Integrating GMB and Games in London's Built Environment*

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Abstract

A participatory research process was carried out with stakeholders in the domain of the built environment in London, U.K. The objective of the study was to improve stakeholder capacity for integrated decision-making by addressing multiple objectives of the built environment while examining the relative contributions of group model building (GMB) and simulation games to group processes. This was done in order to reduce fragmentation, or a lack of integrated planning, among London's built environment decision makers, and to add to the understanding of how system dynamics-based simulation environments or games can be used effectively in participatory GMB process. Therefore, GMB and a simulation game were applied in an integrated process and outcomes were assessed on the basis of questionnaires, observational data and audio recordings of the sessions. The integrated process lead to improvements in participant learning, and developed shared understandings among stakeholders. This is evidence that the process was successful in reducing fragmentation. In addition, scales measuring learning and commitment were found to be higher in the game workshops than in GMB workshops, which were evaluated more positively on scales for consensus and communication. These differences are interpreted on the basis of transcribed audio data. An overall small sample size and other difficulties reduced the reliability of the results. However, the novel aspects of this design provide encouraging implications for future research regarding the contributions of games to facilitated group processes.

Introduction

The built environment serves many roles in human society. It is where the increasingly urban human population lives, works and plays. It is made up of homes, offices, parks, pubs and the intervening elements in between. The built environment must simultaneously meet multiple, different goals, and therefore a more holistic understanding is needed in order to provide an environment where people can thrive, not just survive. In order to do so factors that make up social and individual wellbeing, which can be difficult to measure, must be addressed in a coordinated manner. Approaches are needed that can cope with these challenges in measurement, and investigate the interdependencies that make up the built environment. The design of future policies will benefit from more integrated planning that considers these interconnections, thereby enabling better performance within this complex system.

This study focused on the city of London in the United Kingdom (U.K.) where aggressive policy targets for carbon emissions reductions has led to increased pressure on the housing sector to apply energy efficiency techniques (HM Government, 2011). These policies arose following the passage of the Climate Change Act, which calls for an 80% reduction from 1990 emissions levels throughout the U.K. (*Climate Change Act*, 2008, sec. c. 27). As housing emissions account for more than one quarter of total emissions, this sector has a large role to play in meeting these ambitious targets and more than 14 million homes in the U.K. are targeted for improvements in energy efficiency by 2020 (*The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK*, 2012).

Thus far, U.K. housing policies have consistently underperformed, both in meeting their primary objective to reduce emissions contributed by the housing stock, and in mitigating unintended, unwanted consequences (Davies and Oreszczyn, 2012). This has been attributed to failures in policy development processes that have singular objectives, which has resulted in negative impacts on communities as well as the mental and physical wellbeing of residents (Shrubsole et al., 2014). It has been suggested that, in order to improve the performance of policies in this complex domain, more holistic thinking must be combined with new methods that can better integrate multiple objectives into the planning process (Eker et al., in preparation; Eker and Zimmermann, 2016; Shrubsole et al., 2014; South, 2015). In practice, this requires decision makers to be engaged in processes that can develop their ability to deal with multiple policy goals successfully.

A project about Housing, Energy and Wellbeing (HEW) that addresses this gap has been underway at the University College London that focuses on integrated decision making. This work engaged stakeholders (who are subsequently engaged in this thesis research) using components of the system dynamics (SD) method. Specifically, this work used qualitative causal loop diagrams (CLDs). The HEW project applied CLDs to address the complex challenges facing the built environment. Research began with stakeholder identification and individual interviews. Individual interviews were coded using an inductive process and organized into themes that showed the interconnections between social and technical factors of the built environment. The themes are a distilled representation highlighting the interconnections that emerged from the interviews (Macmillan et al., 2016). An understanding of these multiple dependencies is needed to improve performance of future policy designs and avoid unintended, unwanted outcomes (Shrubsole et al., 2014).

The themes were then refined and developed into nine policy criteria, shown in Table 1. The themes and resulting criteria collectively show the stakeholders' consideration of difficult to measure items such as community connection and other aspects influencing social wellbeing. It is notable that, besides the identification of these criteria, the second most discussed topic (behind energy efficiency) was social wellbeing. The interviews and themes were interpreted as representing improvement in shared understanding of the decisions made in the complex housing system among stakeholders (Macmillan et al., 2016). However, there is remaining need for further efforts toward integrative planning and consideration of the multiple objectives of the built environment pertaining to social, physical, and mental wellbeing.

Table 1. The policy criteria developed by Macmillan et. al. (2016).

Policy Criteria

1. *Carbon emissions from housing*
2. *Community connection*
3. *Fuel poverty*
4. *Housing adaptation to climate change*
5. *Housing affordability*
6. *Mental and emotional wellbeing*
7. *Physical wellbeing/health*
8. *Policy Coherence*
9. *Social and Income Equality*

This understanding was developed after a third workshop, following previous qualitative workshops, where stakeholders indicated that *fragmentation* or, in general, a lack of integrated planning, has led to noticeable gaps between intentions or planned designs and the implementation of these (Zimmermann et al., 2015). This thesis is focused on tackling fragmentation that is present at the *individual level* and occurs between individual decision-makers. It also addresses intra-group fragmentation where implementation breaks down due to the lack of coordination among organizations. In addition it continues the use of the holistic SD approach, advancing beyond the CLD diagrams to address fragmentation and encourage stakeholder consideration of the impacts of policies on the previously described items. Further application of this approach has been suggested as a way to overcome fragmentation by enabling integrated planning and decision making activities (Eker and Zimmermann, 2016).

Overview of Research Process

The overall research process is shown in Figure 1, from the start of the project with stakeholder analysis and interviews, to this study's contribution of 3 GMB sessions plus the final game workshop. The stages are adapted from Macmillan et al. (2016), and the most recent steps, respond to the the authors' recommendations for the use of new approaches that can "integrate the qualitative and quantitative knowledge held by different groups[…] in a collaborative learning process[…] and explore the impacts of policies on a more integrated set of outcomes" (p. 2). In this study, the use of GMB to support the development of a quantified game represents a first iteration of this integration, and is therefore well situated to contribute to the overall HEW project goals.

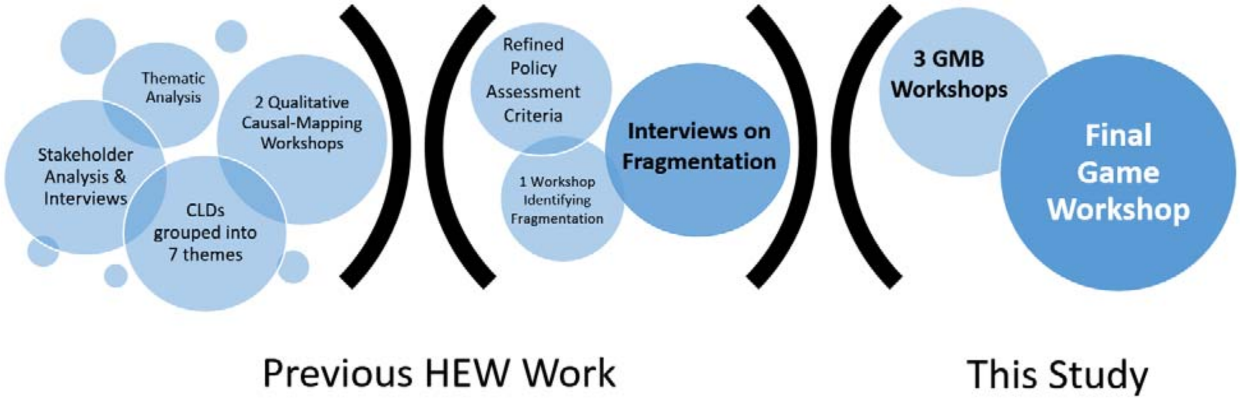

Figure 1. A flow-chart giving an overview of the HEW research program, developing from qualitative interviews towards this study's use of the GMB sessions and simulation game.

The methodology chosen is group model-building (GMB), which has been shown to be effective for developing learning, building consensus, generating commitment and improving communication with client groups (Rouwette et al., 2011, 2002). It has also been demonstrated as useful for resolving management conflicts (Black and Andersen, 2012). In this study, GMB is combined with a simulation game, based on an SD-model. Like GMB, games can be an effective tool for participant learning (Davidsen and Spector, 2015). However, unlike GMB, little else is known about how these games influence different dimensions of intended group process outcomes.

GMB and games have only been compared twice previously (Eskinasi and Rouwette, 2004; Ruud and Baakken, 2003), and only once on the basis of an established questionnaire(Eskinasi and Rouwette, 2004). This thesis added rigor by supplementing results from an established questionnaire with a thorough analysis of audio recordings as well as observational data. Analysis was also performed, on the basis of the audio recordings, in order to measure the extent to which these processes improve stakeholders' consideration of multiple objectives, such as wellbeing and community. Furthermore, this work builds on previous theory regarding the use of visual representations in group processes while piloting the use of a method for eliciting stakeholder knowledge during group process.

Comparing GMB and Games

Both GMB and games have been determined to have positive effects on participant learning. In GMB this is attributed to elements of the *process* encountered while building a model with a small group of people. The elements often assessed are discussions, presence of a facilitator, use of diagrams (including CLDs) and simulations using the model (Rouwette et al., 2011). SD-based games have also been used to facilitate learning. However the assessment of learning using simulations and games has historically focused on the use of the modeling environment, rather than the process of playing the game (Davidsen and Spector, 2015). Evidence for the effectiveness of considering process along with use was given by Kopainsky et al. (2015), when they applied the previously described prior exploration strategy.

GMB has made extensive use of diagrams that serve to improve collaboration among participants, known as *boundary objects* (Star and Griesemer, 1989). Boundary objects are the "tangible representation of dependencies across disciplinary, organizational, social or cultural lines that all participants can modify" (Black and Andersen, 2012, p. 195). Recent work demonstrates the way in which formal theory surrounding boundary objects can be related to GMB interventions. In this study where GMB and games are integrated, this was chosen as a means of analyzing whether or not the game acts to support this process and as well as a lens for interpretation of the observational data.

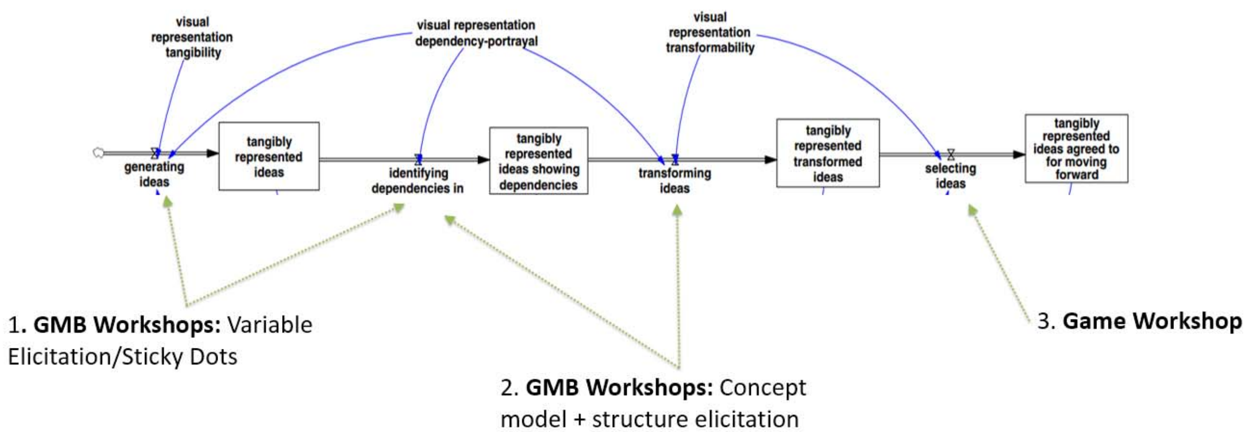

Figure 2. The facilitated process is supported by the use of boundary objects, which drive the accumulation of tangibly represented ideas and dependencies, transformed into ideas for moving forward (Black and Andersen, 2012).

The four stage process proposed by Black and Andersen (2012) is represented as a stock and flow diagram, shown in Figure 2, that accumulates understanding during workshop sessions. They also define three distinct characteristics of boundary objects, which must 1) be a tangible visual element, 2) show dependencies and 3) be modifiable by all participants. The integrated nature of this study's research strategy disperses the phases to be captured in each workshop.

Games encourage critical analysis of the model structure and may indeed act as a boundary object. Some have asserted previously that it is a challenge to fulfill the boundary object requirement of transformability in a simulation setting (Black, 2013). However, others have suggested the use of games as boundary objects (Zimmermann et al., 2015). More investigation is needed to understand the theoretical basis which motivates the use of games.

Both GMB and games lack a standard evaluation method that can be used to relate intervention elements to outcomes (Davidsen and Spector, 2015; Rouwette et al., 2011, 2002). In addition, despite the increased emphasis on the process of game play towards achieving certain outcomes, such as learning, the two have rarely been compared. To better relate GMB process elements and their effects, Vennix et al. (1993, 2000) designed a questionnaire that introduced scales of consensus, insight, communication and commitment to action (CICC). This questionnaire has been shown as an effective way to add rigor to evaluation, serving as an example of a possible standard assessment tool for the method (Rouwette et al., 2011). Though effective measures on the basis of learning have been demonstrated in studies that use simulation environments, standard evaluation methods are also absent (Davidsen and Spector, 2015). Therefore in this study, the CICC questionnaire was used as a means to streamline data collection for both GMB and games, enabling a "more systematic assessment of projects and accumulation of research results (Rouwette et al., 2011, p. 886)." Additionally, it allows a comparison of the process elements which can help to further elucidate important elements of each approach.

Table 2. Dimensions of GMB and games that were compared in this research.

Dimensions Compared	**GMB**	**Games**
Learning	✓ (Vennix, 1996)	✓ (Kopainsky et al., 2015)
Building consensus	✓ (Rouwette et al., 2011)	? (Ruud and Baakken, 2003)
Improving communication	✓ (Rouwette et al., 2011)	? (Ruud and Baakken, 2003)
Use of boundary objects	✓ (Black and Andersen, 2012)	? (Black, 2013; Zimmermann et al., 2015)

Despite the similarities between these two approaches, only three prior studies could be found that specifically combined GMB and games. The most recent study, relating to water and sustainable development, used one GMB session to create a CLD. The relationships defined in that session were used as input for the final model and game. The authors credit the GMB workshop for its contribution to the identification of key variables. However, they do not compare GMB to games, nor do they use any kind of systematic analysis to evaluate the specific contributions made by the GMB session (Bassi et al., 2015).

Ruud & Baakken (2003) combined the methodologies to create a decision support tool for military training. They created a multiplayer game using GMB to inform the process and speak to the use of the approach for learning. They also point out "how people who have worked side by side for a long time could "update" their perception of each other's *understanding* during the modeling process [emphasis added]" (Ruud and Baakken, 2003, p. 6). As this process involved use of the gaming interface, their observation provides some evidence that games can be used to improve consensus and communication. However, this is weakly supported in the study. In addition, respondents in their study also "emphasized how the game is a tool for triggering group discussions "(Ruud and Baakken, 2003, p. 8). This implies the use of the game as a boundary object, however, beyond anecdotal and observational evidence this study provided little support for either.

Another study using both of these methods was also conducted in the realm of the built environment by Eskinasi and Rouwette (2004). Participants in their study used a 'flight simulator' for 15-30 minutes individually as part of a two-hour workshop presenting simulation runs to the larger group. This was part of a larger GMB case study (Eskinasi et al., 2009) that took place in the Netherlands, focusing on the tensions between new construction and the market for subsidized, social housing. They applied a pre-test, post-test design based on a measurement model of intended behaviors of participants. An example of a behavior in this case took the form of intended policies to address this tension. They also asked participants to compare the workshops to their experience of a normal meeting. They report that both groups found the workshops to be more effective than normal meetings. They also found a significant difference for two dimensions of behavior, but they do not provide any comparison of the two on this basis. Taken together, these studies clearly illustrate that there are indeed theoretical gaps in understanding regarding the effects games on group processes. Furthermore it appears that there is perceived positive effect from combining games with GMB in this regard. Clearly, further investigation is still needed to understand how these two methods may complement each other.

Summary of Results

The CICC survey data were compared between the small and large workshops following the examples of Eskinasi & Rouwette (2004) and Vennix & Rouwette (2000). Questionnaire data was collected from 13 stakeholders who participated in the small group workshops. One participant attended the policy and community workshops and is therefore represented twice in the analysis (n=14 in Tables 3, 4 and 5).

The table below shows the results including min, max, mean and standard deviation or the four scales. A 5-point Likert scale was applied ranging from disagree (1) to agree (5). For each scale a two way t-test was used to compare the means of the survey result to a neutral score (neither agree nor disagree, 3). The mean for the results was found to be significant for all scales in both workshop types (*t-test 2-tailed significance <.000)* and, results *between* the two groups were also found to differ significantly (*t-test 2-tailed significance, independent samples < 0.000*). Therefore, both meeting types had positive effects on communication, insight, commitment and consensus. For the GMB workshops insight and commitment were significantly higher. In the game workshop consensus and communication were greater.

*Table 3. Final results summarized, the results of the workshops are significant and positive, however coefficients are above the threshold value (0.60), after applying the Spearman-Brown** prediction formula. The gaming workshop had a significantly greater positive effect* on insight and commitment than the GMB workshops, which performed better on consensus and communication scales.*

Game Workshop							
	# items	α**	n	Min	Max	Mean	Std. dev.
Insight	4	0.74	9	3.25	5	4.31*	0.65
Consensus	3	0.70	9	2.34	5	3.85	1.01
Commitment	3	0.91	9	2.67	5	3.79*	0.86
Communication	3	0.75	8	2.66	5	3.79	0.86
GMB Workshops							
Insight	4	0.62	14	3.25	5	4.19	0.77
Consensus	3	0.88	14	2.67	5	4.12*	0.85
Commitment	3	0.87	14	2.34	5	3.62	0.86
Communication	3	0.87	14	2.34	5	3.98*	0.9

As noted in Table 8, not all tests of reliability were above the threshold value of .80, after a conversion using the Spearman-Brown prediction formula. This formula was used to calculate the reliability of each scale at if it had been extended to 10 total items. The survey has been used with a larger respondent group, where a reliability of .82 was found (Vennix and Rouwette, 2000).

In addition to the four scales, questions asked for a comparison between the workshop they experienced and normal meetings. The results shown in Table 4 show that both workshop types were better on all dimensions over the stakeholder's idea of a standard meeting. However, no significant difference was found between the GMB and game workshops.

Table 4. A comparison of normal meetings to the workshops found no significant difference between those who attended the small GMB workshops and the larger gaming workshop. Scored on a scale of -5 to 5.

	Game			**Small Workshops**			**P-value**
	Mean	*Std. dev.*	*n*	*Mean*	*Std. dev.*	*n*	
more insight	4.44	0.88	9	4.36	2.98	14	0.80
faster insight	4.11	0.93	9	3.71	3.13	14	0.36
better communication	4.33	1.12	9	4.50	2.83	14	0.69
faster alignment of mental models	3.89	1.17	9	4.21	3.37	14	0.76
better alignment of mental models	4.11	0.93	9	4.36	3.72	14	0.75
faster commitment	3.67	0.87	9	3.79	4.13	14	0.32
more commitment	4.00	1.00	9	3.79	4.04	14	0.61

The results shown in the table below are based on specific elements of GMB. The means for the gaming workshop were higher than for the GMB workshop leading to two significant differences.

*Table 5. A comparison of the contribution of specific GMB elements toward the workshop success. Scored on a scale from -5 to 5, *denotes a significant difference among the two workshops.*

	Game			**GMB Workshops**			**P-value**
	Mean	*Std. dev.*	*n*	*Mean*	*Std. dev.*	*n*	
projection of diagrams	3.88	1.46	8	2.71	2.61	14	0.20
presence of a group facilitator	4.22	0.67	9	1.71	2.79	14	*0.00
opportunity for discussion	4.44	0.88	9	4.14	1.10	14	0.48
use of causal loop diagram	4.00	1.66	9	3.29	1.54	14	0.32
computer model simulations	4.33	1.00	9	1.09	1.04	11	*0.00

In addition to the CICC data audio recordings were transcribed for both workshop types and coded beginning at the first indication of use of visual elements in the process and ending at the close of scheduled workshop activities. Only the second and third GMB workshops were recorded following the realization by the facilitation team that this would be a useful supplement for model revision. Due to time restrictions only three groups from the game workshop were transcribed. This was chosen on the basis of the facilitator skill level, in order to better investigate the effect of this variable on outcomes.

Group 1 had a highly-skilled facilitator who had been involved in the HEW project for more than a year. The facilitator for group 2 was representative of an intermediate level of skill, having gained some facilitation experience through involvement in the previous GMB workshops. The group 2 facilitator was relatively new to the HEW project, but had been involved throughout the process and was the main developer of the model. Finally, the group 3 facilitator represented a low-skilled facilitator who was new to the project. This facilitator had many years of experience applying SD in an expert fashion but lacked GMB training and experience and was not involved in the HEW project at the time of this study. The group 4 facilitator shared similar characteristics with that of group 3, and was not transcribed. Time restrictions also informed the unit of analysis with the bottom half of every page representing one unit. Therefore the analysis includes half of the total transcribed data. The results are shown in Table 6 and were analyzed using a two-tailed binomial non-parametric test with a proportion of .50. Results were reported on the basis of a .01 significance level, due to the small sample.

Table 6. This table shows the results of the audio data analysis for each individual workshop, including the proportion positive (in parenthesis) and significant positive outcomes.*

	GMB Community	GMB Policy	Group 1 Game	Group 2 Game	Group 3 Game
Transcript Length	1:58	2:40	1:34	1:42	01:33
Number of Participants	5	7	3	4	4
Multiple Objectives Positive:	12 (1)*	10 (.84)	15 (1)*	36 (.95)*	19 (1)*
Multiple Objectives Total:	12	12	15	38	19
Learning (Insight) Positive:	4 (1)	8 (1)*	21 (1)*	37 (.95)*	10 (.63)
Learning Total:	4	8	21	39	16
Fragmentation Positive:	20 (.87)*	36 (.76)*	22 (.88)*	28 (.74)*	17 (.85)*
Fragmentation Total:	23	47	25	38	20
Boundary Object Positive:	20 (.77)*	41 (.64)*	21 (.63)	26 (.55)	29 (.62)
Boundary Object Total:	26	64	33	47	47

Overall, the results are positive and significant. Indeed, this result was seen for all workshops on the basis of fragmentation, corresponding to the significant results found for the consensus and communication scales of the CICC. The analysis shows one categorical difference regarding the effect of the boundary object between the GMB and game workshops. In all of the game workshop groups no significant positive contribution was found. The ability of the game to function as a boundary object was the primary measurement for successful integration of the two methods. Therefore, this finding does not support the use of the two methods in combination.

Conclusion

The applied objective of this study centered on improving stakeholder capacity for integrated decision making in the built environment of London, U.K., in order to address the problem of fragmentation and improve stakeholders' consideration of the multiple objectives of housing. It also aimed to contribute to current theoretical understanding of the relative contributions that group model-building and system dynamics based games have on group processes. In order to do so, these two methods were integrated, and compared, with regards to their ability to improve participant learning, communication and consensus. In addition, a comparison was made on the basis of how well visual elements used for each intervention type functioned as boundary objects that support group process. Finally, the swing-weighting technique was used to elicit stakeholder perceptions of the relative influences of certain model parameters on others. The aim of which, was to simply demonstrate whether or not this technique could be constructively applied within GMB workshops.

In this applied case study it appears that the both workshop types contributed to solving the issue of fragmentation among the participating stakeholders by fostering learning, communication and consensus among the stakeholder group. Group model-building was used in combination with a simulation game to encourage the involved stakeholders to address multiple objectives of the built environment, with a focus on social and individual wellbeing indicators. This objective was broadly supported by observations, specific stakeholder feedback and coding of transcribed sessions.

Perhaps most interesting is the contribution this study makes on the basis of visual elements used as boundary objects. It demonstrated the way in which a theoretical framework (Black & Andersen, 2012) can be operationalized to support analysis of the use of boundary objects in order to assess the integration of GMB with SD-based games. This assessment method provided supporting evidence of the positive role played by visual objects used in some GMB scripts (Black, 2013; Richardson, 2013). Indeed, this study's approach to analyzing the success of visual objects to function as boundary objects may be a useful addition to standard reporting guidelines that have been suggested for GMB (Rouwette et al., 2002) and can provide a means for formally investigating whether the visual elements some GMB scripts are more effective than others. The effectiveness of the game at achieving positive group outcomes on the same dimensions and based on same questionnaire as the GMB workshops, despite the lack of support of its function as a boundary object in the audio data, suggests that the definition of boundary objects based on current theoretical understanding could be in need of further revision.

Another interpretation is that the impact of the game is achieved in a different manner than a boundary object. Take for example a recent study by Martin et al. (2015) describing the development of social stress that occurs when a person comes in contact with unfamiliar people. Exposure to unfamiliar people results in a 'fight or flight' response, which in turn, blocks the neurological pathways that generate an empathetic response. They demonstrated that playing games can be a way to reduce social stress and therefore increase empathy. To test this, two experimental groups were subjected to a painful stimulus, 1) in the presence of a stranger and 2) in the presence of a friend. Those experiencing the stimulus with a friend reported significantly higher levels of pain than did those sharing the experience with a stranger. *However, this difference disappeared when strangers engaged in only 15* *minutes of playing a game together*. Playing the game alone, on the other hand caused no change in a subjects experience of pain around a stranger. If collaborating in game play can cause an individual to 'share' a stranger's pain burden, by reducing social stress and therefore increasing empathy, perhaps a game can also help motivate decision-makers to better share each other's perspectives regarding policy priorities.

Furthermore, the study adds to theoretical knowledge regarding how SD-games can be used with groups (Bassi et al., 2015; Eskinasi & Rouwette, 2004; Ruud & Baakken, 2003) to facilitate individual learning but expands this to other important outcomes of group processes, namely the ability to generate shared understanding or consensus. Understanding the process elements that contribute to positive participant interaction with games can help practitioners design more effective methods of game-play.

The conclusions based upon these results must be interpreted in a precautionary manner. The small sample size and unforeseen barriers encountered during the research process resulted in time constraints that prevented a more thorough analysis of the data. Still, these outcomes can help guide future stakeholder engagements and research strategies.

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