Meaning-making in the process of participatory system dynamics research

Abridged version (the full version is available from the authors)

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Abstract

Similar to validation techniques, participatory methods try to alleviate bounded rationality in the process of modelling in order to build better models. In addition, they aim to change participants understanding, decision making and actions. While good examples of best practice exist in participatory system dynamics, a unified underlying social theory of collaboration or learning, or even competing theories are missing. To support the development of a theoretically grounded participatory process, we draw on the distinction of bounded rationality represented in model content as well as in the modelling process itself and specifically draw on theories of meaning construction by George Herbert Mead and relate them to a case example in the area of housing. We argue that participatory methods should include four elements of meaning-making (i.e. gesturing, naming, acting, and iterating) in order to change participant's mental models. This will also change the contents represented in the generated system dynamics models, e.g. from a fragmented to a more holistic view.

Key Words

System Dynamics, Participatory Methods, Modelling Process, Bounded Rationality, Learning, Meaning-making

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Introduction

Achieving change in a social system involves changing people's actions, their decision-making, social interactions and cognition. System dynamics models include decision-makers endogenously in the issue to be modelled (Richardson, 2011), and the modelling process can directly involve decision-makers as well. This not only leads to building better models with direct input from problem experts, but also to changing participants' thinking. While best practices have been documented by group process researchers (Andersen, Vennix, Richardson, & Rouwette, 2007; Vennix, Andersen, Richardson, & Rohrbaugh, 1992), these have been established rather inductively, and a social theory of collaboration or learning underlying the participatory modelling process is missing.

Using Mead's (1925; 1934) theory of socially constructing meaning, this paper aims to theoretically ground how meaning changes through participatory methods. By relating theoretical elements to a case study, it provides a lens through which participatory processes can be understood, without seeking to develop a full theory. This paper thus complements previous research on adding science to the craft of participatory modelling (Andersen, Richardson, & Vennix, 1997; Black, 2013; Black & Andersen, 2012) and specifically on how Mead's theory can achieve this (Black, Greer, & Zimmermann, 2014). We relate our theoretical investigation of participatory modelling to bounded rationality captured within the content of system dynamics models as well as within the modelling process itself (Größler, 2004).[1] To shed light on the relationship of theory with group facilitation processes, we relate elements of Mead's (1925; 1934) theory of socially constructing meaning to an empirical case of a stakeholder workshop that included a session on constructing shared understanding of a UK Government housing policy called the Green Deal.

This study can improve group facilitation by providing a theoretical framing of participatory processes. Our conceptual work, supported by evidence from the case study, portrays how stakeholder interactions in participatory processes can be characterized by Mead's four elements of meaning-making, collectively generating an iterative process of a reciprocal relation of individuals to the group purpose. Finally, we offer recommendations for the structuration of group facilitation processes.

Participatory modelling to overcome bounded rationality in the modelling process

Bounded rationality: System dynamics models incorporate boundedly rational decision-making. It is argued that system dynamics models should represent decisions as they happen and not assume full rationality among decision-makers (Größler, 2004). Bounded rationality is a central element of Carnegie School's behavioural theory which also focuses on how people really behave (Cyert & March, 1963; March & Simon, 1958; Simon, 1976; for SD applications see Rudolph, Morrison, & Carroll, 2009; Sastry, 1997; Zimmermann, 2011). Apart from decision-making represented in a model, bounded rationality also affects the modelling process (Größler, 2004). This is why system dynamics modelling follows rigorous conceptualisation processes and validation techniques. As different individuals know different information through different experiences, system dynamics researchers often use participatory methods to elicit and integrate distributed knowledge.

Participatory modelling: Participatory system dynamics modelling aims to structure group processes for learning about social systems (Andersen et al., 2007; Zagonel, 2002). It involves

[1] We thank Andreas Größler for mentioning and pointing us to the relation between the Green Deal modelling and bounded rationality.

problem owners and other knowledgeable individuals in the construction of causal loop diagrams or system dynamics models, or it can refer to a process of facilitating interaction with a model in a group-oriented and participatory way. Consequently, it aims to improve model quality and/or change participants' thinking. Importantly, it acknowledges feedback between both. Zagonel (2002) emphasises the importance of constructing meaning through this process. To be successful, it is recommended to follow group model building (GMB) scripts, i.e. small bits of interactive process structure that have become established as best practices (Hovmand, Rouwette, Andersen, Richardson, & Kraus, 2013). Some research has tried to establish more generally conditions when participatory modelling is successful (Andersen et al., 1997; Rouwette, Vennix, & Felling, 2009).

Adding science to craft: Some researchers have begun proposing a theoretical model. E.g., Rouwette (2009, see also Andersen et al., 1997: 194) draws on Ajzen's (1991) theory of planned behaviour for theorising the transition between consensus, commitment and system change. Black (2013) draws on the concept of boundary objects and Black and Andersen (2012) demonstrate how boundary objects can be used in GMB. Black, Greer and Zimmermann (2014) suggest using Mead's (1934) theory of meaning-making in combination with Lave's (1988) theory of situated cognition as a theoretical framework for interdisciplinary collaboration. They develop a framework of gesturing, naming, acting and iterating, grounded in Mead's work on language, learning and the mind. This paper applies the framework and translates it from visual representations to settings that use participatory elements in general.

Mead's theory of meaning-making

Mead outlines a theory of speech and learning that is in fact a theory of meaning-making. As participatory research also aims at creating shared meaning, Mead's theorising proves valuable in understanding the different elements a participatory session must involve in order to change individuals' understanding and construct shared or interconnected meaning. As Mead's theory is still judged as mostly correct today (Gallagher, 2012), it provides an excellent framework for knowing how individuals and groups come to know something and how their knowledge changes.

Mead establishes a process theory (Mead, 1925; 1934) that addresses the dynamic experience of individuals (Mead, 1934: 18–27) which he constructs around the concept of gesturing. Rather than the gesture itself, Mead focuses on the process of gesturing, thereby developing a theory of cognition and interaction. He understood language as inseparable from gestures. Thus, gesturing is not a predecessor or early form of language, but language is itself a gesture anchored in an individual's subjective experience (Gallagher, 2012: 43, referring to Mead, 1904: 382). Vocal gestures lead to individual consciousness and meaning, but require a context, i.e. a community for exchange.

Gesturing is thus a relational idea, as it includes the gesturer and the addressee. Gestures help individuals to coordinate within a group (Mead, 1934: 179, 323). Drawing on ideas from Wundt (1874), Mead (1934: 42–43) uses the interaction of two fighting dogs to make explicit the relational character as each dog's actions stimulate the other one to respond. His theory is "a feedback theory of consciousness" (Gillespie, 2005: 25, also cited in Gallagher, 2012), implying individuals derive knowledge from the feedback of others. Only through their feedback do actors understand the more general meaning of their gestures and actions (Gillespie, 2005: 25). Mead's theory applies well to the creation of shared meaning in participatory processes because actors repeatedly interact in a way that assumes a shared interpretation. Interactions occur in such a way that actors try to be understood and put themselves into the position of the other and constantly align their worlds.

Mead (1934) related experience to the creation of meaning (see also Black et al., 2014). Arguing similarly by drawing on brain research, McGilchrist (2009) emphasises the importance of experiential understanding and argues that it precedes any abstracted understanding. In summary, Mead emphasises the importance of *gesturing*, which, though *mutual feedbac*k, results in shared and understood *significant symbols*, grounded in the participants' experience.

Application to participatory research beyond Mead's theory of meaning-making

Black et al. (2014) propose a framework based on Mead's meaning-making, described in the second column of Table 1. While proposed for using visuals in interdisciplinary research, participatory and interdisciplinary research are so strongly related that the framework can be translated to the participatory process area and applied more broadly. The following paragraph briefly describes the original framework and how we extend and re-interpret it.

Table 1: Gesturing, naming, acting and iterating

Mead's meaning-making	**Transdisciplinary science meaning-making[2]**	**Participatory process meaning-making**
Gesturing	Creating shared representations to create shared focus	Expressing experiential knowledge
(Relational) Naming	Vocalizing proposed dependencies in shared representations	Abstracting from experiential knowledge, generalising by vocalising concepts and dependencies
(Shared) Acting	Modifying shared representations and simulating mentally to explore consequences of proposed dependencies	Modifying shared representations, exploring consequences of pro-posed dependencies, testing abstractions
Iterating	Iterating	Re-representing verbally or graphically or via simulation

First, *gesturing* serves as the pillar of this framework. In the area of transdisciplinary meaning-making participants' gestures serve to create a shared visual representation (see second column of Table 1). For participatory processes, we argue that gesturing allows participants to express their individual knowledge that is grounded in their experiences and to share the experience with the group (see third column of Table 1). If one participant shares her experience of dogs as pets and sources of amusement, a second describes his dog as his best friend, and a third reports being bitten twice by dogs, they all report experiences on how dogs affect humans and convey different gestures about that relationship to the group. Figure 1 shows how gesturing contributes to the iterative nature of the meaning-making process. It thus allows individuals to participate in the experiences of one another.

Second, in transdisciplinary science and participatory processes, participants relate others' gestures to their own respective expertise and define or *name* how their individual experiences relate to others' and propose dependencies. They relate concepts to experiential knowledge and thus represent them more abstractly. A participant's story about how difficult it was to find an experienced craftsperson may be 'named' as a positive causal relationship from industry experience to the rate of work being implemented. While the individual level of meaning-making risks repeatedly invoking the same interpretation, the relational process of *mutual feedback* allows for an evolving interpretation. While this process involves the risk of relying heavily on old experience instead of being open to recognizing new relationships (Zimmermann & Black, 2014), it is a necessary element in the creation of meaning.

[2] The column on transdisciplinary meaning-making is taken from Black et al., 2014.

Third, by this relational process, participants create significant symbols that allow them to mentally simulate the consequences of proposed dependencies and to *act in an orchestrated, shared way* instead of independently. For transdisciplinary science this means they modify shared representations and explore their consequences predictively and empirically. In participatory processes, through modifying shared representations, they also explore consequences of proposed dependencies and thus test the validity of abstracted relationships against logic and their experiences. This could be mental or quantitative simulation. As it results in an act, this is an abstracting process that converges on proposed courses of action. At the same time, when executed, this act results in a new experience and is thus split between abstracting and experiencing in Figure 1.

Finally, as Mead points out, this is an *iterative* process that evolves continuously. This also holds for participatory processes.

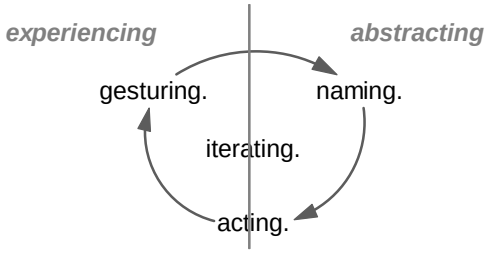


Figure 1: Meaning-making process

With this theoretical framework laid out, it remains to describe how this relates to practice. Here we explore an empirical project and give extra focus on a one-hour session during a stakeholder workshop. The project is participatory in the sense that stakeholders participate through interviews and workshops, but it did not intend to centre on a narrow problem that the participants share and are committed to. The problem focus was rather broad and directed towards more integrated decision-making in the area of housing. As the session we analysed was rather short and is only one among several project themes, we did not expect to find overly shared mental models. Nevertheless and maybe for that exact reason, the empirical setting provides a useful illustrative example.

Application to an empirical case

Our empirical case study is a project on housing that aims to integrate decision-making in housing with affected and affecting social, economic and environmental realms to improve wellbeing. The project proceeded from interviews to modelling and workshop events. First, a system dynamics researcher interviewed 32 individuals from government organisations, non-government organisations, industry, community groups and academia. She asked interviewees for the connections they saw between housing and different kinds of wellbeing, as well as what criteria housing policies should be judged by, and drew causal maps in the interviews that were cross-checked later by one of the authors. Each 1–2 hour interview was recorded and resulted in causal sketches of approximately 50–130 variables and a list of 5 main criteria. She aggregated these maps to 11 causal loop diagrams (CLDs) in 7 topic areas. A first workshop (conducted by a small research team), brought together half of the interviewees plus further participants to review the maps in interdisciplinary subgroups to understand their logic and correct their structure where needed. Participants also voted on a list of 9 criteria by which policy-making should be evaluated. A second workshop used some of the maps in subgroups to qualitatively simulate, i.e. to talk through in the group, how the policy of outlawing poorly performing rental dwellings scored on some of the criteria.

Between workshop 2 and 3, the interviewer (having completed her term) left the project and the first author joined. Before workshop 3, the team asked the stakeholders to rank the criteria that had been developed for multi-criteria decision analysis (MCDA). The team scored short and long-term impacts on the 9 criteria of the rental policy and of a policy to extend funding of community hubs. At workshop 3, the team presented the results of the qualitative policy analyses. They discussed the dangers and potential for insight of comparing policies using interconnected criteria. The workshop included a session on issues and policy options in housing to create focus to advance from qualitative to quantitative modelling. Central to analysis was a session on households' uptake of a UK housing policy called the Green Deal, which provides owners with recommendations on energy efficiency measures for their house and offers them a loan attached to their house that should be paid for by energy savings obtained. This moved the project from a qualitative to quantitative policy assessment and it was chosen as substantial interest in this policy had been expressed by the project stakeholders. The first author acted as this session's facilitator and grounded the example in the CLDs, then presented a reference mode of the Green Deal uptake, followed by a group elicitation of reasons for rather low uptake numbers. Following each participant's vocal gesture, she rephrased the responses in the wording used in a conceptual overview model (Richardson, 2013) that had been developed before and then unfolded the model's 6 components in 3 broader sectors: firstly, a financial-rational perspective including finances plus industry experience because this was at the core of the policy, followed by a simulation run of high uptake; secondly, a user-driven perspective including households' trust in the work done, awareness of the scheme and attitudes and values to energy efficiency measures, followed by a simulation run showing more moderate uptake; and finally, the full model including the interaction of the Green Deal with other government schemes, followed by a run showing poor uptake. (Figure 2 shows the reference mode and simulation runs; the appendices show the components of the model.)

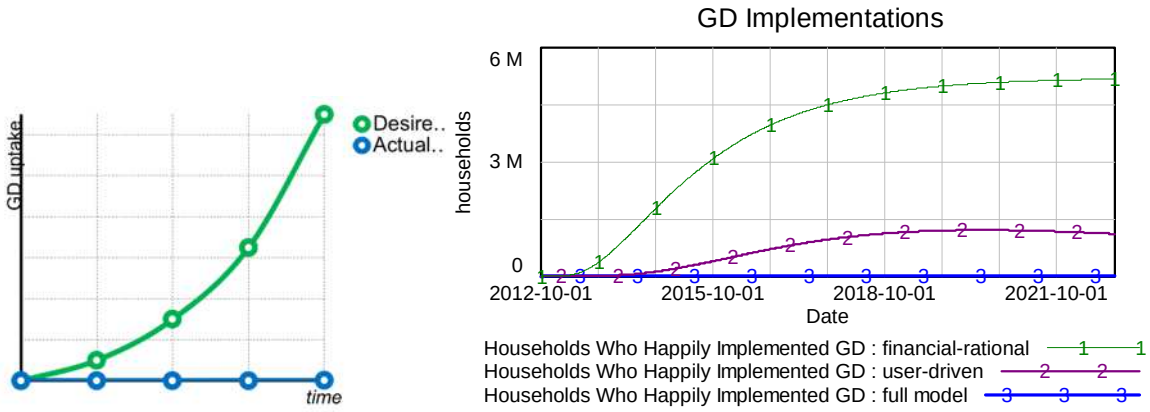


Figure 2: Green Deal reference mode and simulation runs

We relate participatory elements of the general project and the Green Deal session to the elements of socially constructing meaning and present our interpretation in columns 4 and 5 of Table 2. It covers the main elements of the project case without being exhaustive. For the project as a whole, gesturing happened mainly outside the group through individual interviews which contributed to CLD representations. Walking through these CLDs and suggesting improvements (carried out in workshop 1) served to name relationships and to abstract from individual experiential knowledge. Shared acting occurred through the actual change of structural relationships during workshop 1 and the use of the CLDs to estimate outcomes of a rental policy in workshop 2. The participants had 3 iterative encounters with the CLDs over a period of 1.5 years; the facilitator referred back to CLDs repeatedly including at workshop 3; and participants looked at them during breaks. However, they could only modify them during workshop 1 and thus had some but limited ability to repeatedly gesture their evolving understanding.

Gesturing regarding the Green Deal involved a few individual pre-workshop contributions of stakeholders to creating the Green Deal simulation model, which was otherwise developed based on journal, magazine and weblog articles and reports. Considerable gesturing took place through participants' explanations for the reference mode, i.e. the Green Deal uptake pattern.

The facilitator re-phrased participants' vocal gestures and unfolded model sectors with components and detailed causal relationships which served to abstract by vocalising concepts and, explicitly *naming* these causal dependencies. She had also prepared a simulation cockpit for *shared acting*, with the idea that the participants' policy ideas could be tested and related to the model structure, but the cockpit could not be used due to time constraints. Therefore, the session included shared acting only via the presentation of three major model runs. The unfolding of model structure and behaviour in three steps provided some *iteration*.

Table 2: Gesturing, naming, acting and iterating in the project case

Mead's meaning-making	**Transdisciplinary science meaning-making**[3]	**Participatory process meaning-making**	**Project case**	**Green Deal**
Gesturing	Creating shared representations to create shared focus	Expressing experiential knowledge	Individual contributions to creating a representation (through interviews, not done in group)	Few individual pre-workshop contributions to creating a representation (not done in-group) Considerable number of in-group contributions to explain the reference mode, i.e. the Green Deal uptake pattern
(Relational) Naming	Vocalizing proposed dependencies in shared representations	Abstracting from experiential knowledge, generalising by vocalising concepts and de-pendencies	Suggesting improvements to causal loop diagrams in small groups (workshop 1)	Abstracting through facilitator's re-phrasing of contributions and through unfolding the model
(Shared) Acting	Modifying shared representations and simulating mentally to explore consequences of proposed dependencies	Modifying shared representations, exploring explore consequences of proposed dependencies, testing abstractions	Changing structural relationships in the CLDs (workshop 1) Using CLDs to estimate (mentally simulate) outcomes of a selected policy (workshop 2)	While a simulation cockpit was ready, it could not be used due to time constraints and the session ended with the presentation of three major model runs and a discussion of layers of the Green Deal and policy-making. The facilitator related these runs to elements the participants had gestured and named

[3] The column on transdisciplinary meaning-making has been taken from Black et al. 2014.

Mead's meaning-making	**Transdisciplinary science meaning-making[4]**	**Participatory process meaning-making**	**Project case**	**Green Deal**
Iterating	Iterating	Re-representing verbally or graphically or via simulation	The CLDs were iteratively presented to the participants over three workshops and a report. While participants were asked to comment, much iteration could not take place in the sense that participants would continue to modify model structure. (workshops) The gesturing process for the Green Deal, which aimed at eliciting participants' explanations for the reference mode, served to iterate on the project's purpose (workshop 3)	

Discussion and implications

Theoretical implications

Using Mead's theory of socially constructing meaning, this paper helps theoretically ground how meaning changes in participatory processes. It frames how individuals in a group process construct new meaning and thus change their thinking, which can contribute to consensus, commitment and system change (Rouwette et al., 2009). It provides a lens of bounded rationality and meaning-making through which participatory processes can be understood. We propose that stakeholder interactions in participatory processes can be characterized by Mead's (1925; 1934) theory. We relate aspects of participatory modelling to *gesturing*, *naming*, *acting* and *iterating*, four elements of Mead's theory. In addition, we relate Mead's theory to bounded rationality, as its use in the modelling process may improve results in two ways: first, the content of resulting system dynamics models, and second, regarding mental model alignment and interrelatedness as well as consensus (Zagonel, 2002). It thus helps facilitators from the area of system dynamics and beyond to understand and design successful participatory sessions.

The *gesturing* process is an experience-broadening element which serves to identify shared or interlinked experiences and acknowledge divergent experiences. When participants abstract from experiential knowledge through generalising and vocalising concepts and dependencies, they *name*, not how they share exactly the same experience, but how they their experiences are important for one another (Black, 2013; Black et al., 2014). This allows them to *act* in a shared way and to *iteratively* explore consequences of their proposed interdependencies. We thus transfer the interactive and feedback character of Mead's theory to participatory meaning-making, providing a framework against which the success of scripts, of concept or overview models, etc. can be assessed.

In contrast to work by Black et al. (Black, 2013; Black & Andersen, 2012; Black et al., 2014) who focus on visual representations, this work includes representations in general and comprises explanations, stories and other gestures. However, it fully acknowledges the power of

[4] The column on transdisciplinary meaning-making has been taken from Black et al. 2014.

visual representations for explicitly and directly illustrating abstract knowledge. In addition, while their work addresses the form of representations, this paper focuses more closely on experiences and provides insight into how the emergence of new knowledge needs to be grounded in subjective experiences.

Practical implications for participatory processes

Our findings suggest that use of simulation cockpits / flight simulators or story-telling might have benefits if they are used as learning environments. Both help participants to gesture intensively. However, sessions need to be designed to make sure that naming occurs, i.e. that the group abstracts from single gestures and names interdependencies. We thus suggest that a discussion of the causes of the effectiveness of different policies needs to occur. By relating structure and behaviour, learning environments can well be used not only to gesture ideas about effective policies, but also to act and iterate on proposed dependencies. While this may also help participants build more *appropriate* mental models, our analysis showed that in particular their mental models can become more *aligned*. It thus can affect consensus, commitment and system change (Rouwette et al., 2009).

Limitations and future research

While this paper provides a number of suggestions on how to apply the theoretical framework, e.g. through using a model as a learning environment, it just begins to establish a framework of how meaning is created through participatory processes. It therefore describes a starting point of research. Here, two routes are possible. The suggested framework can be applied to participatory modelling sessions that aim at building causal loop diagrams or quantitative models, but it can also be tested for participatory processes in general that aim at building boundary objects or creating shared mental models. Work on group model building scripts and on the success of participative modelling suggests how this can be done, perhaps through more rigorous combination of this research with the proposed framework. Future work can also focus on single scripts regarding issue elicitation, the use of learning environments or concept models, and analyse in depth, e.g., how they serve to establish experiential knowledge, or how they serve to relate causal structures to what participants know already. As Mead's theory explains the creation of meaning both in the individual as well as in the group, this research can also be used to closer investigate individual, group and organisational outcomes ranging from refining individual mental models to achieving system change.

References

Ajzen, I. 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes* **50**(2): 179–211.

Andersen, D. F., Richardson, G. P., & Vennix, J. A. M. 1997. Group model building: adding more science to the craft. *System Dynamics Review* **13**(2): 187–201.

Andersen, D. F., Vennix, J. A. M., Richardson, G. P., & Rouwette, E. A. J. A. 2007. Group Model Building: Problem Structuring, Policy Simulation and Decision Support. *The Journal of the Operational Research Society* **58**(5): 691–694.

Black, L. J. 2013. When visuals are boundary objects in system dynamics work. *System Dynamics Review* **29**(2): 70–86.

Black, L. J., & Andersen, D. F. 2012. Using Visual Representations as Boundary Objects to Resolve Conflict in Collaborative Model-Building Approaches. *Systems Research and Behavioral Science* **29**(2): 194–208.

Black, L. J., Greer, D. R., & Zimmermann, N. S. 2014. Constructing Joint Action in Transdisciplinary Research. Paper presented at the *EGOS Colloquium*. Rotterdam: European Group for Organizational Studies.

Cyert, R. M., & March, J. G. 1963. *A Behavioral Theory of the Firm*. Englewood Cliffs, NJ: Prentice-Hall.

Gallagher, T. J. 2012. G.H. Mead's Understanding of the Nature of Speech in the Light of Contemporary Research. *Journal for the Theory of Social Behaviour* **42**(1): 40–62.

Gillespie, A. 2005. G.H. Mead: Theorist of the Social Act. *Journal for the Theory of Social Behaviour* **35**(1): 19–39.

Größler, A. 2004. A content and process view on bounded rationality in system dynamics. *Systems Research and Behavioral Science* **21**(4): 319–330.

Hovmand, P. S., Rouwette, E. A. J. A., Andersen, D. F., Richardson, G. P., & Kraus, A. 2013. Scriptapedia 4.0.6, retrieved 1. March 2015, from http://tools.systemdynamics.org/scrpda/scriptapedia_4.0.6.pdf.

Lave, J. 1988. *Cognition in Practice: Mind, Mathematics and Culture in Everyday Life*. Cambridge, MA: Cambridge University Press.

March, J. G., & Simon, H. A. 1958. *Organizations*. New York, NY [et yyyal.]: Wiley.

McGilchrist, I. 2009. *The Master and his Emissary: The Divided Brain and the Making of the Western World*. New Haven, CT: Yale University Press.

Mead, G. H. 1904. The relations of psychology and philology. *Psychological bulletin* **1**(11): 375–391.

Mead, G. H. 1925. The Genesis of the Self and Social Control. *International Journal of Ethics* **35**(3): 251–277.

Mead, G. H. 1934. Mind, Self, & Society from the Standpoint of a Social Behaviorist. In C. W. Morris (Ed.). Chicago: University of Chicago Press.

Richardson, G. P. 2011. Reflections on the foundations of system dynamics. *System Dynamics Review* **27**(3): 219–243.

Richardson, G. P. 2013. Concept models in group model building. *System Dynamics Review* **29**(1): 42–55.

Rouwette, E. J. A., Vennix, J. M., & Felling, A. A. 2009. On Evaluating the Performance of Problem Structuring Methods: An Attempt at Formulating a Conceptual Model. *Group Decision and Negotiation* **18**(6): 567–587.

Rudolph, J. W., Morrison, J. B., & Carroll, J. S. 2009. The Dynamics of Action-oriented Problem Solving: Linking Interpretation and Choice. *Academy of Management Review* **34**(4): 733–756.

Sastry, M. A. 1997. Problems and Paradoxes in a Model of Punctuated Organizational Change. *Administrative Science Quarterly* **42**(2): 237–275.

Simon, H. A. 1976. *Administrative Behavior: A Study of Decision-making Processes in Administrative Organizations* (3. ed.). New York, NY: The Free Press.

Vennix, J. A. M., Andersen, D. F., Richardson, G. P., & Rohrbaugh, J. 1992. Model-building for group decision support: Issues and alternatives in knowledge elicitation. *European Journal of Operational Research* **59**(1): 28–41.

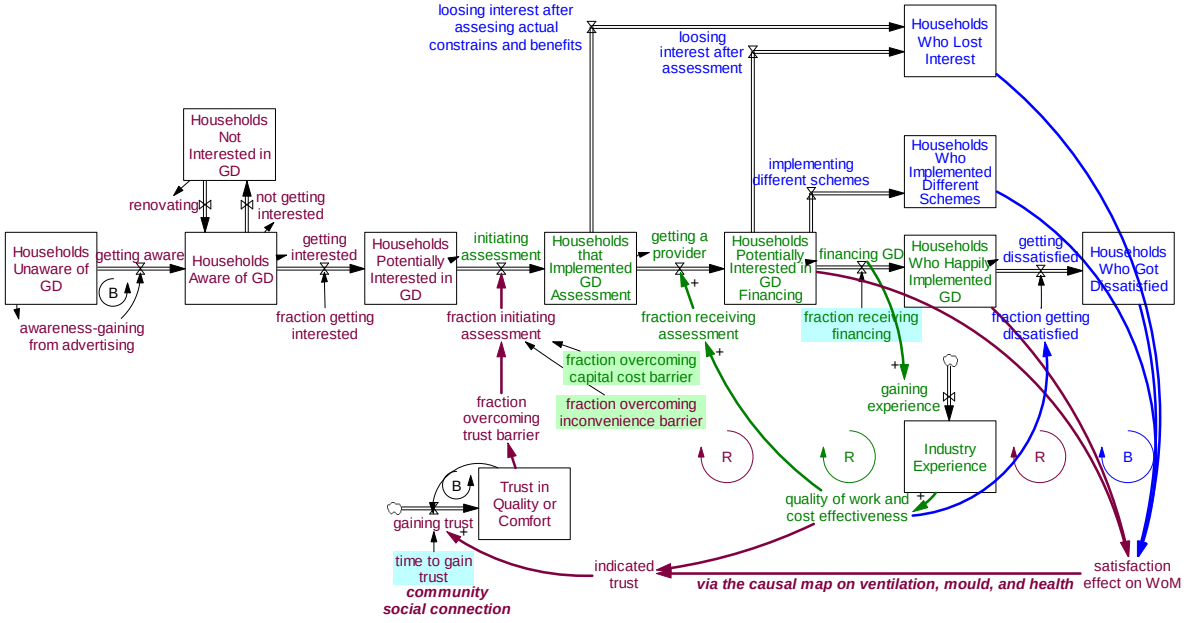
Wundt, W. M. 1874. *Grundzüge de physiologischen Psychologie*. Leipzig: Engelman.

Zagonel, A. A. 2002. Model Conceptualization in Group Model Building: A Review of the Literature Exploring the Tension Between Representing Reality and Negotiating a Social Order. Paper presented at the *Proceedings of the 20th International System Dynamics Conference*. Palermo: System Dynamics Society.

Zimmermann, N. 2011. *Dynamics of Drivers of Organizational Change*. Wiesbaden: Gabler.

Zimmermann, N. S., & Black, L. J. 2014. Dynamics of strategizing practices and framing processes in organizational identity transitions, *EGOS Colloquium*. Rotterdam: European Group of Organizational Studies.

Appendix 1: Model structure as presented to participants, omitting some constants and feedback relationships



Appendix 2: Model structure indicating thematic model components