from early group facilitation systems into broader, online collaborative environments, highlighting the need to reassess their emergent affordances in today's ubiquitous digital contexts (Yearworth and White 2021; Lami and White 2022). To cite some prominent examples, the Strategic Options Development and Analysis (SODA) methodology (Eden and Ackermann 2001) has been supported by the use of Decision Explorer (Henao and Franco 2016; Ferreira et al. 2022) and then Group Explorer (Ackermann 2021; Abuabara and Paucar-Caceres 2021). It uses causal mapping to build a hierarchy of objectives, which is in turn analysed and discussed to identify the most appropriate objectives to pursue. These software programs permit each participant to contribute to the causal map, potentially anonymously, as a transitional object for facilitating interaction causal mapping (Eden and Ackermann 2018). The Strategic Choice Approach (SCA) methodology (Friend and Hickling 1987) has been supported by the use of STRAD (Strategic Adviser) (Cartwright 1992; Friend 1993; Friend and Hickling 2005; Smith and Shaw 2019), designed to interactively and graphically draw the SCA tools.

MuVAM is a decision support software, developed by I. Lami and DEM Future, designed to address complex problems by enabling collaborative discussions, shared solutions, and deliberation through an intuitive interface (demfuture.com/en/project/muvam). It implements the Multi-Values Appraisal Methodology (Lami and Todella 2023), integrating SCA with AHP in a single participatory workflow. SCA is used to engage multiple stakeholders and manage uncertainty, AHP contributes hierarchical problem structuring, pairwise comparisons, and preference synthesis, offering a more systematic basis for choice than SCA's compare/choose modes alone. Participants can collaborate on a project in two modes: (i) *in-place mode*: on-site collective data entry with real-time updates; (ii) *remote mode*: distributed collaboration with feedback and comments that can be synchronous or asynchronous. The *in-place mode* involves participants collaborating in person, typically working in small groups to collectively define the elements of the model. In this setting, the use of a laptop by each participant is not mandatory, and, in some cases, the facilitator may enter all inputs into the software. In contrast, during the *remote mode*, each participant independently provides their inputs, either synchronously or asynchronously. In both modes, participants use individual laptops when contributing directly, and one participant (or the facilitator) assumes the role of moderator, guiding the group through the different stages of the process. Importantly, the software records, whenever multiple inputs are provided, who introduced each specific element (e.g., decision areas or decision options). Moreover, every workshop concludes with co-created tangible outputs (indicated in *italics* in the following section on the phases of the process), and each application is fully logged in the software, with all stages remaining accessible for review even after the workshop concludes.

The methodology unfolds across four phases (for further information, see Lami and Abastante 2025):




**Fig. 1** The "problem focus" in MuVAM

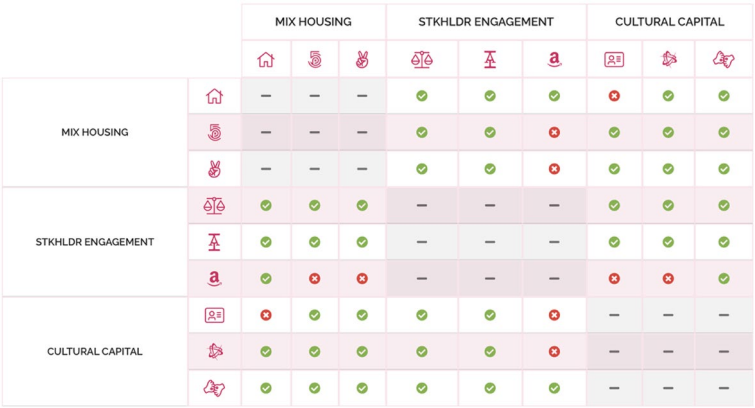



**Fig. 2** The "incompatibility grid" in MuVAM

1. "Shaping mode". Decision areas are surfaced to frame the enquiry thanks to a live negotiation: stakeholders iteratively build a shared decision graph and recalibrate urgency through dialogue (*problem focus*, Fig. 1).
2. "Designing Mode". This phase moves from naming issues to crafting what might be done about them: alternatives are surfaced, logged, and compared one another in an *incompatibility grid* that expresses conflicting choices (Fig. 2). Then, the software folds the record into an *option tree* that renders the feasible space at a glance.
3. "Comparison". Once the option tree is in view, MuVAM's attention narrows to the solutions worth examining and the yardsticks for judging them, echoing the first moves of SCA's comparing mode and the logic of AHP (Fig. 3). The

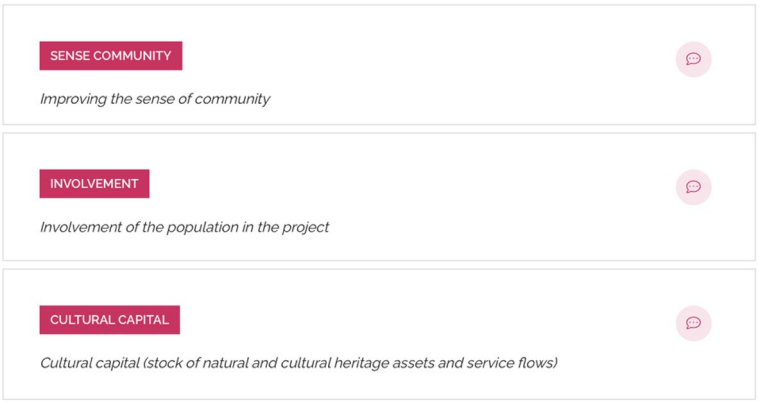



**Fig. 3** The identified "criteria" in MuVAM




**Fig. 4** The results of the "analysis" in MuVAM

outcome is a collaboratively developed set of evaluation criteria ready for pairwise analysis.

4. "Analysis": The fourth phase is an individual exercise: each participant assigns criterion weights and scores solutions pair-by-pair, with the software trimming the workload to the minimum needed for coherence. Results are presented through a *ranking* (Fig. 4) and a *dashboard* with concise graphs, showing partial scores and criterion weights for both individuals and groups.

Compared to causal-mapping-based group support systems such as Decision Explorer and Group Explorer, which focus on developing a shared visual representation of a problem while leaving choice implicit, MuVAM explicitly reasons toward rankings of alternatives.

## 3 Research Design

### 3.1 Research Setting

The study investigates the software's affordances on group interaction through the analysis of eight workshops, conducted over a span of 15 months, held in four different European countries, in three languages (English, French and Italian) and on four different case studies, all related to sustainable urban development. Interestingly, the participants in the workshops were also quite diverse: Bachelor's, Master's, PhD and Lifelong Learning Master's degree students, with a varied experience in terms of educational level and background. Moreover, in many cases the students involved in our study had never worked together before, mirroring the collaborative conditions often found in real urban-transformation processes. The workshops are listed and labelled in Table 1.

Despite the variety of cases and cohorts, three design moves kept the workshops on a single analytical rail. First, each session tackled a live urban-transformation dispute stocked with public data and controversy, sharpening engagement and realism (Midgley et al. 2013). Second, participants were seeded into 3- or 4-person teams that mixed gender and expertise but shared comparable educational capital, giving like-for-like baselines across groups. Third, the sample was deliberately weighted toward participants with little prior exposure to PSMs, and any MCDA-experienced individuals were systematically allocated across teams to control for expertise-related biases, ensuring that each one included at most one member with this type of expertise.

**Table 1** The eight workshops conducted in the research

| Institution | Program | Participants | Mode | ID | Output |
|---|---|---|---|---|---|
| Université Gustave Eiffel, Paris (FR) | Master 2, sustainable urban development | 15 | In-place | WS/01 | Report |
| Politecnico di Torino (IT) | Ph.D. urban and regional development | 13 | In-place + remote | WS/02 | Report |
| Politecnico di Torino (IT) | 2nd level master's degree in governance of resilient territories | 13 | Remote | WS/03 | Survey |
| Slovak University of Technology, Bratislava (SK) | Erasmus+ project "blended intensive programme", bachelor's degree | 30 | In-place + remote | WS/04 | Survey |
| Polis University, Tirana (AL) | Horizon Europe project "GreenFORCE", bachelor's degree | 9 | In-place | WS/05 | Survey |
| International Training Centre of the ILO, Turin (IT) | Master's degree in technology and public policy | 15 | In-place | WS/06 | Survey |
| Université Gustave Eiffel, Paris (FR) | Master 2, sustainable urban development | 13 | In-place | WS/07 | Report |
| Politecnico di Torino (IT) | Ph.D. urban and regional development | 9 | In-place | WS/08 | Report |

A fixed five-step script structured each workshop, from wicked-problem framing to final option ranking, into identical half-day blocks (Fig. 5, whose columns read chronologically from left to right, with sections denoting activity types, theory, home work, group work, workshop, and black labels indicating the actions within each step, which lasted about three hours with minor variations across settings). Each workshop began with a theoretical lecture introducing wicked problems, PSMs, SCA, and the multi-methodological approach adopted, followed by a presentation of the case study and the related decision problem. Students then worked independently and in groups to explore the case and define their perspective on the transformation. A second short lecture introduced MCDA, AHP, and the procedural use of MuVAM, after which the software was demonstrated. The following steps alternated between group work and plenary discussions to define the problem focus, identify options, and develop the option tree, concluding with scenario comparisons and a final analysis. Importantly, none of the introductory lectures discussed or introduced the concept of affordance, reducing potential influence on students' interpretive responses. These controls forged a stable setting for examining how facilitation techniques and digital artefacts nudge collective reasoning.

### 3.2 Data Collection

To probe how MuVAM's affordances were actualised into outcomes and related group dynamics, the study focused on participants' perceptions, complementing a well-established stream that links facilitated modelling to consensus quality but laments the scarcity of post-hoc evidence (Rouwette 2011; De Gooyert et al. 2022). Two sources informed the analysis:

- Workshop feedback reports. After each session, teams were given three to four weeks to compile a structured report (Fig. 6). The template evolved iteratively, adding or pruning questions as insights accumulated, yet always retained core items on (i) group dynamics, (ii) values guiding collective and individual choices, and (iii) satisfaction with outcomes.
- Immediate Google surveys. When course timetables precluded longer reflection,

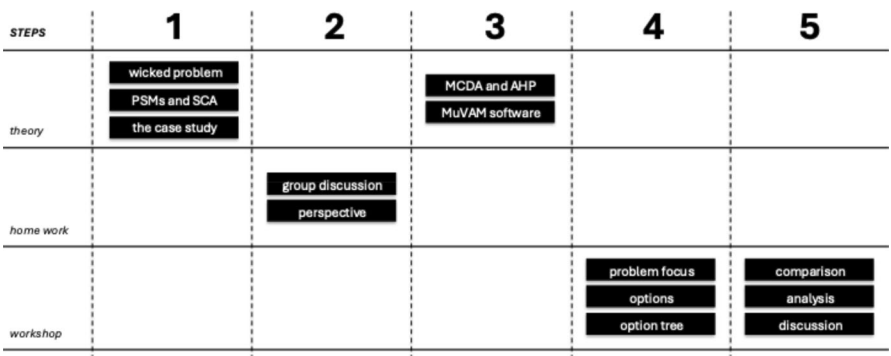



**Fig. 5** The workshops' structure

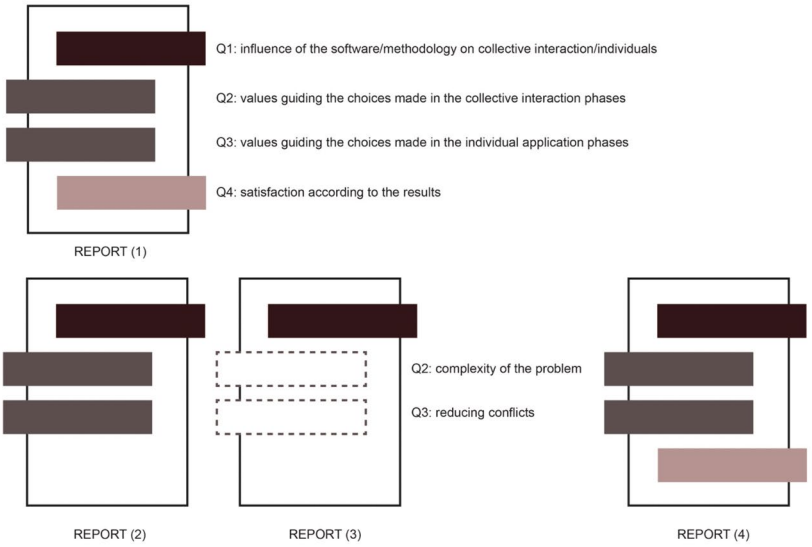



**Fig. 6** The structure of the report

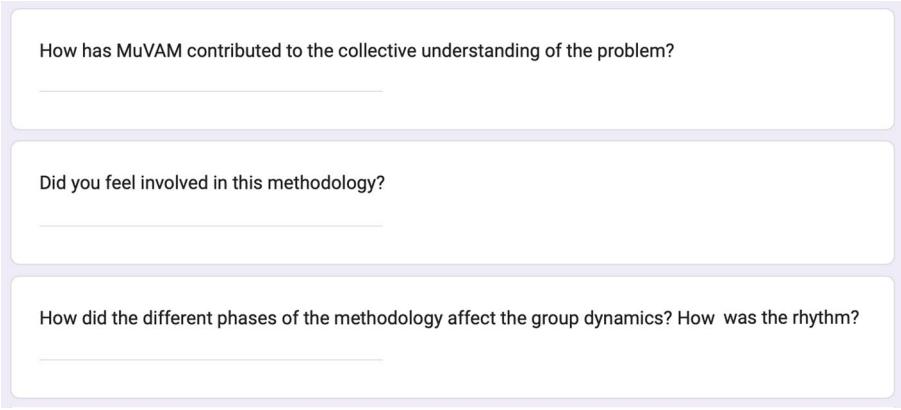



**Fig. 7** The questions proposed by means of the Google survey

a short survey was administered at the workshop's close (Fig. 7). Items mirrored the report's invariant sections, providing an in-situ snapshot against which to triangulate the slower, more considered narratives.

We employed multiple data sources, but the heart of our study was the structured report. Therefore, due to their brevity and limited contextual depth, the survey responses were not used as the main source of analysis. According to Gioia et al.

(2012), this enables us to gather both past reflections and real-time insights from individuals who are directly experiencing the phenomenon of interest. As noted above, the software records a complete log of each application, and all stages remain available for post-workshop inspection. Accordingly, students prepared their reports by revisiting their cases step by step within the software and using the exported outputs to support their observations. The dual method follows recommendations to combine real-time observation with participant retrospection (Ackermann et al. 2018; Tavella 2021) and to balance depth with comparability across interventions (Midgley et al. 2013). Content mapping against Hjortsø's (2004) criteria also confirms coverage of key PSMs outcomes: mutual understanding, stakeholder involvement, conflict management and decision transparency. Taken together, these data from different sources create a complementary evidence base (Bazeley 2018) to produce a more rounded understanding, and their convergence strengthens claims about how digital artefacts steer collaborative reasoning, such that each one reinforces the other.

### 3.3 Data Analysis

The data were analysed through a content analysis (Carley 1993) of participants' reports and Google survey responses, interpreting textual material to identify underlying themes (Duriau et al. 2007). Building on Gioia et al. (2012), the process was highly iterative, involving several rounds of coding. First, a "1st-order" analysis was conducted, based on informant-centric terms and codes. Drawing on the research question, each author conducted a process of coding on the reports and Google surveys transcripts, identifying themes through transcript segments (Tavella and Lami 2018). Second, the identified codes were examined to determine segments that would be suitable for a theoretically meaningful interpretation (Franco and Rouwette 2011). This represents a "2nd-order" analysis, using researcher-centric concepts and dimensions, aimed at a description and explanation of the phenomenon under investigation. Third, the authors organised the codes and excerpts into tables and collaboratively refined the coding scheme, consolidating overlapping codes and clustering related ones into broader categories. To ensure the reliability of the coding, the workshops were coded independently by the authors, while meeting regularly to ensure process integrity until reaching consensus. Also, using the same analytical logic across all responses ensured comparable robustness between long-form reports and brief survey answers.

These analytical steps revealed how certain elements can be interpreted as software affordances and some others as outcomes deriving from the actualisation of such affordances, giving rise to recognizable and recurring group dynamics. Through the coding process, these affordance-related group dynamics were categorised into two macro-categories (Fig. 8): (1) MuVAM's role in facilitating knowledge transfer and fostering the creation of a "Plural Subject", and (2) its performativity as a computer-supported technology acting as both a boundary and a "transitional object".

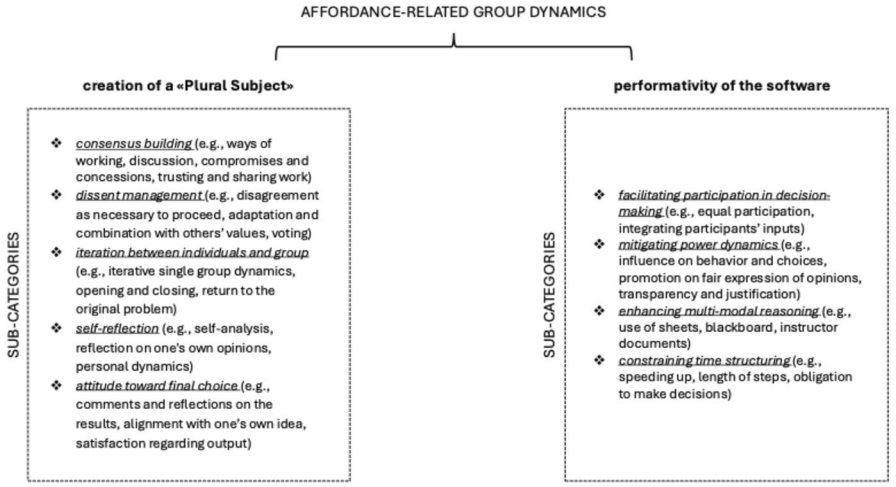



**Fig. 8** Emerging affordance-related group dynamics of MuVAM

## 4 Findings

Our analysis identified two macro-categories of affordance-related group dynamics through the analysis of participants' reports and surveys. This section examines how each group or individual dynamics is associated to a concrete outcome and derives from affordances perceived and actualized by participants.

Across the excerpts, participants explicitly describe how features of the methodology and the software shape group dynamics and guide action; these affordances are reported by participants, not inferred by the authors, within model-supported interactions.

To avoid conflating affordances with outcomes, we use the term affordance to refer to software-enabled possibilities for action (what participants can do with or through MuVAM's features), while we refer to outcomes and group dynamics as resulting from the actualisation of those possibilities during the workshops. Accordingly, Tables 2, 3, 4, 5, 6, 7, 8, 9 and 10 are organised to report the emerging group dynamics and to make this linkage explicit, reporting (i) the perceived software affordance, (ii) the concrete outcomes associated to the affordances' actualisation, and (iii) an illustrative excerpt. Reports, given their richer narratives, serve as the primary analytical source, while shorter survey excerpts are used complementarily and highlighted in the tables in italics.

### 4.1 The Creation of a "Plural Subject"

#### 4.1.1 Consensus Building

Table 2 maps participants' accounts on MuVAM's software affordances to the process dynamics of consensus-building and its outcomes. Participants associated the actualisation of these affordances with different outcomes such as the role of the

**Table 2** Examples of the dynamics of "consensus building"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Shared workspace (shaping, designing) | Improved expression of the group voice over individual voices | (1) We can see that the group's words were much more important than individual words. We can assume that listening might not have been as good without the software and the organization it provided | WS/01 |
| Structured input aggregation (shaping, designing, comparison, analysis) | Convergence through compromise and avoidance of deadlock | (2) Little by little, it's the group that has chosen, and the compromises […] are gradually being erased as the choices are made. A situation in which individual wishes could have got in the way has been avoided by gently eliminating anything that was not the will of the group | |
| Shared workspace (shaping, designing) | Emergence of shared working dynamics and negotiated consensus | (3) Although we had never all worked together before, we were able to find common dynamics. […] We have always managed to make concessions and find consensus that suits everyone | |
| Structured input aggregation (analysis) | Balancing perspectives and moving toward a collectively acceptable position | (4) The analysis step in the software is probably the most impressive and useful step as it allows users to integrate each member's opinion in a standard and systematic way. […] to find a balance between maintaining and supporting your views while also embracing the other members' opinions | WS/02 |
| Stage-gated workflow (shaping, designing) | Perceived legitimacy and acceptance of intermediate and final outputs | The software is very useful to justify, legitimize and democratize the decision-making process. […] Any step was previously discussed and eventually approved by everyone or at least by the majority | |
| Process scaffolding and iteration (shaping, designing) | Sustained deliberation that helps resolve sticking points | The strength of this decision-making process lies in its ability to spark discussions that help resolve sticking points by forcing the various actors to constantly engage in dialogue, debate and defend their positions | WS/07 |
| Shared workspace (shaping) | Shared understanding that orients subsequent discussion and decision making | The development of decision areas, decision links and problem focus was informed by the group's collective understanding. These stages, characterized by participatory and interactive processes, shape the course of group discussions and collaborative decision-making | WS/08 |

software's organized structure in expressing the group's collective voice (ex. 1) and in harmonising divergent opinions while preventing deadlocks (ex. 2). Even among first-time collaborators (ex. 3), shared working dynamics and negotiated consensus were reported to form through compromise and adaptation gradually. The excerpts highlight how the software balances perspectives toward agreement, legitimising the acceptance of outcomes (ex. 4, 5) and ensuring equal consideration of diverse inputs. The software further sustains deliberation and consensus in specific sticking points (ex. 6), particularly during the initial shaping phase (ex. 7), where participation and discussion contribute to a shared understanding that orients subsequent discussion.

### 4.1.2 Dissent Management

Table 3 makes explicit which software affordances participants linked to dissent management and the outcomes reported as following from their actualisation. Disagreement is often portrayed as a constructive element of progress, managed through

**Table 3** Examples of the dynamics of "dissent management"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Stage-gated workflow (shaping, designing, analysis) | Potential frustration when repeated disagreement is not reflected in the group choice | (1) The tool allows the group's voice to be heard more clearly, but individuals may feel aggrieved when their opinion is repeatedly ignored by the group | WS/01 |
| Shared workspace (shaping, designing) | Early surfacing of divergence as a basis for negotiation | (2) The collective interaction saw multiple discussion which highlighted some initial individual divergences | WS/02 |
| Visual structuring and comparison (designing) | Focused mediation of strong positions toward a workable 'average' agreement | (3) The decision options and the discussion of incompatibilities forced the stakeholders (we students) to discuss and mediate their preferences. […] I found the graphic translation of the incompatibilities very useful in the software. I have seen how two very strong positions […] clash and find an ideal average agreement for this case study. I am sure that this constitutes a significant strength of this software | |
| Traceability and transparency (shaping, designing, comparison) | Disagreement becomes explicit, accountable, and discussable | *(4) It was nice working in groups in this methodology because even when we had a disagreement, anyone of us could write opinions and be listening in decision* | WS/05 |
| Participation structuring (shaping, designing, comparison) | Recognition of different approaches while maintaining equal voice | *(5) It was great as everyone was able to contribute equally and give their contribution and it was interesting as we found out that although we have the same agenda we might have different views on how to approach it* | WS/06 |
| Stage-gated workflow (shaping, designing) | Conflict transformed into negotiated, collectively endorsed outcomes without imposition | (6) This perpetual debate helped create a consensus, as we all validated our choices unanimously, without anyone feeling that they were being imposed on by others | WS/07 |
| Participation structuring (shaping, designing, comparison) | Diversity leveraged to generate new ideas and clearer problem definition | (7) Despite differences in opinions, the methodology facilitated his easy integration into discussions. This diversity sparked new ideas, expanded discussion topics, and contributed to a clearer definition of problems | WS/08 |

collective interaction that integrates (and sometimes reveals) divergent views (ex. 1, 2), although some participants reported that their perspectives were repeatedly overlooked or ignored during group deliberations. The software appears to help mediate the debate and offers visual tools that focus discussion and guide movement toward what participants define a workable "average agreement" (ex. 3). Written contributions make disagreements explicit and accountable, then discussable in equal ways (ex. 4, 5), while transparency and dialogue seem to help transform conflict into negotiated, collectively endorsed outcomes (ex. 6). Ultimately, the methodology is perceived to leverage diversity to turn disagreement into shared understanding and to stimulate new ideas (ex. 7).

**Table 4** Examples of the dynamics of "iteration between individuals and group"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Individual reflection capture (comparison) | Autonomy to form judgements without immediate group pressure | (1) This individual involvement allows participants to put the group's discussions into perspective and thus make their own decisions. […] to express their own opinions and ideas without constraints or the scrutiny of other group members | WS/01 |
| Process scaffolding and iteration (comparison) | Sense of controlled freedom after negotiation phases | (2) The software is very good in this phase, and it is clear to follow each step. It lets a good sense of freedom of choice after the previous steps of negotiation. I would find useful to use it in real situations | WS/02 |
| Scoring/voting aggregation (comparison, analysis) | Fair evaluation and efficient consolidation into a final ranking | (3) The individual vote ensured a fair evaluation of the best scenario, an aspect that might be overlooked in ordinary decision-making processes. […] The final weighting of preferences is an excellent way to guide efficient decision-making processes | |
| Individual reflection capture (comparison) | Greater awareness of individual perspectives alongside the collective trajectory | (4) The aspect that is particularly intriguing is the fact that the final part of the analysis, preceding the definition of the solution, is carried out independently. This allows each participant to actively attribute their own personal and professional standpoint | WS/08 |

### 4.1.3 Iteration between Individuals and Group

In contrast to the earlier phases, the comparison/analysis phases reintroduce personal decision-making, allowing participants to express opinions independently of group influence while ensuring everyone's voice is heard, and the "weighting" stage shifts the focus to individual values. Table 4 maps the affordances allowing the individual phase to act as counterpart to the group's discussion that collectively shaped the decision-making process, autonomously forming judgments (ex. 1). Participants emphasise the software's ability to balance freedom and structure (ex. 2), combining and equally weighting diverse viewpoints. The final evaluation is thus seen as an effective means to support fair evaluation toward an efficient decision-making process (ex. 3). By alternating collective and individual phases, the process appears

**Table 5** Examples of the dynamics of "self-reflection"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Process scaffolding and iteration (all the phases) | Increased self-awareness and desire to adjust future participation | (1) This process has made me question my opinions, and perhaps in future it would be better if I asserted my ideas a little more forcefully | WS/01 |
| Process scaffolding and iteration (analysis) | Clearer understanding of why certain preferences were held | (2) I think the software was very useful in allowing me to rationalize my decisions and really understand why I had certain preferences | WS/02 |
| Input schema constraints (all the phases) | Perceived limitation of expressive flexibility in supporting sensemaking | (3) On the other side, the software does not allow for much flexibility. I personally had to use a piece of paper to draw down some schemes and clear my thoughts and then report them on the software | |
| Time structuring and pace (designing) | More informed decisions through broader exploration of scenarios | *(4) The tool has helped […] to make more informed decisions by providing a structured approach and facilitating the exploration of various scenarios. I reckon this step was pretty straightforward in forcing me to slow down* | WS/04 |
| Shared workspace (shaping, designing) | Deeper appreciation of problem complexity and scenario space | (5) Without methodology or software, my perception of the complexity and relevance of the problem was erroneous and superficial. Writing down all the constraints/possibilities for a given situation forces us to consider all possible scenarios | WS/07 |
| Process scaffolding and iteration (all the phases) | Reconsideration and re-establishment of one's reasoning | (6) This is a process that helps us rethink and re-establish our thinking | WS/08 |

**Table 6** Examples of the dynamics of "attitude toward final choice"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Traceability and transparency (all the phases) | Acceptance of the outcome even when not fully convinced, because the rationale is understandable | (1) I'm not totally convinced by our solution, but I accept it and can understand it. […] We've all restricted ourselves a little in our decisions so as not to get in the way of each other's proposals | WS/01 |
| Visual structuring and comparison (designing, comparison) | Expectation of more contested discussion in contexts where decisions have real-world consequences | (2) Certainly, in a different context where the process leading to the development of this space would be real, searching for the "best solution" would have made the options much more thoughtful and subject to debate | |
| Structured input aggregation (all the phases) | Perceived rationality and balance in the final choice | (3) However, we got a happy ending at last. MuVAM supports us in making a rational decision under multiple values. It integrates well | WS/02 |
| Structured input aggregation (analysis) | Sense that the software materially shaped interaction and enabled agreement on a solution | (4) The software was extremely useful in supporting the collective interaction and we agreed that we would not have got to the same final solution had we not had this type of support. […] Even better, it allows users to compare single responses with the final group results | |
| Process scaffolding and iteration (all the phases) | Recognition that the method redirected the group relative to intuitive decision making | (5) I think that the methodology and the decision-making process that we followed led us in a direction that we wouldn't necessarily have taken intuitively | WS/07 |
| Shared workspace (analysis) | Satisfaction because outcomes reflect shared reflections one can endorse | (6) I would say the collective results are very satisfactory to me since they came from shared reflections that I agreed with | WS/08 |
| Traceability and transparency (all the phases) | Repositioning of the software's role as sensemaking and explanation, rather than outcome-determining | (7) I posit that, even without the use of the software, we might have arrived at comparable results. Therefore, it is likely that the software, in my case, serves as a tool for explaining these choices rather than fundamentally influencing the decisions themselves | |

to enhance awareness and autonomy while preventing the collective trajectory from overshadowing individual perspectives (ex. 4).

#### 4.1.4 Self-Reflection

Table 5 outlines the affordances through which MuVAM may support self-reflection, while also pointing to potential trade-offs in how reflection is elicited and constrained. Tensions between personal convictions and collective outcomes are evident (ex. 1), and the reported intention to "assert ideas more forcefully" can be read not only as reflective learning but also as a response to feeling insufficiently heard within the group dynamic. Participants describe that the stepwise procedure helps them rationalise decisions and clarify the reasons underlying their preferences (ex. 2); however, this clarity may come with a cost, as the standardised representation can limit expressive flexibility and require external workarounds (ex. 3). Similarly, articulating motivations and making constraints explicit can deepen awareness of one's preferences

**Table 7** Examples of performativity in terms of "facilitating participation in decision-making"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Shared workspace (all the phases) | More equal voice, reduced exclusion and greater engagement | (1) No one is left out, and we take the time to see what everyone thinks before making a decision. With the use of this tool, all members of the group have been given a voice in the decision-making process […]. The fact that we were grouped together around the software encouraged everyone to give their opinion on each of the ideas, which might not have been the case without it | WS/01 |
| Stage-gated workflow (shaping, designing, comparison) | Perceived procedural fairness throughout the process | (2) From the very beginning of the problem structuring and decision-making, the software allowed an equal and democratic approach to the problem; first, the "technical" necessity for the software to have each member's approval of every decision phase's conclusion is indeed a distinctive sign that every voice and every opinion matters in order to proceed | WS/02 |
| Traceability and transparency (all the phases) | Perceived support for legitimacy and procedural fairness, coupled with constrained peer-to-peer interaction | (3) In my opinion, the software is very useful to justify, legitimize and democratize the decision-making process … However, if not in presence, I feel the interaction between the participants is not very encouraged by the software; it didn't allow much discussion due to the impossibility to edit each other's inputs, i.e., decision areas, etc. | |
| Visual structuring and comparison (all the phases) | Transparency and clarity about what is being decided and why | *(4) Absolutely, we entered information, made choices, used icons and tables, concretely, all our research, our thoughts were in front of us* | WS/04 |
| Visual structuring and comparison (shaping, designing) | Improved understanding of priorities and evolving problem structure | *(5) By having a schematic view, it allows an understanding of which problem is the most urgent, but also to properly redesignate our thoughts about the case* | WS/05 |
| Participation structuring (all the phases) | Improved mutual understanding and consensus-oriented collaboration | (6) MuVAM enables stakeholders to actively participate in the decision-making process, reducing feelings of exclusion as each member of the group has been able to give their opinion and participate in the various stages of the process. In addition, the use of a common platform has improved mutual understanding | WS/07 |

and broaden engagement with the problem space (ex. 5, 6), yet the "built-in pacing" is described in terms of forcing a slowdown (ex. 4), suggesting that reflective effects may partly derive from procedural imposition rather than intrinsic support. Overall, the excerpts indicate that MuVAM can enable self-reflection, but in ways that may simultaneously channel how reflection is performed and how individual perspectives are carried into collective deliberation.

### 4.1.5 Attitude Toward Final Choice

Participants generally express approval of the final choices, often because the results seemed to align with their perspectives (Table 6). Acceptance of results, including when not fully convincing, was frequently attributed to the method's transparency and comprehensible rationale (ex. 1), but participants also noted that this legitimacy

**Table 8** ...Examples of performativity in terms of "mitigating power dynamics"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Participation Structuring (all the phases) | More balanced relationships and reduced dominance | (1) Generally speaking, the process proposed by the software allowed everyone to express themselves as they wished. Relationships seemed balanced, and there was no real leader | WS/01 |
| Time structuring and pace (all the phases) | Greater awareness and more considered participation relative to 'usual' processes | (2) That's the difference with the "usual" process: usually, we don't take this time and we directly confront the ideas that come to mind, trying to reach a quick consensus | |
| Scoring/voting aggregation (comparison, analysis) | Reduced risk of interest predominance and fairer influence distribution | (3) The individual vote ensured a fair evaluation of the best scenario […]. We often do not realize that there could be a predominance of one stakeholder's interest (by power or centrality); even putting in place multicriteria compensatory analyses […]. On the contrary, I have observed that in this software the participants' positions are weighed equally. The final weighting of preferences is an excellent way to guide efficient decision-making processes | WS/02 |
| Participation structuring (all the phases) | Potential to mediate power imbalances across social/economic positions | (4) This is very important specifically when dealing with multiple stakeholders whose (usually economic) power force is consistently distant or the distance is given by a different social class and consequently exposes a more fragile social category. The current software structure then suggests a high potential […] | |
| Structured input aggregation (comparison, analysis) | Ability to maintain one's view while incorporating others, perceived as fair | (5) With this, the software addresses the problem […] to find a balance between maintaining and supporting your views while also embracing the other members' opinions – because it integrates all member's responses in a fair manner | |
| Visual structuring and comparison (comparison, analysis) | Legitimacy and discussion catalysed and streamlined by an explicit evaluative frame | (6) Introducing a mathematically based evaluation at this juncture, not only justifies concentration but also catalyzes the discussion in a particular direction | WS/08 |

may be harder to sustain when decisions carry real-world stakes and higher contestation (ex. 2). While the structured workflow was described as integrating individual and collective viewpoints and thereby producing a "rational" choice (ex. 3), the excerpts also suggest that agreement can reflect how the process channels interaction and convergence: some participants felt the software materially shaped deliberation (ex. 4) and even redirected the group away from more intuitive paths (ex. 5). Overall, satisfaction appears to stem from the coherence between outcomes and both individual and group positions, fostered by the software's transparent, stepwise approach (ex. 6). However, in the absence of a direct comparison, the question remains open as to whether the software was primarily perceived as supporting the explanation of choices, rather than determining outcomes (ex. 7).

In summary, participants' accounts point out affordances through which MuAM may support the emergence of a "Plural Subject", while also indicating that these effects depend on how the software is taken up in practice and may involve trade-

**Table 9** Examples of performativity in relation to "enhancing multi-modal reasoning"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Hybrid tooling (designing) | Clearer comparative view across alternatives | (1) To get a clearer picture of our 10 solutions, we wrote them down and compared them side by side, looking at each one separately and as a whole, because we had to reason by comparison too | WS/01 |
| Hybrid tooling (shaping) | Alignment on 'the same wavelength' and shared grasp of the software's value | (2) We put a set of issues on a sheet of paper. […] A common document allowed us to share a set of issues specific to each of us. We reread all the documents sent to us to see if we were all on the same wavelength, and if we had understood the value of using this decision-making tool | |
| Hybrid tooling (all the phases) | Compensating perceived rigidity while keeping a shared reference point | (3) The lack of flexibility was evident while relying on pen and paper to schematize and flash out some parts of our rationale and then report the results back on the programme. […] Though having pen and paper proved at times indispensable to keeptrack of an overview of the project, the programme managed to provide a step-by-step and shared system to refer to | WS/02 |
| Hybrid tooling (designing) | Individual clarification of thinking that can then be contributed to the group artefact | (4) I personally had to use a piece of paper to draw down some schemes and clear my thoughts and then report them on the software | |
| Shared workspace (shaping) | Continuity between phases and coherence in collective work | (5) We essentially pointed our focus toward the areas we had previously agreed upon for our presentation. As we entered the first phase, we relied on our previous work to guide us through the unpacking of the Decision Areas | |
| Hybrid tooling (designing) | More fluid coordination and communication during option generation | (6) To define the options for each area, a brainstorming session was carried out where all the members were proactive, some of them wrote the proposals directly in the program, one person wrote on the board and another person waited for the information to be uploaded. […] The resource of writing their ideas on the board so that everyone can have an overview of what is being defined | WS/07 |

offs (e.g., convergence pressures, uneven recognition of minority positions, and procedural constraints). Tables 2, 3, 4, 5 and 6 show how, when actualised through micro-processes such as discussion, compromise, concession, constructive disagreement and reflexive moments, participants' outcomes translate into a set of core group dynamics such as consensus building, dissent management, iteration between individuals and the group, self-reflection, and attitude toward the final choice.

## 4.2 The Performativity of the Software

### 4.2.1 Facilitating Participation in Decision-Making

The excerpts suggest that participants associated the software with engagement, collaboration, and clarity in decision-making, often linking these effects to perceptions of procedural fairness (Table 7). In line with the idea that fair procedures can enhance meaningful engagement and, in turn, the richness and authenticity of the qualitative material generated during workshop interventions (Kaur and Carreras 2021), par-

**Table 10** Examples of performativity in relation to "constraining time structuring"

| Software affordance | Associated outcome | Excerpts | ID |
|---|---|---|---|
| Time structuring and pace (all the phases) | Faster concessions and shorter negotiation phases | (1) Without the software, it's certain that compromises would have been made, but within a longer timeframe. […] This tool therefore helped to structure the debate and organise the train of thought | WS/01 |
| Individual reflection capture (all the phases) | More deliberate consideration of personal convictions before debate | (2) MuVAM software takes us step by step, and forces us to take the time to think for ourselves, according to our own convictions, before discussing them with each other | |
| Time structuring and pace (shaping, designing, comparison) | Richer and more inclusive debates, at the cost of longer decision-making times and temporal constraints | (3) This method allowed everyone to express themselves and for debates to be more substantial and interesting. However, the downside is that we took a lot of time for each decision, and we were sometimes constrained by time | |
| Time structuring and pace (all the steps) | Shift in perceived decision driver from collective reasoning to temporal constraints | (4) During our work together, what influenced decisions was the passing of time, not the group | |
| Process scaffolding and iteration (shaping, designing) | Efficient generation of options and rapid grasp of the problem | *(5) The program is a guiding tool for reaching possible concrete options which, approaching the problem for the first time, we could not have obtained otherwise in a short time. It helped me to get a general idea of the problem […]* | WS/03 |
| Time structuring and pace (all the phases) | Pressure of time can be felt as urgency, yet decisions still reached | (6) Perhaps the short amount of time gave the impression of having to process a decision in an emergency situation, and yet we managed to get an answer to our question | WS/08 |
| Structured input aggregation (comparison, analysis) | Smoother and more expeditious progress, especially in individual steps | (7) Notably, sections requiring individual efforts demonstrated smoother and more expeditious progress. Even in instances necessitating collective input, those allowing for individual responses on personal devices, subsequently presented on a communal board for acceptance, exhibited superior efficiency compared to entirely collective steps | |

ticipants valued the shared platform and co-present interaction as mechanisms that may reduce exclusion and broaden participation (ex. 1). Likewise, the requirement of approval at phase transitions was interpreted as a safeguard against unilateral moves and as a basis for legitimacy (ex. 2). However, Excerpt 3 points to a key trade-off: the same design that supports accountability and ownership can also constrain peer-to-peer influence, since participants cannot directly edit each other's inputs, potentially limiting deliberation unless supplemented by co-present discussion. Visualisation was widely perceived as improving transparency and intelligibility (ex. 4, 5) and the structured format as supporting mutual understanding (ex. 6).

#### 4.2.2 Mitigating Power Dynamics

Table 8 suggests that participants experienced the mitigation of power dynamics and more balanced relationships by limiting dominance and ensuring fair expression of opinions (ex. 1). By structuring group reasoning, MuVAM was perceived to promote greater awareness and more considered participation than "usual" processes (ex. 2). Participants also framed the approach as potentially helpful for mediating divergent stakeholder interests and reducing reliance on the moderator, although these effects are reported as perceptions and may depend on the context and group composition (ex. 3, 4). Integrating all participants' inputs seemed to foster a more even distribution of influence (ex. 5), while Excerpt 6 points to a more ambivalent mechanism: the mathematically grounded evaluation provides an explicit rationale that can concentrate attention and steer discussion "in a particular direction", potentially streamlining deliberation but also shaping what counts as relevant or legitimate within it (ex. 6).

#### 4.2.3 Enhancing Multi-Modal Reasoning

In Table 9, participants express a need for a "clearer picture" when using the software, complementing it with paper and other media to articulate and visualise evolving solutions (ex. 1). Such supports help surface issues, align understandings, and compensate perceived rigidity by clarifying ideas and broadening perspectives (ex. 2, 3). These practices suggest that collaboration extended beyond the interface, enabling shared visualization and iterative refinement (ex. 4, 5). A common extra whiteboard, present in the physical environment of the classroom, and not as feature of the software, was also mentioned as complementing it, fostering communication and brainstorming, especially in option generation (ex. 6).

#### 4.2.4 Constraining Time Structuring

The use of the software was perceived to contribute to shorter negotiation phases, compared to the first discussion conducted as home work. Table 10 maps the affordances embedded in MuVAM's workflow, with faster concessions and quicker aggregation, which some participants found helpful in group settings (ex. 1). Rather than producing new outcomes, MuVAM was described as streamlining the process, enhancing efficiency while prompting reflection on convictions to be debated with others (ex. 2). While the method broadens participation and deepens the discussion (ex. 3), it also makes time pressure more salient. In practice, these temporal constraints can end up steering decisions more than the group's collective reasoning, revealing a methodological trade-off in which inclusivity is achieved at the cost of deliberative autonomy (ex. 4). The inclusion of an individual reflection phase, typically absent in traditional methods, appeared to help focus and prepare collective discussion, partly aligning with participants' creative routines. Although this acceleration supported decision-making (ex. 5), it sometimes required adaptability to maintain balanced group dynamics (ex. 6). Individual phases generally ran more smoothly, with the software reported to facilitate quicker consolidation of responses (ex. 7).

In summary, participants' accounts point out affordances through which MuVAM unfolds software-mediated collaboration as a transitional object, and related outcomes. Across Tables 7, 8, 9 and 10, these affordances are described as emerging through micro-processes in a shared and transparent setting, often in hybrid configurations that rely on external tools and explicit negotiations of timing and pace. In this sense, reported outcomes cluster around core group dynamics (participation in decision-making, mitigation of power asymmetries, multi-modal reasoning, and time structuring), but not without frictions: some mechanisms that support fairness and accountability may also shift deliberation toward what the interface renders legible, or allow temporal constraints to weigh more heavily than collective reasoning. The resulting shared models appear to be built incrementally, integrating individual perspectives over time, yet this integration is portrayed as also contingent on situational adjustments rather than guaranteed by the software alone.

## 5 Discussion and Conclusions

This study sheds light on how software-enabled affordances are perceived and actualised in interaction, giving rise to specific outcomes and group dynamics in a students' case-based group-artefact interaction. The paper investigates how the process and structure of PSMs influence workshop outcomes (Franco and Greiffenhagen 2018; Lami and Tavella 2019), with particular attention to the distinction between software affordances (software-enabled possibilities for action) and outcomes (the effects that arise when those possibilities are actualised in practice). Building on work that locates facilitated modelling at the nexus of social practice and material artefacts (Ackermann et al. 2018; Burger 2020), and on the notion of collaborative viewing of models (Franco and Greiffenhagen 2021), the findings confirm that digital models operate on two entwined planes: socially, by rendering divergent views visible and negotiable and thus supporting the emergence of a "Plural Subject", and technically, by acting as "transitional objects" that continually reshape the problem space. In doing so, the paper extends the situated understanding of OR practice by identifying how PSMs' processes and structural features influence workshop outcomes and how models support group dynamics. It focuses on participants' perceptions rather than real-time observation, using an inductive, participant-centred approach to explore how specific features of the software influence interaction and outcomes.

In line with Franco and Greiffenhagen (2021) analysis of Group Decision Support practice "as it happens", MuVAM functions as a transitional object whose meaning and effects are continually negotiated through use. What characterises MuVAM more distinctly, compared to other PSM-supporting software, is its capacity to combine shared, co-present modelling with individual moments of reflection and formal aggregation, thereby making individual values explicit while keeping them accountable to a shared representational space.

Empirical insights sharpen this contribution in three respects. First, the software affords structured visibility of contributions (e.g., shared workspaces, stage-gated transitions, traceable inputs), which participants associate with outcomes such as consensus building and dissent management. Importantly, dissent is not eliminated

but rendered discussable, enabling disagreement to be worked through rather than bypassed, an effect consistent with theories of joint commitment and the formation of a Plural Subject. Second, the platform's capacity for immediate, collective updates lowered the transaction costs of iterating alternatives and helped level power asymmetries, illustrating how technical features can widen participation yet also nudge groups towards mainstream framings when left unchallenged. Third, the drift toward self-facilitation, especially in remote and hybrid settings, raises new questions about the evolving role of the human facilitator and the trade-off between procedural rigour and creative exploration.

These findings have practical implications. Introducing MuVAM into decision routines requires attention to how software affordances are staged and combined, rather than assuming that desirable outcomes will automatically follow from software adoption. In-person settings may be preferable when legitimacy, mutual learning, and commitment are paramount, whereas remote configurations can expand participation and efficiency but risk compressing deliberation unless complemented by explicit reflective or dissent-capturing mechanisms. In this sense, the software supports, but does not replace, facilitative work, which may be distributed across the workshop design, participants and the software itself.

These insights sit alongside clear boundaries. Evidence is confined to a single platform and to educational, low-stakes contexts that are nonetheless analogous to early-stage urban transformation settings, leaving the counterfactual of traditional or rival digital tools unexplored. The analysis privileges participant perceptions over fine-grained behavioural traces, and the procedural structure embedded in the software may constrain exploratory or non-convergent forms of reasoning. Future work should therefore stage direct comparisons with analogue and alternative digital methods, test the approach in high-stakes arenas and probe how emerging generative-AI capabilities might enlarge (or narrow) the space for collective reasoning.

Taken together, these insights recast decision-support software not as a neutral container of methods, but as a socio-technical actor whose affordances shape who speaks, what becomes visible, and how collective outcomes are stabilized. By analytically separating software affordances from their outcomes, the paper advances a more precise account of how PSM-supported group decision and negotiation unfold in practice, contributing to ongoing debates within Group Decision and Negotiation on the situated, performative nature of decision support.

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## Declarations

**Competing interests** The authors declare no competing interests.

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