# Social learning in participatory multi-modelling: Crossing boundaries for multi-party collaboration

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# 1. Introduction

Sustainability transformation in the energy transition is a wicked problem, given the complexity of the socio-technical infrastructures and systems involved and the changes required. Not only do these systems consist of a complicated technical infrastructure, they also involve a complex set of institutions and a wide variety of stakeholders with different interests at stake (Tarim et al., 2020; Cuppen et al., 2020). All of these elements interact with and influence each other, making it difficult to change this system. To represent the system and these interactions and to facilitate transformative change, models and simulations are often used. Models are mostly used to generate shared conceptualisations of the problem at hand, and to explore the possible scenarios and results of these different scenarios (Calder et al., 2018; Cuppen et al., 2020). Within the context of the energy transition, many models have been constructed over the past decades that represent parts of the socio-technical system and infrastructure. To gain a more complete understanding of the changes required and the consequences of various modifications in the energy system, multi-models are essential.

Modelling can benefit from a participatory approach. In participatory modelling, different stakeholders interact to either build a model together or to jointly interpret the outcomes of the model (Jones et al., 2009). Participation is a broad concept: it can range from knowledge transfer to knowledge co-production, and from sharing ideas on what the model should look like to actively cocreating the model (Jones et al., 2009). Participatory modelling can help to connect modelling science with stakeholder expertise to create shared understandings within the participant group (Anjum et al., 2021). The benefits of participatory modelling consist of a wider knowledge base including more specialised or strategic knowledge and a higher degree of involvement with the project. Participatory modelling can provide opportunities for integrating viewpoints and representations of reality among the participants. Multi-models take this integration a step further. Rather than displaying one aspect of the energy system, multi-models couple multiple single models to provide a more coherent overview of the system and its many interacting elements. This allows for a more complete understanding of the changes required and the consequences of various modifications in the energy system (Cuppen et al., 2020). Participatory (multi-)modelling has the potential to lead to social learning (Voinov et al., 2018; Jones et al., 2009; Anjum et al., 2021). Social learning can be enhanced by the introduction of boundary objects, defined as artifacts that can help translate meaning between people or social groups with different sets of knowledge and worldviews (Star & Griesemer, 1989). Social learning has been proven to enable innovation and facilitate sustainability transformations and is therefore an important development to analyse when

researching the process of participatory multi-modelling and its potential to accelerate system change (Sol et al., 2013).

To this end, this paper aims to answer the research question: In what ways do participants within participatory multi-modelling processes engage in social learning and how does the use of boundary objects help stimulate this? This paper builds upon previous exploratory research by Cuppen et al. (2020) on energy infrastructures in the Rotterdam Port Industrial Cluster. In this research, the authors concluded that certain design choices of the participatory multi-modelling process can facilitate mutual understanding amongst stakeholders and help translate concepts between participants and between participants and their external organisation. Our research takes this idea a step further in monitoring if, how, and when social learning occurs in a participatory multi-modelling process, which obstacles to social learning may emerge, and how the process can be effectively monitored and designed as to overcome these obstacles and improve social learning and collaboration among stakeholders. We base our research on the MMvIB project[1], a project in which participatory multi-modelling is used to improve inter-organisational decision-making related to the planning of energy infrastructure. Within the project, a range of private organisations and knowledge institutes meet on a regular basis to jointly build a multi-model infrastructure. Although the project spans a time period of two years, we executed this particular research within the first six months of the project. This was the preparatory iteration in which existing knowledge and models were shared and catalogued and expectations and requirements were defined. Within this iteration, we measured participants' changing expectations, understandings, and learning processes through surveys and observations during the MMvIB meetings in order to understand how participants engage in social learning and how the use of boundary objects aids this process.

This paper will both provide an explanation of how social learning can be monitored, as well as our analysis of how participants within a participatory multi-modelling project engage in social learning and how boundary objects facilitate social learning. Accompanied with this paper is a manual outlining the steps to take during the remainder of the MMvIB project, including suggestions on how to more effectively structure participatory multi-modelling sessions to enhance social learning, which can be adapted and implemented to also improve future participatory multi-modelling projects.

We structured our paper in the following way. First, section 2 will provide a brief overview of the MMvIB project as a case study. Then, section 3 will include an

[1] MMvIB: Naar een nationale Multi-Model infrastructuur voor Integrale Besluitvorming in de energietransitie. www.multi-model.nl

elaboration on the theory behind multi-actor collaborations and social learning. We will also introduce the notion of the multi-model infrastructure as a boundary object ecology and elaborate on how boundary objects can form the basis of effective social learning. In section 4, we introduce the methodology used, after which section 5 includes our analysis of the preparatory iteration of the MMvIB project, comprising of both a study of the surveys we conducted, as well as a more qualitative description of our observations of the social processes. In this section we also analyse our observations through the lens of our conceptual framework. Section 6 consists of a discussion of this analysis, after which we draw a final conclusion in section 7.

# 2. Case study

The project within which we analyse social learning is "MMvIB: To a national Multi-Model infrastructure for integrated decision-making in the energy transition" funded by Topsector Energy, System Integration Program[2]. To implement long-term energy transition strategies, it is crucial that the stakeholders involved in accelerating this transition have a similar understanding of the energy system. To reach this, MMvIB is taking the first step in creating a multi-model infrastructure that bridges the known data, scenarios, technical models, and organisational preconditions. The project is participatory in every phase of the process, with active engagement of participants from the start of the project until the delivery of the final multi-model infrastructure. The project involves a wide community of practice including modellers, researchers, and decision-makers who share their knowledge and expertise during workshops and co-creation processes in which decisions are made on the infrastructural design, the use of the multi-models, and the application of the multi-models to a variety of use cases. The project runs from September 2021 to August 2023 and is divided into four iterations, of which this research investigates the preparatory iteration (referred to as iteration 0 in the project) in which the main goal was to share best practices, define and categorise model requirements, and communicate the participants' expectations of the project. In this first iteration only modellers and researchers took part. The participants involved included people from TNO, Hanzehogeschool Groningen, Alliander, DNV GL, Gasunie, Kalavasta, Quintel, Quo Mare, Stedin, Delft University of Technology, and Leiden University. Within this preparatory iteration, there were two separate phases. The Exploratory phase was aimed at setting the foundations for interaction and collaboration between the participants on which the rest of the project could be constructed. Second, the Infrastructure Expectations phase revolved around aligning the ambitions and goals for the multi-model infrastructure that would allow for the

[2] https://www.topsectorenergie.nl/en/system-integration

interaction and communication between the different models. This phase included the creation of a shared understanding of concepts.

# 3. Conceptual framework

### Multi-party collaboration

An important aspect of a participatory multi-modelling process is the multi-party collaboration. Multi-party collaboration entails the involved stakeholders communicating and jointly making decisions to achieve a common objective (Bouwen & Taillieu, 2004). The ultimate goal of such collaboration is to streamline individual and independent thoughts and actions to create a more concerted decision-making approach. This is a complex process, however, as the participants have different interests, identities, values, perspectives, and power positions within the project. This makes the process inherently paradoxical, since participants need to concurrently stress both their underlying differences as well as similarities in values and understandings in order to reach a collaborative advantage (Curşeu & Schruijer, 2018). These different points of view shape the social interactions within the participatory process. This is in line with interdependence theory, which suggests that participants' behaviour is influenced by their expectations of the social situation they are part of (the participatory multi-modelling project), as well as their expectations of the behaviour and motives of the other participants (Curşeu & Schruijer, 2018). Such adjustment of behaviour is a continuous process with no fixed state: with every development and additional social interaction, participants' behaviour and expectations might change. It is important to keep this in mind when analysing collaborations: a consensus now does not automatically mean future agreement, and social behaviour and expectations are prone to change in every phase of the project.

Multi-party collaboration eventually means reaching a shared objective, or experiencing a degree of progress in the multi-modelling project. There is then a tension between getting participants on the same page and keeping them critical of each other's viewpoints. An important term here is social learning.

### Social learning

Social learning is crucial when it comes to multi-party collaborations. Within a participatory multi-modelling process, different sets of knowledge, expertise, and viewpoints are exchanged. Learning occurs when individuals obtain new information and apply this newly-acquired knowledge to their subsequent behaviours and actions (van Mierlo & Beers, 2020; van de Kerkhof, 2004). Learning implies improvement: the change in knowledge and actions is assumed to be a positive one, resulting in a more

comprehensive understanding of the topic or an improved way of dealing with the issues at hand (van de Kerkhof, 2004). Within a participatory multi-modelling process, there are two main types of learning related to the subjects of the learning process: individual and group learning (van der Knaap, 1997). Individual learning is linked to individual participants assimilating new information from social interactions within their own social world. Group learning, on the other hand, means that the participants as a group acquire new insights. The latter implies that a "shared set of meanings and a common thinking process" develops in which the participants all interact and influence each other's ideas (Schein, 1993, as cited in van der Knaap, 1997, p. 63). Group learning involves an eventual convergence of the viewpoints of the actors involved (van der Wal et al., 2013). Nonetheless, this convergence of perspectives is not a linear process, nor is it a fixed final state, as participants within the group continuously both accept and contest each other's knowledge and worldviews (van der Knaap, 1997). Within participatory multi-modelling, social learning is a challenging process, as there is an underlying goal of developing a shared understanding of the project and its elements to benefit decision-making within the modelling process, without closing off the opportunity for open social learning and the constructive development of new perspectives.

There are two levels of social learning: single-loop learning and double-loop learning. Single-loop learning is the process of learning in which individuals acquire knowledge and/or change their actions when they discover errors in their thinking process or find out that their actions do not result in the desired outcomes (van der Wal et al., 2013; van de Kerkhof, 2004). This type of learning concerns one loop of error correction, and is limited to a simple cause-effect learning process. Double-loop learning, on the other hand, involves the addition of a second feedback loop in which the underlying frame of goals, norms, policies, objectives, and beliefs is reviewed and modified (van der Wal et al., 2013; van de Kerkhof, 2004; van Mierlo & Beers, 2020). These two types of learning are strongly related to two levels of learning: first-order and second-order learning (Figure 1). Within first-order learning, participants generate new understandings of the facts and expectations of the participants concerning the issue at hand. This means that participants learn from each other's ideas, tasks, interests, and concerns about the project and that they are involved in the problem definition, analysis of possible solutions and effects of these solutions, and evaluation of the effectiveness of these solutions (van der Meij, 2017; van de Kerkhof, 2004). Participants do not question the factual status of claims that are being made by others, as these do not contradict their existing frame of reference. They rather acquire new factual information that is beyond their own knowledge or understanding of the problem at hand (van de Kerkhof, 2004). Second-order learning takes the social learning process a step further, in that it involves the acquiring of new insights into participants' underlying values and

assumptions, opinions, and core beliefs. Within second-order learning, participants challenge each other's worldviews and factual and causal claims are analysed in light of the normative paradigms within which they are embedded (van der Meij, 2017; van de Kerkhof, 2004).

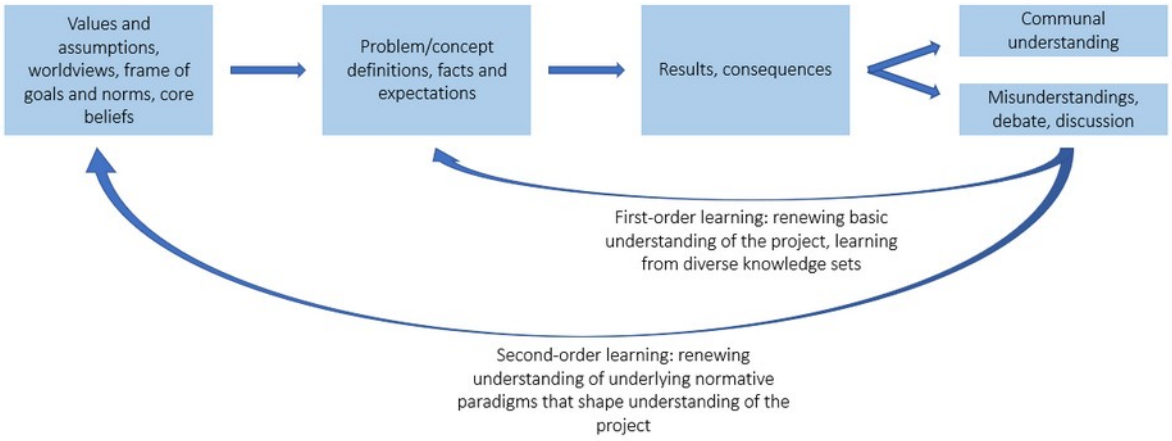


*Figure 1. Social learning: first- and second-order.*

In encouraging social learning in participatory processes, van de Kerkhof (2004) introduces four key conditions that influence the success of social learning: group composition, commitment and trust, transparency, and fairness. First, the group composition matters. For first-order learning, a homogeneous group of participants (for example with regards to their background and expertise) is preferred, as this generally speeds up the learning process due to the higher chances of an already communal understanding of the problem at hand (van de Kerkhof, 2004). However, for second-order learning to be successful, a heterogeneous group of participants is preferred (van de Kerkhof, 2004). Diversity in the participant group can for example be reflected in a mixture of backgrounds and expertise, a diversity in networks to which the participants belong, and a variety of interests and paradigms the participants adhere to. When participants do not share the same worldviews and perspectives, it is easier for them to comment on and disintegrate each other's 'constructed reality'. This wider pool of perspectives and higher chance of disagreement allows for a broader understanding about the problems at hand and enhances second-order social learning (van Mierlo & Beers, 2020; Sol et al., 2013). Second, the levels of commitment and trust of the participants are important. For social learning to be successful, participants need to commit to the process of debating worldviews and trust is an enabling factor, making it easier for participants to share their ideas and take on other participants' ideas (Sol et al., 2013). Related to this is transparency in the project – or the ability of participants to verify whether the modelling process is valid and whether the possibility of reaching their personal objectives offsets their efforts of participation (van de Kerkhof, 2004). The final condition influencing the success of social learning is fairness, meaning the ability of participants to equally contribute to the discussion (van de

Kerkhof, 2004). This is influenced by the group dynamics as well as the power structures within the participant group.

### Boundary objects

Social learning implies that boundary crossing happens. A boundary indicates a sociocultural difference in understanding, values, demands, or knowledge between different groups of people, or communities of practice (Akkerman & Bakker, 2011). Boundaries are shaped by a group's context, depending for example on their level of technical knowledge or practical orientation, and serve as a way to demarcate the extent of someone's knowledge and sensemaking (Fox, 2011). Boundaries can lead to communication problems once knowledge is transferred from one group to another. Boundary crossing therefore involves negotiating and combining different knowledges from different participants and backgrounds (Engeström et al., 1995). When a boundary is successfully crossed, a shared understanding is found, and social learning occurs (Akkerman & Bakker, 2011). To facilitate boundary crossing, boundary objects are introduced as artifacts that can fulfil this function of bridging diverse knowledge sets and worldviews (Akkerman & Bakker, 2011). Boundary objects are "both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use … The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds" (Star & Griesemer, 1989, p. 393). In other words, boundary objects can function as a way to translate meaning from one person to another, or establishing a "shared syntax or language" (Carlile, 2002, p. 451) despite their differences in expertise and understanding of the problem at hand (Cuppen et al., 2020). A model can serve as a boundary object, being the shared object among participants and serving as a way to help participants understand one another's worldviews and knowledge sets by crossing the boundaries of their own perspectives on the problem (Barreteau et al., 2014). Following Cuppen et al. (2020), we introduce a broader view on models as boundary objects by looking at participatory (multi-)modelling as a process in which multiple connected boundary objects emerge that consequently enable the (multi-)model to function as a boundary object in itself. In this sense, the development of one boundary object is dependent on the emergence of another. According to Cuppen et al. (2020, p. 4) this larger, interconnected infrastructure of boundary objects is called a boundary object ecology which we define as "an interacting group of boundary objects that interact and co-evolve with one another within the context of a dynamic participatory process" (Figure 2). Within the participatory multi-modelling process, certain design choices can be made that allow for boundary objects to come into being and that enhance social learning (Cuppen et al., 2020).

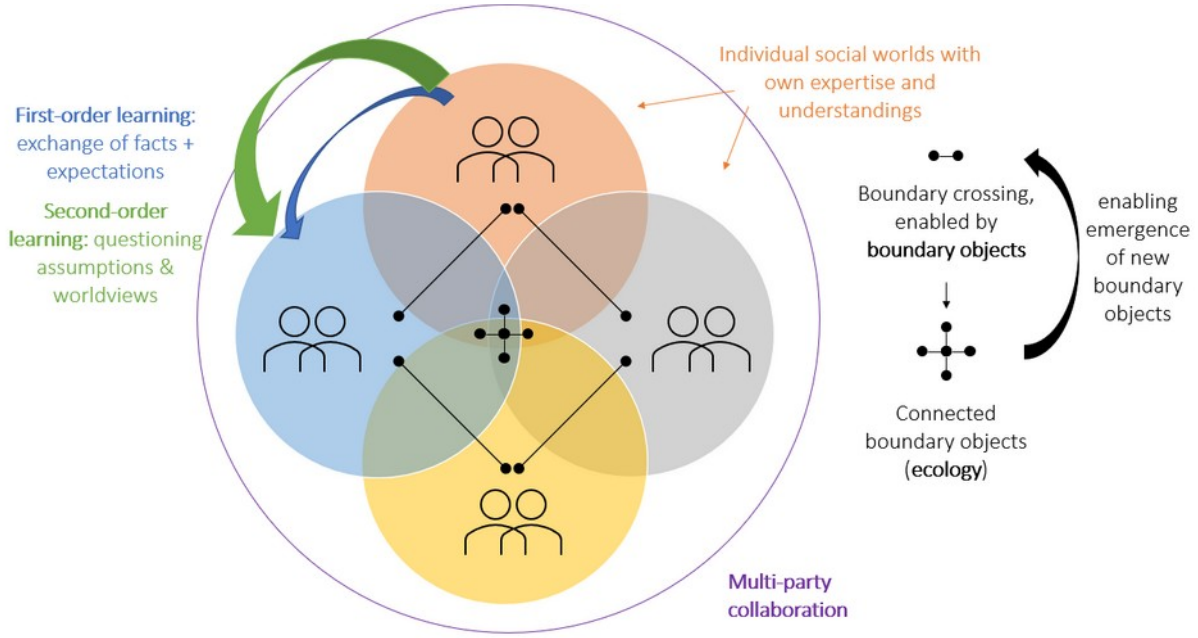


*Figure 2. Theoretical framework visualised.*

The next section will provide a description of our methodology in monitoring the multi-party collaboration process. Our methodology is aimed at exploring if and how, within participatory multi-modelling, participants engage in group learning and communicate and develop a shared set of meanings and thinking processes. We investigate whether this learning is of first or second-order, and how the emergence and use of boundary objects can facilitate second-order learning.

# 4. Methodology

The methodology we adopted to monitor social learning was twofold: we conducted meeting observations during the first iteration of the MMvIB project and we conducted surveys during the second phase of this first iteration (the Infrastructure Expectations phase). Figure 3 provides an overview of the phases and their corresponding meetings and method.

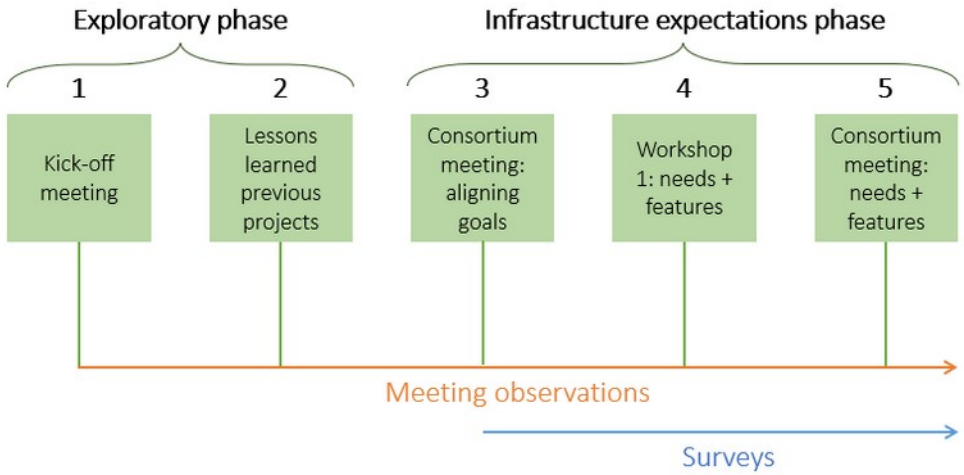


*Figure 3. Overview of meetings analysed.*

### Meeting observations

During all the meetings, which took place online, and with the help of the video recordings that were made during each meeting, we took extensive notes of what was discussed, who discussed it, and what was eventually concluded. To further assess the multi-party collaboration, we took notes on the output of each meeting, for example on what participants contributed to digital tools used during the meeting (such as a Miro board, further explained in section 5) or what they commented on each other in the meeting chat. Our notes included observations of the process as a whole, especially on moments of disagreement about definitions, choices, and expectations among the participants. We also recorded participants' body language and non-verbal communication when other participants shared their ideas and thoughts. This had the aim of understanding better whether participants (dis)agreed with each other and whether they actively and equally engaged within the multi-party collaboration. Interpreting body language is subjective and especially convoluted in a digital environment, which is why we only recorded non-verbal communication when it was fairly obvious – such as when a participant was actively shaking their head – or subsequently reacted on by other participants. The reason for taking note of these moments was to analyse whether there was disagreement or (eventual) consensus among participants, as such disagreement may indicate boundaries of participants' social worlds, whereas eventual agreement may signify the crossing of boundaries and hence may be a sign of social learning.

After each meeting, we revised our notes and analysed the observations we made to better understand how multi-party collaboration in each case did or did not lead to social learning. To do this, we more explicitly identified moments when there was a lot of discussion or disagreement, as well as situations in which participants overcame disagreements. With this, we tried to understand whether certain dynamics or design choices within the multi-party collaboration could aid in reaching agreement or

enabling social learning. To find these moments, we searched our meeting notes for a variety of key verbs that relate to the process of social learning, including: define, expect, explain, think, understand, believe, (dis)agree. To add to this, we looked for moments when there was no discussion whatsoever and very little input from the participants. Although these moments may have been situations of perfect agreement, they may also flag that participants needed more time to formulate their thoughts or did not understand what was being discussed. To conclude whether these were situations of perfect agreement or otherwise, we compared these moments to our analysis of the dynamics of the multi-party collaboration and to the other moments of discussion in meetings to see if the non-discussed topics were referred to at a later stage. If these topics were repeated, it either indicated that participants did not completely agree with each other in the first place, or that they changed their minds at a later stage. Both situations imply that participants are learning: either about each other's understandings or about their own.

Once we identified these moments of (dis)agreement, we identified the role of boundary objects therein and their contribution to social learning. As boundary objects help translate meaning between participants, regardless of participants' initial differences in understanding, they can facilitate the development of social learning. We examined whether agreement was affected by or disagreement was overcome by the introduction of a certain concept, visual, overview, model, activity or other "object". We then labelled these as boundary objects. Combining this identification of boundary objects with our analysis of increased understanding among the participants allowed us to assess the contribution of boundary object to social learning.

### Surveys

In the Exploratory phase of the project, we developed surveys which we introduced in the infrastructure expectation phase. We introduced three types of surveys. First a baseline survey, which was used to measure the initial expectations and goals of each of the participants about the MMvIB project as a whole. Thereafter, we introduced general opening and exit surveys which we created with the aim of monitoring developments in social learning throughout the project while occupying a maximum of five minutes at both the start and end of a project meeting. This survey design allows the project leaders to conduct these at any later stage of the project and enable them to meaningfully compare their results to previous iterations.

We designed the survey questions in collaboration with two of the project leaders, employed at TU Delft and Leiden University. Social learning in participatory multi-modelling processes is a novel field with no extensive literature on systematically and quantitatively monitoring the learning processes. Therefore, we based the questions

for each of the surveys on previous studies on education and participatory processes in which the authors developed questionnaires to assess (social) learning and critical (self-)reflection (Hoverman et al., 2011; Lethbridge et al., 2011; Gilstrap & Dupree, 2008). We developed the baseline survey to specifically measure expectations at the start of the whole MMvIB project and therefore the survey would not be repeated at a later time. Questions were thus tailored to serve this specific purpose.

The questions in the opening and exit surveys were kept general, as to allow for repeated use at every stage of the project. The questions ranged from the (expectations of) usefulness of the meeting and the individual's participation, to whether the participants believed that all expectations and opinions were aligned. We also included open questions on what participants learned and what was surprising in the meeting. The exact questions asked are included in Appendix 1. We conducted the surveys using Qualtrics[3], as this software allows questionnaires and collected data to be shared with other researchers, allowing other project leaders to continue the monitoring process.

We analysed the survey data in two steps. First, we used the RStudio software[4] to visualise the quantitative survey data. To allow for insights into the development of perspectives, we graphed the data in violin plots per meeting, per question, and per participant. Examples of these are shown in the Analysis section (section 5). Second, we compared the analysis of the meeting observations to participants' input in the surveys. This allowed us to see whether a social learning process we identified for a participant during the meetings was also reflected in their answers in the surveys. This synthesis of observations and survey data allowed us to construct the narrative in the following section.

# 5. Analysis

### Exploratory phase

The Exploratory phase consisted of the first two official meetings of the project: the kick-off meeting and a meeting on the lessons learned from previous projects (Figure 3). Three questions were of main concern to the participants. The first general meeting included all participants and focused on two questions: Who are we, and how do we structure our working process? The second meeting was attended by project leader TU Delft, TNO, and Quintel as experts on two previous multi-modelling projects. The

[3] Qualtrics: https://www.qualtrics.com
[4] RStudio: https://www.rstudio.com

central question for this meeting was: What can MMvIB learn from these two projects, especially in regards to best practices and challenges that might be encountered?

**Meeting observations**

*Multi-party collaboration*

During this phase, multi-party collaboration commenced to take shape. As many participants had previously worked together on other projects, the atmosphere was friendly and at times informal. This relational history may have increased participants' trust level, but might also have impacted the trust of "outsiders" who are new to the group and not as quick to understand each other's intentions. Project leader TU Delft took the lead in presenting the structure of the multi-party collaboration and the overall goals of the project as presented in the project proposal. TU Delft furthermore encouraged an open discussion on participants' motives for joining the project and on their knowledge from previous projects. This helped in streamlining participants' expectations of both the project and the behaviour and intentions of other participants. Despite this room for discussion and open debate on expectations during this phase, discussions were still few and agreements were reached relatively quickly, or postponed to future meetings.

A challenge related to this was the unequal participation of participants during both this phase and the next phase. A small group of participants employed at knowledge institutes were more eager to speak up than the rest and thereby often provided necessary input for discussions. Other participants appeared less actively involved. This division in who was a vocal participant and who was silent stayed roughly similar throughout both phases. This may have led to not all perspectives and ideas being voiced, hindering the multi-party collaboration. The challenge of handling participants' inputs persisted in the second meeting and was exacerbated by the lack of a clear meeting agenda. Some participants were unaware of the input that was expected of them and were therefore not well prepared to provide this input during the meeting. Others instead thought that the main point of the meeting was to hear their experiences from previous projects. In addition, there was no clear approach to handling comments from the participants, with some raising their points in the chat function of Microsoft Teams, others using the 'raise hand' option, and others yet simply speaking up and adding to the discussion. This put most emphasis on the opinions of the more vocal group, with the opinion of others sometimes being overlooked. The lack of a clear agenda also meant that only one previous project was discussed, with the discussion of the other project being postponed to a later date. This absence of meeting structure hampered multi-party collaboration, as not all participants could equally contribute to the discussions.

Nonetheless, at the end of every meeting, the consensus was that participants were happy and eager to work together on the same goals, which they independently and repeatedly formulated during the first meeting as combining all available models for the energy transition to help inform decision making on all levels. Commitment and trust among the participants and to the project seemed high. All in all, during this first phase, mostly similarities and agreements were highlighted, without much active, critical evaluation of each other's viewpoints. Nonetheless, the basis was set for effective multi-party collaboration.

*Social learning*

The first tentative signs of social learning arose during the Exploratory phase. We observed group composition, one of the four conditions for social learning (van de Kerkhof, 2004), to be of importance here. The group composition in the MMvIB project is relatively homogeneous. All participants work at organisations or research institutes engaged with modelling, and therefore have high knowledge of modelling practices. Most have experience with similar participatory (multi-)modelling projects. This enabled their first-order learning, as most participants were able to quickly understand the topics discussed and the technical language spoken. Van de Kerkhof argues that more heterogeneity in the group composition is useful for second-order learning, as there is a need for a critical analysis and disintegration of participants' paradigms and perspectives to come to higher-level conclusions. Especially within the first phase, this lack of diversity was prevalent in the discussions on expectations and goals. All participants appeared to be on the same page and accepted each other's constructed realities. Discussions were still minor and were mostly focused on problem definition and project structure.

For example, topics that were not elaborately devised in the project proposal caused minor discussions, but did not lead to renewed understandings of goals, concepts, or beliefs, as no clear conclusions were reached. This happened on three different occasions. A discussion on the order of use cases for testing the multi-model in different stages of the project was moved to a private meeting two to three weeks later. Similarly, there was a debate on the exact governance structure of the project, concerning the necessity and composition of an advisory group, executive board, and possible legal entity. This was postponed multiple months. The agreements reached in these later meetings, if any were reached, were not relayed back to the other participants. Additionally, in meeting 2, the importance of choosing between types of use cases for validating the multi-model (generic vs. specific) and of setting and discussing expectations was stressed. Participants voiced contrasting opinions, but in the end made no choice between generic or specific use cases and reached no conclusion for dealing with different expectations. Since these discussions arose in the

very first phase of the project, it is understandable that no definite decisions were made. However, during this phase clear communication on how to proceed with this diversity of expectations and choice preference in the future was lacking. These three observations suggest tentative signs of first-order learning, as some participants verbalised distinct ideas and expectations on the project structure and joined initial discussions to overcome these differences. However, they did not yet manage to find common ground.

In addition, two parties warned against being oblivious to divergent understandings of key concepts in modelling and in the energy transition. In previous projects, they had noticed that sometimes participants held different definitions, leading to different understandings of the problems at hand and the possible solutions. The other participants immediately agreed that such situations should be avoided and that they should stay aware of such divergent understandings in the remainder of the project. This reflection implied first-order learning, as the participants shared their expectations and knowledge and lessons from previous experiences. This awareness of possible misunderstandings in the future could potentially lead to second-order learning at a later stage, as participants became more aware of possible differences in understandings of key concepts between themselves and their fellow participants.

*Boundary objects*

In the Exploratory phase, only few boundary objects were introduced to facilitate social learning. The pre-designed project proposal served as the first boundary object in providing the basis for the conversation on participants' expectations on the project. An extension of this is the website multi-model.nl, which was launched during the first months of the project and served to provide all the basic information about the project for participants and outsiders to resort to when in doubt about the project structure or key concepts and decisions. The project proposal and website thereby functioned as a way to provide a common framework on which the remainder of the project would be built. The project proposal and website as a boundary object did not measurably result in second-order social learning, but did enable first-order learning by aiding in the translation of primary definitions and broader expectations of the project and the multi-party collaboration.

### Infrastructure Expectations phase

The second phase comprised meetings 3, 4 and 5, taking place in October, November and December 2021 respectively (Figure 3). Meeting 3 was a consortium meeting on progress made in the working groups (called Work Packages). This was followed by meeting 4, a first workshop in which the entire consortium discussed and decided upon their needs and the necessary features of the multi-model infrastructure to fulfil these

needs. Meeting 5 was again a consortium meeting. The discussion on features of the multi-model infrastructure that started in meeting 4 continued in meeting 5.

#### Survey results

In the Infrastructure Expectations phase, the surveys were conducted and the differences in participants' expectations of and goals for the project came to the forefront. The results of the open-ended questions in the baseline survey, conducted at the start of meeting 3, indicated that most participants could be roughly divided into two groups regarding the results, challenges, goals, and learning processes they envisioned for the project (Table 1). One group, hereafter referred to as Group A, focused mostly on the technical aspects of building a multi-model (infrastructure). Useful results of the MMvIB project for Group A would be an understanding of the differences between models and thereby an understanding of how these could be coupled to allow models to communicate and interoperate. Similarly, Group A described the main challenge of the project as the actual process of coupling technically-different models. Therefore, Group A hoped to learn how and to what extent models could be coupled in a useful way, with the ultimate goal achieving the creation of an infrastructure for coupling models. Group A was primarily represented by Stedin, DNV GL, Kalavasta, TU Delft, and part of Quo Mare. The other group, Group B focused primarily on the social and practical aspects of building and using multi-models with several stakeholders. They expressed the hope to find ways of making the multi-model infrastructure applicable to real-life use cases in the energy domain. According to Group B, the main challenge within the project involved finding ways to use the output of the multi-model to inform decision-making in the energy domain. Group B was primarily represented by TNO, Gasunie, Quintel, and part of Quo Mare.

*Table 1. Group A versus Group B.*

| | **Group A** | **Group B** |
|---|---|---|
| **Focus** | Technical aspects | Social/practical aspects |
| **Goal** | Achieving the creation of a multi-model infrastructure | Making multi-model infrastructure applicable to real-life use cases |
| | Multi-model infrastructure as goal | Multi-model infrastructure as means to an end |
| **Expectations** | Similar project descriptions | Differing project descriptions |
| | Similar goals | Differing goals |
| | Quick agreement among participants | Slow agreement among participants |
| **Members** | Stedin, DNV GL, Kalavasta, TU | TNO, Gasunie, Quintel, Quo |

| | | |
|---|---|---|
| | Delft, Quo Mare | Mare |

This divide identified in the baseline survey was reflected in most opening and exit surveys throughout this phase. A summary of their results and those of the baseline survey is available in Appendix 2. The divide between Group A and B is visible especially in question 7 of the opening surveys and question 6 and 7 of the exit surveys (Table 2). For these questions, the survey results showed the highest standard deviation, indicating a large spread in the responses to this question. Note that low scores indicate a positive answer (for example that participants' goals are similar), whereas high scores indicate a negative answer (dissimilar goals).

*Table 2. Mean, standard deviation and median of question 7 of the opening survey (O) and question 6 and 7 of the exit survey (E).*

| | | **Mean** | **Standard deviation** | **Median** |
|---|---|---|---|---|
| **O.7** | To what extent do you think that the participants' goals within the MMvIB project are similar? | 2 | 1.30 | 1 |
| **E.6** | To what extent do you think that all of the participants would describe the project in a similar way? | 2.70 | 1.03 | 3 |
| **E.7** | To what extent do you think that the participants' goals within this project are similar? | 2.74 | 1.10 | 3 |

A closer look at both the multiple choice and open ended questions makes the divide clearly visible. These show that Group A – the group focused on technical aspects – mostly thought that the participants held similar to very similar personal descriptions of the project itself and its goals, and thought the participants would quickly agree on topics during the meetings. In contrast, members of Group B – focused on practical/social aspects – were either unsure whether participants held similar interpretations and expectations or thought that the participants differed in these aspects. This can be seen in Figures 4 to 7, which compare boxplots displaying the answers to questions on agreement, goals, and descriptions for all of the opening and closing surveys. In both the opening and exit surveys, Group A generally indicated that they thought participants would agree and share similar goals and descriptions. This is in contrast to Group B, who generally indicated that they expected participants to agree less and to diverge more in their goals and descriptions.

A remarkable diversion from this group division was encountered in the exit survey of meeting 4, a workshop in which participants discussed their goals of the multi-model infrastructure and their interpretation of key concepts. When asked about the surprising elements, nine out of ten respondents to the exit survey commented on the

dissimilarity of the goals, interpretations, points of view, and ideas of the others. These were members of both of the groups. Interestingly, in the next opening survey (meeting 5), both groups answered that they thought that the goals of participants were very similar. In the exit survey of meeting 5, the Group A-B divide was back. This could indicate that the participants might have interpreted the questions in the opening surveys differently from those in the exit surveys.

Regarding the setup and structure of the meetings, the surveys did not clearly show group divisions. For each of the meetings, the participants were somewhat positive to neutral about the usefulness of the meeting for themselves, the meeting setup, the amount they learned, the meeting subjects, and the clarity of the conclusions of the meetings. However, the more silent participants, identified in the previous phase, valued their ability to contribute to the meetings slightly less than the more vocal group. This is visible in Figure 8. It shows for meetings 3 and 4 that a number of participants agreed with the statements that their contribution was useful to others (score 2), whereas the other group, the more silent participants, indicated that they neither agreed nor disagreed with the statement (score 3).

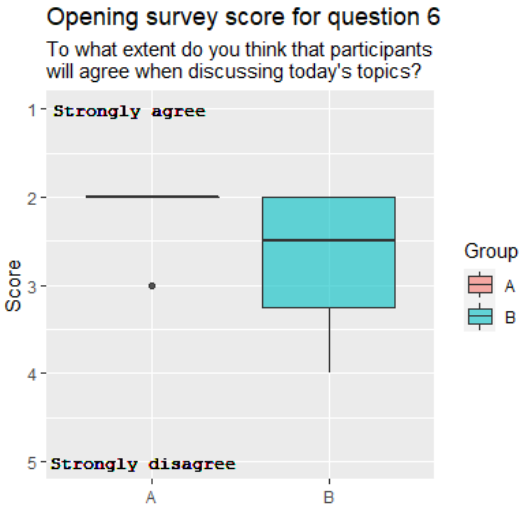


*Figure 4. Responses for Group A and B to the opening survey statement 6.*


*Figure 5. Responses for Group A and B to the opening survey statement 7.*

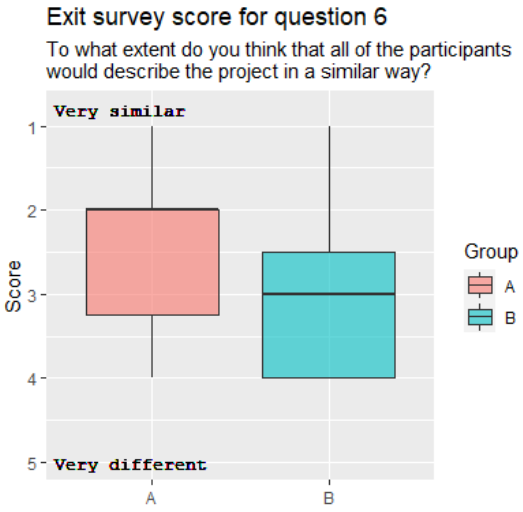


*Figure 6. Responses for Group A and B to the exit survey statement 6.*

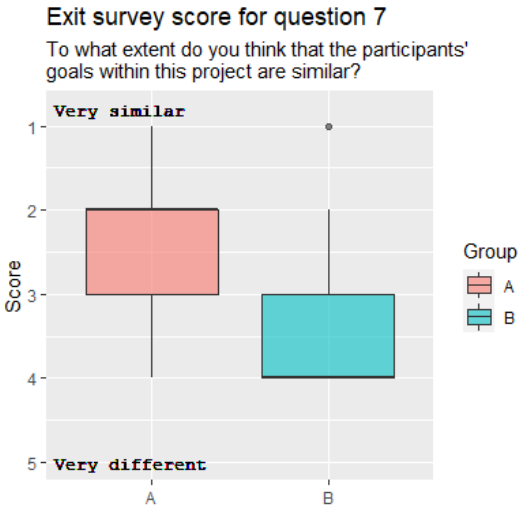


*Figure 7. Responses for Group A and B to the exit survey statement 7.*

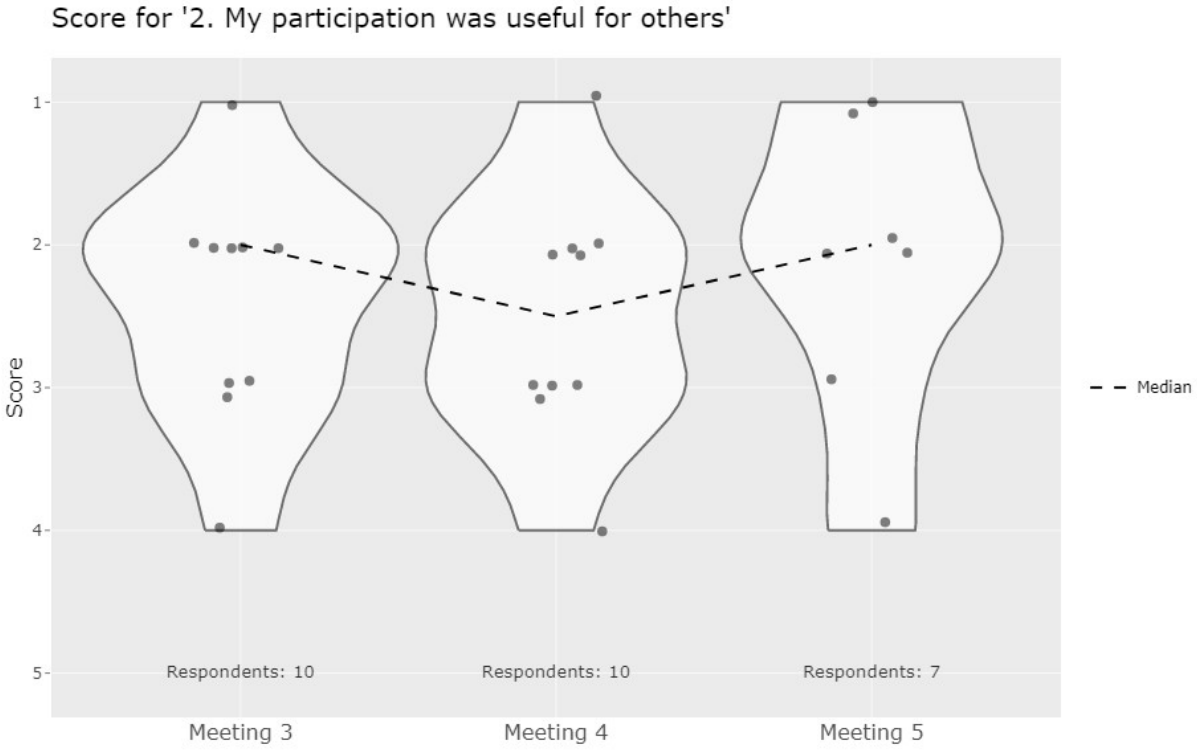


*Figure 8. Responses to the statement "My participation was useful for others" in the exit survey. Note especially the two groups in the first two meetings, indicated by the clusters of dots at scores of 2 and 3.*

## Meeting observations

*Multi-party collaboration*

The more vocal group had a considerable impact on the multi-party collaboration in this phase. During the workshop (meeting 4), a Miro board[5] was introduced to

[5] Miro is an online whiteboard platform in which participants can visualise ideas and react to other participants' input.

collectively accumulate, organise, and prioritise the needs of participants and the necessary features of the multi-model infrastructure. All participants provided their input as digital sticky notes on the board. When discussion on a note started, the vocal group, which still comprised the same participants as in the Exploratory phase, was often the first to respond to it, to debate the correct interpretation of a note, and to decide on its prioritisation. The more silent authors of these notes only joined the discussion after several minutes, or when they were specifically asked for their input. Following Curşeu and Schruijer (2018), this might indicate that more silent participants followed their expectations of the social situation and the behaviour of other participants in expecting that the vocal group might already provide (sufficient) answers to questions or raise the points that more silent participants themselves would otherwise have raised. During meeting 5, however, part of the vocal group could not be present. The result of this was that topics were hardly discussed and that participants often did not have feedback or comments when asked by the chair to provide these.

There may have been different reasons for less active participation from some of the participants. One is the lack of breaks during the meetings. In addition, during the workshop, clear rules were set for taking the floor (raise hand before talking, one person speaks at a time, maximum of five minutes speaking time) to allow as many people as possible to provide input. These were, however, not enforced, which could have hindered some participants from providing input, as others were quicker in responding. In addition, due to the COVID-19 situation, all meetings were hosted in an online environment. This made equal participation in the multi-party collaboration more difficult. Active debate was more forced, barriers to contribution were higher, and it was more challenging to understand participants' non-verbal communication. Personal reasons for less vocal participation might also have been the product of insecurity of participants' own contributions or a lack of trust in either their own knowledge level or that of the other participants. This was reflected in the surveys, in which the group of more silent participants valued their ability to contribute to the meetings less than the more vocal group (Figure 8).

Even though some participants were less vocal than others, they still showed that they were invested in the project. During meeting 3, two groups of mostly silent stakeholders indicated that they were not invited to participate in the Work Packages that they were part of, whereas they would very much like to partake in these discussions. In addition, when participants were directly asked for a response during the workshop in meeting 4, they most often immediately knew what was discussed and what their opinion on the matter was. This suggests that although more silent, their participation was of high level.

A clear meeting agenda helped in structuring the multi-party collaboration. In meeting 3, no agenda was sent out by participants and participants did not know what to expect from the meeting. In meeting 4 and 5, an agenda was sent out beforehand and participants were asked to prepare input for the meetings. This allowed for the opinions of the more silent participants to be taken into account and resulted in a more active contribution to the discussions from all participants, sometimes aided by the project leader asking direct questions to individual participants. The project leaders also continued to emphasise the importance of the project, the constructive interactions within the participant group, and the value of being part of this project. Most participants appeared energised, motivated, and more committed to the project by these comments and it helped in increasing the trust among and the active participation of participants.

All in all, although the divide between silent and vocal participants still hindered multi-party collaboration in the second phase, steps were taken to include the silent participants more. A clear agenda, explicit questions to individuals, and continuous positive feedback from the project leaders improved the sharing of ideas, values, and understandings of all participants and allowed for improved collaboration.

*Social learning*

The effect of the vocal-silent divide on multi-party collaboration hindered the social learning process in this phase. The silence of some participants meant that participation was unequal. As a result, not all perspectives were considered and agreements were sometimes made that were only at a much later stage critically evaluated and renewed.

Nevertheless, several aspects in the second phase enabled first- and second-order learning. The project team opened up the floor for discussions on participants' expectations, based on the results of the baseline survey conducted at the start of meeting 3. This survey and the following discussions led to the realisation among the participants that their group composition was not as homogeneous as they assumed to be before commencement of the project, even though they all had high knowledge of modelling practices and experience with participatory (multi-)modelling projects. This heterogeneity also expressed itself in the divide between Group A (with a technical focus) and B (with a social focus), which allowed for disagreement and more critical discussion.

Group A and B differed in their concern regarding the expectations and goals of their fellow participants. A discussion emerged in meeting 4 regarding how each of the participants would like to use the multi-model once finished, and therefore what each

of them required the multi-model infrastructure to be capable of doing. In line with their focus on the social and practical aspects of this multi-modelling project, Group B deemed it important to agree on expectations and demands before starting to work on the technical details of coupling models. Group A made clear that “talk is cheap” and that it would be best to first start work on the infrastructure and then see what problems would arise, instead of wondering about challenges that the group might never have to face. In this, the Group A-B division identified in the baseline survey was reflected in their discussion during the meetings.

These discussions in meeting 4 led to second-order learning. A discussion on the goal of the MMvIB project centred around the question of whether the multi-model infrastructure itself was the goal or just a means to an end. The baseline survey had already indicated that Group B hoped that the MMvIB project would identify ways to use the output of the multi-model in real life use cases in the energy domain. Group members now shared this hope with their fellow participants. This meant being transparent on their (organisation’s) demands for this project. This transparency, one of the four key conditions for social learning (van de Kerkhof 2004), allowed for a common understanding of the goals and motivations of all participants. Thus, many members of Group B explained that they did not see the multi-model or its infrastructure as the goal of the project, but rather as a means to an end. Conversely, members of Group A made clear that they saw the multi-model (infrastructure) as the ultimate goal. Although this discussion did not resolve in one perspective being chosen as the future group goal, it did lead to participants from the two different groups better understanding the other’s expectations and views on the project. The exit survey of meeting 4 indicated that participants did indeed appreciate these contrasting opinions on the project, as nine out of ten respondents commented on the dissimilarity in the goals, interpretations, points of view, or ideas of the others. Therefore, second-order learning was achieved as participants gained an appreciation and understanding of the underlying assumptions of their fellow participants’ goals.

Further signs of second-order learning appeared during discussions about key concepts, which started in meeting 4 and continued in meeting 5. Some key concepts were understood differently by different participants. Several of these concepts were resolved after active discussions among many of the participants. For example, participants discussed when a (multi-)model should be seen as centralised and when it is decentralised. In addition, they debated the difference between a multi-model and a multi-model infrastructure. This discussion had implications on the communal goal of the project as a whole: working towards building a multi-model or towards an infrastructure to couple multiple models requires different features, efforts, and input from participants. Therefore, resolving this dichotomy was crucial. This was achieved,

and it was concluded that the project should work towards building a multi-model infrastructure. This overcoming of disagreement implies that second-order group learning occurred, as participants challenged each other's core understandings of the goal of the project and eventually converged to a communal understanding of this goal.

Other concepts were interpreted too dissimilarly by participants to reach any conclusions on their exact meaning. This included the difference between operational and strategic decisions, between an operational phase and an operational model, between a model scenario and an experiment, and the definitions of orchestration, the orchestrator and an orchestrating mechanism. One of the participants compiled the debated concepts into a large list for which common definitions would be created at a later stage. Even though this last step did not yet take place in the two phases we discuss in this paper, an eventual shared set of meanings would imply second-order learning.

*Boundary objects*

In the Infrastructure Expectations phase, two boundary objects and one attempt at the creation of a third boundary object were introduced that helped bridge diverse knowledge sets and expectations between the participants involved. These boundary objects consequently facilitated social learning.

First of all, during meeting 3, we made an overview of participants' expectations (Figure 9) based on the qualitative results from the baseline survey. This overview included participants' expectations on the social and technical processes and results of the MMvIB project and was used during the meeting to promote discussion on the different expectations. Most participants initially agreed with all the expectations, and some - mostly from Group A - even indicated that explicit repetition and comparison of expectations was not necessary and that they would rather start discussing modelling features. Others yet agreed with most of the information on the overview at first, but disagreed on a few aspects or asked for clarification when they examined the overview a bit longer. The overview enabled tentative steps towards second-order learning for those participants who realised and appreciated that expectations differed among participants.

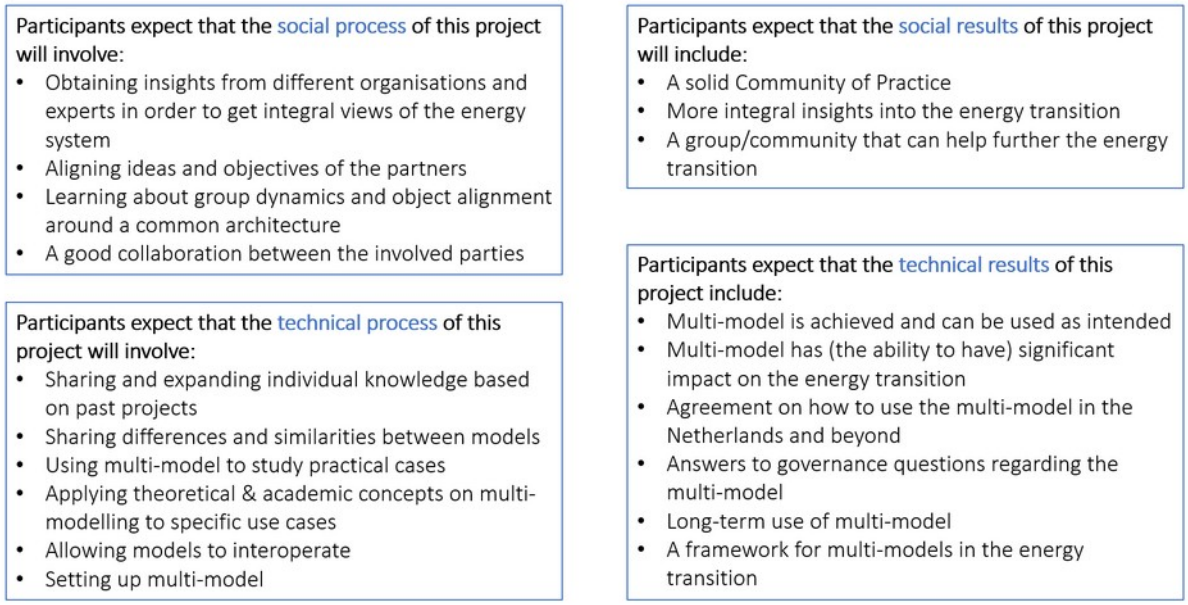


*Figure 9. Overview of participants' expectations during meeting 3.*

Second, during meeting 4 and 5, the Miro board served as a boundary object in that it facilitated discussion on the necessary requirements of the multi-model and it sparked debate on key definitions and understandings of what a multi-model infrastructure entails. For example, a discussion arose on the difference between a multi-model and a multi-model infrastructure, even though most participants had assumed they held a similar definition of these concepts. This boundary object thereby enhanced second-order learning as it helped participants in challenging each other's core underlying values and assumptions on the multi-modelling process as a whole.

An attempt at the creation of a third boundary object occurred after meeting 5. Several key concepts were debated while using the Miro board. These key concepts, such as multi-model infrastructure, generic vs. specific models, and scenarios, could have served as boundary objects, being concepts that are plastic enough to be used by different participants to fit their own frame of reference, but specific enough to help understand each other's different viewpoints. At times, however, interpretations of these concepts diverged too much to allow participants to reach conclusions in their discussions. One of the participants therefore compiled a draft list of definitions, but no further steps were taken to agree upon the final definitions. Converging the different participants' definitions a bit more may allow the participants to reach joint conclusions while leaving room for individual interpretation of these concepts.

# 6. Discussion

Throughout the participatory multi-modelling process, the participants engaged in social learning. During the first phase, the participants mostly joined in building a solid multi-party collaboration. This entailed streamlining the diverging thoughts and actions to understand each other's desired contributions to and expectations of the project structure. Participants mostly engaged in first-order learning in this phase: merely improving their understanding of the project and each other's behaviour and definitions. We observed the multi-party collaboration paradox here: the required tension between stressing similarities and finding agreement between participants while leaving room for critical discussion of each other's viewpoints. In the first phase, we observed a convergence of perspectives that helped in improving the collaboration. Phase 2, however, consisted of increased misunderstandings and critical discussions on underlying assumptions, values, and goals. Although no final conclusions were reached on any of the topics discussed, almost all participants started to acknowledge that there were differences in understanding of core concepts. An initial divergence of views therefore eventually facilitated a better understanding of each other's perspectives, although second-order learning was yet tentative. It should also be noted that social learning is not a fixed state: adjustment of expectations and understandings is a continuous process and might still improve or worsen in the next phases of the project.

Within our research project, we also detected the four conditions for successful social learning – group composition, commitment and trust, transparency, and fairness – as identified by van de Kerkhof (2004). We acknowledged that the homogeneity of the participants enabled first-order learning in phase 1, although the participants themselves realised there was more diversity among them in phase 2, allowing for more critical evaluation of each other's viewpoints and hence enabling second-order learning. We also detected high commitment to and trust in the project, although commitment did not always result in active participation, thereby hindering social learning. Transparency became a key condition during phase 2, when participants commenced sharing their personal and their organisation's objectives with the project. Fairness was the main obstacle to second-order learning, as not all participants equally contributed to the discussions and were thereby hindered from sharing their perspectives and engage in social learning.

In line with earlier work by Cuppen et al. (2020), we found that design choices in the multi-modelling process can allow for boundary objects to emerge and enhance social learning. We identified clear communication, the setting of agendas, and explicit requests for individuals' input before or during the meetings as key design choices to accelerate social learning. In addition, boundary objects such as the project proposal and website aided first-order learning through the translation of primary definitions. A

potential list of key concepts would also enable boundary crossing, as sometimes individuals' understandings were too far removed from each other to reach shared conclusions. Moreover, structuring the workshop (meeting 4) around the Miro board facilitated active and equal input on multi-model infrastructure requirements and participants' underlying values, facilitating second-order learning. We found that although Group A and B differed in their opinions on whether the others held diverging expectations, goals, and assumptions, when the meeting setup allowed for these differences to be explicitly verbalised, almost all participants acknowledged a diversity in perspectives. This was clearly observed in the exit survey of meeting 4, when both Group A and B indicated that they realised that participants very much diverged in their views and expectations on the project. Based on this finding, we conclude that if explicit room is made during meetings for discussion on these differences in expectations and understandings of expectations, second-order learning can be enhanced and a more communal understanding can be obtained. Even if not all participants are eager to continuously discuss (changing) expectations, we saw that still doing so allowed for second-order learning and is therefore valuable for the multi-party collaboration.

A surprising result was found in the opening survey of meeting 5, when both Group A and B indicated that they thought that the goals of participants were similar. This was remarkable, as the previous meeting had concluded in a clear divergence of understandings. This change could have been caused by several factors: participants may have interpreted the questions in the opening and exit surveys differently; there may have been additional meetings among smaller groups of participants in the meantime; or participants may have had time to reflect on their differences between the two meetings and concluded they were actually fairly aligned in their perspectives. We could not pinpoint the exact cause of this change. At the end of meeting 5, the Group A-B divide had returned.

Our study has a few limitations. Because of the small number of participants in each meeting, the response rate to the opening and exit surveys was low. In addition, because not all participants joined every meeting, there were some differences in which individuals filled out which surveys. Moreover, often, more individuals participated in the meetings than responded to the surveys, resulting in more individuals being observed than included in the surveys. Furthermore, we only analysed the first out of four iterations of the MMvIB project, covering six months, rather than the full two years. It is recommended to continue with the surveys and meeting observations to analyse whether the tentative signs of second-order learning will actually result in solid social learning in the long term. Moreover, with regards to the participant composition, the group was rather homogeneous as all participants were familiar with (multi-)modelling. Further research is needed to investigate whether different types of

participants engage in social learning in a similar way, and if the identified boundary objects still serve a similar function if the participant group is more heterogeneous.

# 7. Conclusion

This paper has investigated how participatory multi-modelling processes can be designed in such a way that the participants engage in social learning. The ultimate aim of encouraging social learning is to enable multi-actor collaboration and achieve higher-level results within projects contributing to sustainability transitions. Within the MMvIB project, we monitored social learning among the participants through meeting observations and surveys. Our analysis showed that multi-level collaboration can be facilitated by a number of meeting design choices: a clear agenda and structure to meetings; active participation of all participants, which can be encouraged by the project leaders making explicit space for less vocal participants to share their ideas; continuous room for discussion and open debate on expectations and key definitions; and regular positive feedback on the progress of the project to encourage commitment, trust, and solidification of relationships among participants. We detected first-order learning and tentative signs of second-order learning, with discussions increasing from occasional to more frequent and from being about basic project design to high-level values and assumptions. We identified two groups (with a more technical focus versus a social focus) who differed in their expectations and goals of the project. Their dissimilarity in understandings and interpretations were not yet completely overcome, but tentatively understood and appreciated by almost all participants. Furthermore, we identified boundary objects that helped bridge the participants' diverse perspectives, expectations, and understandings of the project. These included the project proposal and website, the overview of expectations, the Miro board, and potentially the concept list. The combination of boundary objects as identified in this research serves as the basis for a solid boundary object ecology. In such an ecology, the primary boundary objects pave the way to future boundary crossing leading to second-order learning and improved multi-party collaboration and joint decision-making.

This paper has taken the first steps in exploring how participants in a multi-party collaboration engage in social learning and how boundary objects can enable this social learning. Further research should assess whether the recommended design choices to multi-party collaboration improve social learning in the longer term as well, and whether interactions with more diverse groups of participants have similar implications for social learning.

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# Appendix 1. Survey questions

Privacy statement

Your answers will not be shared with third parties and will only be accessible to the Leiden University & TU Delft researchers (right now Annemiek de Looze, Sander ten Caat, Eefje Cuppen and Igor Nikolic). Your data will be anonymised for use in publications. We still ask you to provide your name, but this is only for internal use.

Baseline survey

**English**

1. I consent to the use of my anonymised data for research purposes. *(Yes/No)*
2. What is your full name?
3. I think the MMvIB project will provide my organisation with results which will be:
    a. *Extremely beneficial*
    b. *Very beneficial*
    c. *Moderately beneficial*
    d. *Slightly beneficial*
    e. *Not at all beneficial*
4. What kind of results do you think these will be? Which of these is the most important for you? *(Text answer)*
5. What is the most important problem/challenge that this project will address? *(Text answer)*
6. How would you define the ultimate goal of this project? *(Text answer)*
7. How much knowledge do you have on the topic of multi-modelling?
    *a. A great deal*
    *b. A lot*
    *c. A moderate amount*
    *d. A little*
    *e. None at all*
8. How much knowledge on the topic of multi-modelling exists in your organisation?
    *a. A great deal*
    *b. A lot*
    *c. A moderate amount*
    *d. A little*
    *e. None at all*
9. How much do you expect to learn from your participation in this project?
    *a. A great deal*
    *b. A lot*
    *c. A moderate amount*
    *d. A little*
    *e. Not at all*
10. What do you expect to learn? *(Text answer)*

11. How much will your organisation learn from your participation in this project?
    a. *A great deal*
    b. *A lot*
    c. *A moderate amount*
    d. *A little*
    e. *Nothing*
12. How much do you expect that the other participants will learn from you?
    a. *A great deal*
    b. *A lot*
    c. *A moderate amount*
    d. *A little*
    e. *Nothing*
13. The MMvIB project will be a great success! *(Yes!)*

**Dutch**

1. Ik stem in met het gebruik van mijn geanonimiseerde data voor onderzoeksdoeleinden. *(Ja/Nee)*
2. Wat is uw volledige naam? *(Open antwoord)*
3. Ik verwacht dat het MMvIB project zaken zal opleveren waar mijn organisatie:
    a. *Zeer veel aan heeft*
    b. *Veel aan heeft*
    c. *Enigszins wat aan heeft*
    d. *Weinig aan heeft*
    e. *Helemaal niets aan heeft*
4. Wat voor zaken verwacht u dat dat zijn? Welke daarvan vindt u de belangrijkste? *(Open antwoord)*
5. Wat is het belangrijkste probleem/uitdaging dat dit project zal aanpakken? *(Open antwoord)*
6. Hoe zou u het ultieme doel van dit project definiëren? *(Open antwoord)*
7. Hoeveel kennis heeft u over multimodelleren?
    a. *Zeer veel*
    b. *Veel*
    c. *Niet veel, niet weinig*
    d. *Weinig*
    e. *Helemaal niets*
8. Hoeveel kennis heeft uw organisatie over multimodelleren?
    a. *Zeer veel*
    b. *Veel*
    c. *Niet veel, niet weinig*
    d. *Weinig*
    e. *Helemaal niets*

9. Hoeveel verwacht u te leren van uw deelname aan dit project?
    a. *Zeer veel*
    b. *Veel*
    c. *Niet veel, niet weinig*
    d. *Weinig*
    e. *Helemaal niets*
10. Wat verwacht u te leren? *(Open antwoord)*
11. Hoeveel zal uw organisatie leren van uw deelname aan dit project?
    a. *Zeer veel*
    b. *Veel*
    c. *Niet veel, niet weinig*
    d. *Weinig*
    e. *Helemaal niets*
12. Hoeveel denkt u dat andere deelnemers van uw deelname zullen leren?
    a. *Zeer veel*
    b. *Veel*
    c. *Niet veel, niet weinig*
    d. *Weinig*
    e. *Helemaal niets*
14. Het MMvIB project wordt een groot succes! *(Ja!)*

## Opening survey

**English**

I consent to the use of my anonymised data for research purposes. *(Yes/No)*

What is your full name? *(Text answer)*

1. I expect that today's meeting will be useful for the progress of this project
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
2. I expect I will be able to meaningfully contribute to today's discussions
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
3. I expect to learn a lot from today's meeting
    a. *Strongly agree*
    b. *Somewhat agree*

    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
4. I feel prepared for this meeting
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
5. I know what is expected of me today
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
6. To what extent do you think that participants will agree when discussing today's topics?
    a. *Strongly agree with each other*
    b. *Somewhat agree with each other*
    c. *Neither agree nor disagree with each other*
    d. *Somewhat disagree with each other*
    e. *Strongly disagree with each other*
7. To what extent do you think that the participants' goals within the MMvIB project are similar?
    a. *Very similar*
    b. *Somewhat similar*
    c. *Neither similar nor different*
    d. *Somewhat different*
    e. *Very different*

*Only displayed if question 1 was answered with "Somewhat disagree" or "Strongly disagree":* You indicated that you expect today's meeting to not be too useful. What topics should rather be discussed today, in your opinion? *(Text answer)*

*Only displayed if question 4 or question 5 were answered with "Somewhat disagree" or "Strongly disagree":* You indicated that you do not feel prepared for this meeting and/or that you do not know what is expected of you for today's meeting. How could we help to improve this situation for future meetings? *(Text answer)*

**Dutch**

Ik stem in met het gebruik van mijn geanonimiseerde data voor onderzoeksdoeleinden. *(Ja/Nee)*

Wat is uw volledige naam? *(Open antwoord)*

1. Ik verwacht dat de bijeenkomst van vandaag nuttig zal zijn voor het verloop van het project
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
2. Ik verwacht dat ik een waardevolle bijdrage kan leveren aan de discussies van vandaag
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
3. Ik verwacht veel te leren van de bijeenkomst van vandaag
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
4. Ik voel me goed voorbereid voor deze bijeenkomst
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
5. Ik weet wat er van me verwacht wordt vandaag
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
6. In hoeverre denkt u dat de deelnemers het met elkaar eens zullen zijn vandaag over de onderwerpen die tijdens de bijeenkomst besproken worden?
    a. *Helemaal met elkaar eens*
    b. *Met elkaar eens*
    c. *Niet met elkaar eens en niet met elkaar oneens*
    d. *Met elkaar oneens*
    e. *Helemaal met elkaar oneens*
7. In hoeverre denkt u dat de doelen die de deelnemers met het MMvIB project hebben overeenkomen?

a. *Zeer overeenkomstig*
b. *Overeenkomstig*
c. *Niet overeenkomstig, niet verschillend*
d. *Verschillend*
e. *Zeer verschillend*

*Only displayed if question 1 was answered with "Mee oneens" or "Helemaal mee oneens":* U gaf aan dat u verwacht dat de bijeenkomst van vandaag niet al te nuttig zal zijn. Welke onderwerpen zouden volgens u vandaag beter besproken kunnen worden?

*Only displayed if question 4 or question 5 were answered with "Mee oneens" or "Helemaal mee oneens":* U heeft aangegeven dat u zich niet voorbereid voelt op de bijeenkomst en/of dat u niet weet wat er van u wordt verwacht voor de bijeenkomst van vandaag. Hoe kunnen we deze situatie helpen verbeteren voor toekomstige bijeenkomsten?

### Exit survey

**English**

What is your full name? *(Text answer)*

1. This meeting was useful for me
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
2. My participation was useful for others
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
3. I learned a lot from this meeting
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*

    *Only displayed if question 3 was answered with "Strongly agree" or "Somewhat agree":* What did you learn? *(Text answer)*

    *Only displayed if question 3 was answered with "Strongly disagree" or "Somewhat disagree":* Could you explain what caused your lack of learning in this meeting? *(Text answer)*
4. What did you think of the set up of this meeting?

a. *Very good*
b. *Good*
c. *Sufficient*
d. *Some improvements recommended*
e. *Significant improvements recommended*

*Only displayed if question 4 was answered with "Some improvements recommended" or "Significant improvements recommended":* What would you like to see improved in the process of these meetings? Please suggest one improvement. *(Text answer)*
*Only displayed if question 4 was answered with "Very good" or "Good":* What made this meeting work so well? *(Text answer)*

5. This meeting focused on the right subjects
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
6. To what extent do you think that all of the participants would describe the project in a similar way?
    a. *Very similar*
    b. *Somewhat similar*
    c. *Neither similar nor different*
    d. *Somewhat different*
    e. *Very different*
7. To what extent do you think that the participants' goals within this project are similar?
    a. *Very similar*
    b. *Somewhat similar*
    c. *Neither similar nor different*
    d. *Somewhat different*
    e. *Very different*
8. To what extent are the conclusions of this meeting clear to you?
    a. *Very clear*
    b. *Clear*
    c. *Neither clear nor unclear*
    d. *Unclear*
    e. *Very unclear*
9. I know what is expected of me for the next meeting
    a. *Strongly agree*
    b. *Somewhat agree*
    c. *Neither agree nor disagree*
    d. *Somewhat disagree*
    e. *Strongly disagree*
10. What was surprising in this meeting? *(Text answer)*

**Dutch**

Wat is uw volledige naam? *(Open antwoord)*

1. Deze bijeenkomst was nuttig voor mij
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
2. Mijn deelname was nuttig voor de andere deelnemers
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
3. Ik heb veel geleerd van deze bijeenkomst
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*

    *Only displayed if question 3 was answered with "Helemaal mee eens" or "Mee eens":* Wat heeft u geleerd? *(Open antwoord)*

    *Only displayed if question 3 was answered with "Mee oneens" or "Helemaal mee oneens":* Kunt u aangeven waardoor u denkt dat het komt dat u weinig geleerd heeft? *(Open antwoord)*
4. Hoe vindt u de manier waarop de bijeenkomst was opgezet?
    a. *Zeer goed*
    b. *Goed*
    c. *Voldoende*
    d. *Voor enige verbetering vatbaar*
    e. *Zeer voor verbetering vatbaar*

    *Only displayed if question 4 was answered with "Zeer voor verbetering vatbaar" or "Voor verbetering vatbaar":* Wat zou u willen verbeteren aan de opzet van deze bijeenkomst? Voer alstublieft één verbetering in. *(Open antwoord)*

    *Only displayed if question 4 was answered with "Zeer goed" or "Goed":* Wat zorgt ervoor dat deze bijeenkomst zo goed werkt? *(Open antwoord)*
5. Deze bijeenkomst behandelde de juiste onderwerpen
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*

6. In hoeverre denkt u dat alle deelnemers het project op dezelfde manier zouden omschrijven?
    a. *Zeer vergelijkbaar*
    b. *Vergelijkbaar*
    c. *Niet vergelijkbaar, niet verschillend*
    d. *Verschillend*
    e. *Zeer verschillend*
7. In hoeverre denkt u dat de doelen die de deelnemers met het project hebben overeenkomen?
    a. *Zeer overeenkomstig*
    b. *Overeenkomstig*
    c. *Niet overeenkomstig, niet verschillend*
    d. *Verschillend*
    e. *Zeer verschillend*
8. In hoeverre heeft u een duidelijk beeld van wat de conclusies van deze bijeenkomst zijn?
    a. *Zeer duidelijk*
    b. *Duidelijk*
    c. *Niet duidelijk en niet onduidelijk*
    d. *Onduidelijk*
    e. *Zeer onduidelijk*
9. Ik weet wat er voor de volgende bijeenkomst van mij verwacht wordt
    a. *Helemaal mee eens*
    b. *Mee eens*
    c. *Niet mee eens en niet mee oneens*
    d. *Mee oneens*
    e. *Helemaal mee oneens*
10. Wat was verrassend tijdens deze bijeenkomst? *(Open antwoord)*

# Appendix 2. Summary of survey results

*Table 2.1. Mean, standard deviation and median of the quantitative results of the baseline survey.*

| | Mean | Standard deviation | Median |
|---|---|---|---|
| I think the MMvIB project will provide my organisation with results will be: | 2.09 | 0.54 | 2 |
| How much knowledge do you have on the topic of multi-modelling? | 2.91 | 0.83 | 3 |
| How much knowledge on the topic of multi-modelling exists in your organisation? | 2.45 | 1.13 | 2 |
| How much do you expect to learn from your participation in this project? | 1.91 | 0.70 | 2 |
| How much will your organisation learn from your participation in this project? | 2 | 0.63 | 2 |
| How much do you expect that the other participants will learn from you? | 2.36 | 0.81 | 3 |

*Table 2.2. Mean, standard deviation and median of the results of the opening surveys.*

| | | Mean | Standard deviation | Median |
|---|---|---|---|---|
| 1 | I expect that today's meeting will be useful for the progress of this project | 1.75 | 0.44 | 2 |
| 2 | I expect I will be able to meaningfully contribute to today's discussions | 2.05 | 0.69 | 2 |
| 3 | I expect to learn a lot from today's meeting | 2 | 0.65 | 2 |
| 4 | I feel prepared for this meeting | 2.25 | 0.72 | 2 |
| 5 | I know what is expected of me today | 2.4 | 0.82 | 2.5 |
| 6 | To what extent do you think that participants will agree when discussing today's topics? | 2.4 | 0.68 | 2 |
| 7 | To what extent do you think that the participants' goals within the MMvIB project are similar? | 2 | 1.30 | 1 |

*Table 2.3. Mean, standard deviation and median of the results of the exit surveys.*

| | | Mean | Standard deviation | Median |
|---|---|---|---|---|
| 1 | This meeting was useful for me | 2.07 | 0.78 | 2 |
| 2 | My participation was useful for others | 2.37 | 0.88 | 2 |
| 3 | I learned a lot from this meeting | 2.26 | 0.59 | 2 |
| 4 | What did you think of the setup of this meeting? | 2.56 | 0.75 | 3 |
| 5 | This meeting focused on the right subjects | 2.04 | 0.76 | 2 |
| 6 | To what extent do you think that all of the participants would describe the project in a similar way? | 2.70 | 1.03 | 3 |
| 7 | To what extent do you think that the participants' goals within this project are similar? | 2.74 | 1.10 | 3 |
| 8 | To what extent are the conclusions of this meeting clear to you? | 2.44 | 0.58 | 2 |
| 9 | I know what is expected of me for the next | 2.67 | 1.04 | 3 |

| | | | | |
|---|---|---|---|---|
| | meeting | | | |