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A Physical Modeling Tool to Support Collaborative Interpretation of Conversations

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Abstract: In this paper, we describe our work on producing physical tools for people doing collaborative text interpretation of conversational texts. Recognizing that although there is a linearity to conversation, we nonetheless believe that in many cases the content might better be represented as a physical, spatial object, where parts of the discussion can be modified out of their initial sequence, other parts can be added or subtracted, and gaps can be identified and filled. We prepared a series of functional prototypes of a toolkit consisting of a set of separate elements, which could be assembled into large spatial structures. While addressing research questions on how the artifacts facilitate cooperation, interaction and communication, we found the significant advantage of this kind of modeling is its ability to facilitate shared collaborative understanding without compromising individual perspectives. It also prompted discussion on the metalevel of conversation.

Keywords: conversational model, collaboration, hermeneutics, social media

Introduction

> "The power of the unaided mind is highly overrated. Without external aids, memory, thought, and reasoning are all constrained. ... The real powers come from devising external aids that enhance cognitive abilities. How have we increased memory, thought, and reasoning? By the invention of external aids: it is things that make us smart." (Norman, 1993, p. 5)

Norman (1993) argues that offloading cognitive work to external aids plays a significant role in the extension of human intelligence. The design of effective new aids of this kind is

therefore an important step in helping people to work smarter, especially in the case of more mentally challenging tasks such as the analysis of complex textual material.

The purpose of this project was therefore to explore the relationship between the collaborative processes of teams analyzing texts of conversations, and the external representations these teams made for facilitating the process of building their shared understanding. Conversations were chosen because (a) they form a large portion of qualitative research data and (b) they are often sufficiently complex that they require specialized processes and tools (e.g. NVivo, TAMSanalyzer, usenineteen.org). We were particularly interested in providing opportunities for people doing these kinds of analysis to use visual, spatial, and temporal representations, since we believe that few people outside design use visuospatial representation on a regular basis.

Possible reasons are many, including an educational bias toward word-, page-, and screen-oriented culture, the current design of computer hardware, and the lack of accurate and easy to use media and techniques. In some ways, the design profession is in a privileged position, since in the course of the design process the designer regularly uses visual, spatial and temporal representations to work with abstract ideas (Schön, 1992). In transferring this concept to analytical modeling of conversations, it was important for us to understand how tangible material outcomes relate to concepts articulated in a conversation and at the same time how the material shapes the conceptual during the process of modeling.

It is true that every designed object or process mediates in the communication between the designer and the viewer. However, in the case of the analytical models, the roles may not be entirely clear. It is possible that designer and viewer are the same people, and that the conversation they are modeling is their own. In fact, we reported elsewhere on a study of this kind involving graduate design students discussing a research paper in class (Derksen et al. 2013). They may also be the same people, but modeling, as in the case of the workshops reported in this paper, the conversation of others. Or there may be one person or team doing the modeling, and a completely distinct viewer or viewers of the model.

In all cases, however, the conversational model allows an open approach interaction leading to understanding, with good margins for representing and exploring the unexpected, for providing fast “prototyping” of connections between ideas, and for finding the “geometry” of the relationships among ideas in the space of alternatives (Frazer, 1995). There are also opportunities for improvisation, enriching the common language of communicative interaction.

On one hand, the cooperative aspect of the modeling process allows constructing one coherent view of a text; on the other, it can articulate contrasting views, when interlocutors "agree to disagree" (Pask, 1980).

Literature Review

A broad range of studies agree upon the fact that people are able to build mental three-dimensional structures from very early in their lives. According to Downs and Stea (1977) the

first evidence that a child understands spatial relations can be traced in a 3–6 year old child's "representational outputs"— built structures or drawings. Learning the language also forces the child to think about abstract entities in terms of spatial relations, e.g. to approach the problem, to face the problem (Gentner, 2001). Unfortunately, later education makes less use of this ability than could be optimal for application in information processing and knowledge building.

In this context experiments by Piaget (1954) and Vygotsky (1986) aimed at providing means for examining hidden cognitive events are worth mentioning. The aim of these experiments was to draw out the concepts formed by a respondent about the given problem situation through the externalization of otherwise inaccessible "data structures" revealing the participant's knowledge about a particular topic or to examine her way of thinking. Vygotsky and his associates developed a methodology in which the problem faced by a participant of the study was embedded in a physical artifact. The participant was encouraged to deal with them by verbal explanation or manipulation of the object. Piaget's experiments also modeled problematic situation with a help of physical objects. Especially in the case of children the possibility of manipulations of an actual object were stressed as crucial element of the whole experimental situation to help concretize their operations and avoid troubles in providing verbal explanations. In both cases, the participants were urged by the experimenter to reveal their concepts about the problem in conversation.

Pask (1980), referring to Piaget and Vygotsky, was interested in methods of eliciting explanations of problems as well as how the knowledge is represented for the external observer. He argued that problems of interaction should be considered within the research context of ecology of conversation. He developed the Conversation Theory to model this fundamental mode of interaction and mediation.

Kunz and Rittel (Kunz and Rittel, 1970) developed Issue-Based Information System (IBIS) as a system for documenting and structuring arguments needed due to the complexity of issues ("wicked problems"). The challenge is to precisely document key points in discussion for further reference. In order to accomplish this task documentation of the discussion should incorporate ways to provide descriptors, with contextual information usually being an important part. Finally, they argue that a transparent working procedure can result in better reasoning, more explicit arguments, and easier development of proper questions, revealing the actual core of the problem. The only suggestion for possible visual embodiment of the system is an "issue map" as a part of the IBIS structure. It is meant to provide a graphic representation of relationships between system elements but still without any particular proposal about the actual visual realization.

In their now-classic introduction to boundary objects, Star and Griesemer (1989) distinguish among four types: repositories, ideal types, coincident boundaries and standardized forms. Repositories are indexed piles of objects; ideal types are taxonomies; coincident boundaries are objects with a shared outline but different interiors, like maps for divergent purposes; standardized forms are templates.

Phelps and Reddy (2009) similarly describe the role of boundary objects used in construction projects as being not only informational, but also influential in guiding the group collaboration. For Fleming (1998), the importance of objects in the discussion among designers is that they facilitate a different language, where deictic reference plays a key role.

An important part of boundary objects is their role in mediating communication. Drawing on Austin's (1975) speech act theory, Hisarciklilar and Boujut (2009) describe the design of a boundary approach that attaches annotations to 3D virtual objects, for use in the asynchronous process of disambiguation throughout a design project. Their model includes predefined semantic categories such as proposition, clarification, evaluation, and purpose.

Further on the subject of the role of models in the design process, Pialot et al. (2011) describe a conceptual model for use in the early phases of innovation. Its three components are concept, technology, and potential. They emphasize the importance of dealing with the interactions of these three factors in order to produce a tree structure of possible designs.

Purpose

The purpose of this study was to do preliminary testing of the concept of a physical tool intended to facilitate collaboration between participants in idea-generation and conceptual model building during the process of analyzing the texts of previous conversations of others. We developed and tested three different versions of the physical tool (see Methods, below).

3.1 Research questions

For each form of the tool, we addressed the following research questions.

1. How can a visuospatial modeling kit designed for carrying out an analysis of conversational materials facilitate cooperation, interaction and communication?
2. Does the interaction between people and the model create interesting outcomes in the form of shared understanding, which might be associated with material features of the model?
3. Does the process facilitate individual reflection on the problem at hand?
4. Does the process augment communication of ideas between the people involved?
5. Can the result serve for transmitting the findings in meaningful ways to those not involved in the process?
6. What kind of a common language (both verbal and visual) is established as a shared platform to exchange ideas and to make understanding between the involved parties easier?
7. In what way does the model integrate multiple modes of information representation to facilitate the processes of understanding, communicating, and creating new concepts?

Methods

4.1 Participants

We had 48 participants in a total of 9 workshops. The participants were all graduate students or faculty members in design programs. Their age ranged from mid-20s to mid-50s; male and female genders were roughly equally represented; we had no participants who self-identified as being of alternative genders (i.e. LGBTQ).

4.2 Conversations used for participants to model

We chose 3 different types of conversation in order to see how the complexity of the content influenced the outcomes of the modeling process. The simplest conversation was an email exchange between 2 people about the logistics of setting up a meeting. We used this conversation with the first and simplest version of the model (the pillars). We describe this as the simplest model because it had the fewest affordances.

The second type of conversation was much more complex in terms of both structure and content. It was a transcript of an interview between 2 researchers and 2 participants, so the number of speakers was double the number in the email exchanges. The subject matter was also difficult to interpret, since it ranged widely across topics, with occasional reversions of the discussion to previous topics—a feature we considered important because it reduced the linearity of the conversation. We used this conversation with the remaining 2 increasingly complex models (windows and magnetic panels).

The third type of conversation (i.e. Winner 1989) was a departure in the sense that it was a non-fiction book chapter, written in a relatively conversational style but with only a single speaker (the author). We estimated that the material was as complex in structure and content as the interview transcript, but removed the aspect of having multiple speakers. We used this third text with teams that had the magnetic panels (the model with the most affordances).

4.3 Three different prototypes of the physical tool

We prepared a series of functional prototypes of a tool consisting of a set of separate elements, which could be assembled into large spatial structures. The structures can hold and position in space any kind of information written or sketched by participants during the session. The construction of elements was intended to enable them to configure the object as freely as possible to create an openwork structure. The structural elements and the means of connecting the elements varied with each of the three iterations of the tool.

MODEL 1: PILLARS (1 TEAM OF 2 MEMBERS; 2 THIRD-PARTY REVIEWERS; SIMPLE EMAIL EXCHANGE)

This version of the prototype used thin pillars inserted into square bases. The main element was a post, onto which a small white board was fastened using a magnetic strip. The pillars could be arranged in groups but not connected horizontally. One iteration was made with

foam core (Figure 1), which meant that it could be easily disassembled and flatpacked for transport; the next used wood for added weight and stability, since the foam core version was too easy to accidentally knock and send flying.

The pillars were used by one team to analyse an email exchange among conference organizers, to first determine and then try to communicate the key points in the discussion.

Figure 1. Discussing the 4 main categories of topics and 1 subtopic in an email exchange.

Model 2: Rectangular windows (4 teams of 5 participants each; 4 third-party reviewers)

The rectangular windows provided a larger working surface for posting notes; the windows also came in sets of 4 that were hinged together with a colourful foam frame (Figure 2).

Teams used this model to represent their understanding of an interview transcript taken from a video recording, which they also watched prior to the modeling activity.

Figure 2. Workshop team members discuss their analysis of an interview transcript.

Model 3: Magnetic Panels (4 teams of 5 members each)

The panels are the most flexible solution to date. They consist of clear plastic squares, rectangles, and triangles with magnets inserted around the periphery (Figure 3). Two workshop teams using this version created models of the content of Langdon Winner's book chapter "Do Artifacts Have Politics"; two other teams used it to model the interview transcript previously used with the window frames version.

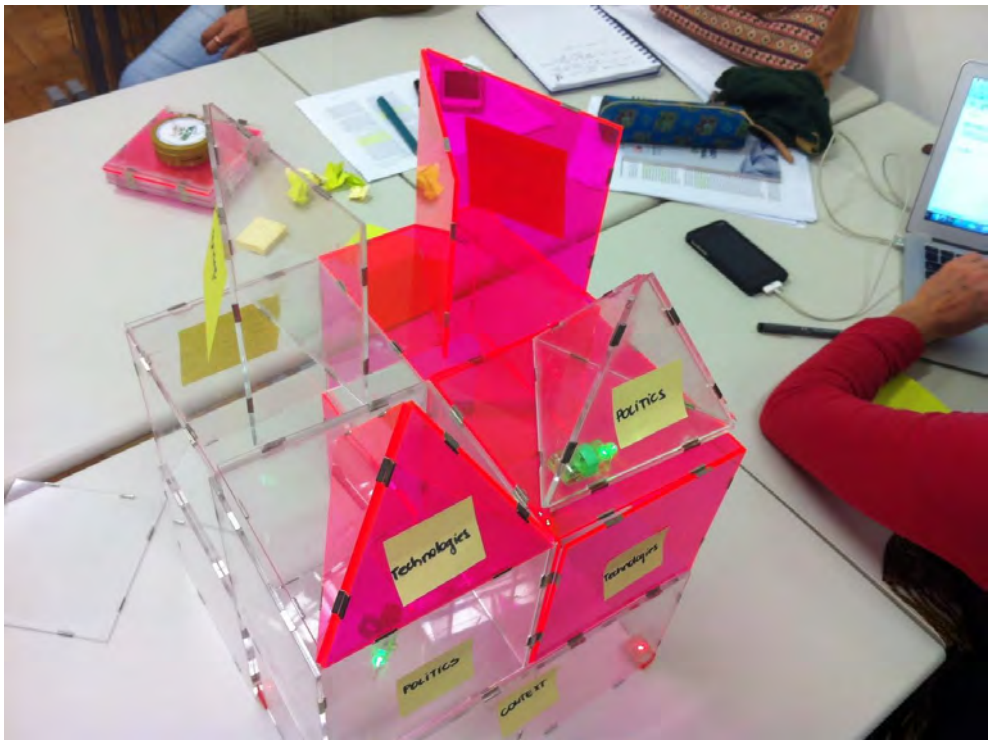

Figure 3. Study participants capture the key points of an academic article. Note the addition of LEDs to highlight specific points.

4.4 Activities

The research was conducted in two main phases, preceded by an introduction. The whole session typically took about 2 hours:

- Introduction (approximately 10 minutes). The researcher explained the activity to the participants: its goals, characteristics etc. The content of the toolkit to be used during the session is introduced.
- Phase I: Activity (90 minutes). The participants take part in the collaborative ideation process intended to build a conceptual model of their object of study, with the help of the provided tool. The time is measured and checkpoints are taken with the teams. After approximately 90 minutes the activity is considered to be finished.
- Phase II: Interview (approximately 20 minutes). The participants in their teams are asked to formulate some opinions about the main advantages and disadvantages of the tool on the basis of Phase I. Free discussion is welcomed with the active involvement of the researchers. Important statements and main points from the discussion are documented by the researcher in the form of written notes.

4.5 Data Collection and Analysis

Each session was videotaped, audio taped, and photographed. These materials were analysed by the researchers reviewing the various media for evidence related to the research questions previously listed. The evidence could take the form of expressions by the participants through speaking or acting. We considered the individual expression as the unit of analysis, rather than attempting to develop any conclusions based on frequency in a qualitative study where n was never intended to be sufficient for statistical analysis.

Results

5.1 Pillars prototype

Participants in this workshop analysed an email exchange, after which a third party who had not been involved in the analysis attempted to interpret the results. The process was carried out twice, with a different person acting as third party each time (both were professors of design). In the first instance, the participants attempted to represent in the model not just the key topics of the email exchange, but also the information about who had written what in the emails. The third-party review of this first model was not successful: that is, the reviewer struggled to understand what the people doing the modeling had understood about the email exchange. In the second version of the model, the focus was entirely on the key topics in the emails, and no attempt was made to keep track of which email writer addressed which topic. The third-party reviewer in this case was immediately able to explain what the analysis of the email exchange had captured.

5.2 Windows prototype

Participants in these 4 workshops analysed an interview transcript, after which a third party attempted to interpret the results. After reviewing the outcomes, we realized that the request to include this communicative element to the exercise had restricted the kinds of models that the teams created: "I need to see where it starts and where it ends: our goal is to show it to someone." In one team, the room itself was used as an element; the model had an intended starting point that was facing the door, so that the third-party reviewer was naturally placed in the right position to begin the process of following the model in order to understand what had been done.

5.3 Magnetic panels prototype

In this version, the most complex models were used, and we eliminated the idea of communication to a third party in order to encourage a more analytically oriented approach by the teams. The combination of these changes resulted in the most complex models we had seen to date; in these versions, the teams had a tendency to emphasize that the models represented simultaneously a variety of viewpoints on the material. This was in contrast to the windows versions, where 3 of the 4 teams had specified a starting point for examining the model, implying that there was one right way of seeing the results of the analysis.

5.4 General Observations

One general result we consider important is that we have come to understand our modeling kit as a kind of language for the creation of boundary objects. As such, it shares some aspects of each of the categories proposed by Star and Griesemer (1989) (repositories, ideal types, coincident boundaries and standardized forms), although it does not fall cleanly into any of them. Instead, it may constitute a new category, perhaps shared in some of their affordances by more generic tools like chalkboards, white boards, and paper. It is a communicational medium, but one with a collaborative aspect. That said, it can be used to create models not only for mediation but also for transmission. We observed from the workshops with the pillars and windows that models intended to transmit the results of an analysis may differ from the models created mainly for collaborative thinking.

We were also able to observe the facilitating function of creating local language between participants (deictic reference) in all of the workshops, with growing frequency as the affordances of the toolkit allowed participants to make the structures more expressive and less dependent on prior conventions.

5.5 Research Questions

We now turn our attention to how our analysis of the workshops provided insights into the list of research questions.

1. How can a visuospatial modeling kit designed for carrying out an analysis of conversational materials facilitate cooperation, interaction and communication?

The task of joint construction of the model creates a specific social situation. For our participants, it was a new experience to be engaged in that kind of activity. At the beginning of a session the novelty brings about a distant attitude because it is a quite unusual situation – not like ordinary conversation, with strong associations with children' playing, for example with blocks, but then, a moment later, the curiosity overcomes the fear and people became involved in the construction of the model. Participants pointed out that in general the activity was enjoyable, free, and creative. They referred to the notion of improvisation, as the method to obtain unexpected results from the thinking process. They found, as the main advantages of the activity, the possibility of fast visualization of concepts, showing in meaningful and clear ways the connections and hierarchies. They were speaking about the enrichment of the discussion through creating the spatial context for thoughts and their visual equivalents, which enabled us to easily refer to previous threads. They also noted that the elements of the tool were quite effortless to operate, although at each stage these comments were combined with suggestions for subsequent improvements, which we made.

2. Does the interaction between people and the model create interesting outcomes in the form of shared understanding, which might be associated with material features of the model?

   The material aspects of the model are crucial to the entire process. The new possibilities and constraints of three-dimensional real construction influence the process of interpretation. For example the construction, to be stable, must be balanced. So a specific idea already placed in the structure needs to be "balanced" by another in the structure to make the construction more "reliable".

   In some cases, where the model resulted in conflicting ideas being placed on facing panels, it became clear that anyone looking at the model would need to engage their kinesthetic intelligence by looking first one way, then another, in order to see the two perspectives. Having moved their heads will help them internalize the idea that the two perspectives are opposed—it may also help them remember the moment. Finally, because of the structural bias towards symmetry, or at least balance of some sort, participants can see conversations that do not readily lend themselves to this kind of balanced representation as being possibly somehow deficient.

   Another example involved the participants lifting up the whole structure in order to place a concept at the bottom. The new concept became more memorable by associating it with this particular activity. We called this type of action around the model "meaningful gestures."

3. Does the process facilitate individual reflection on the problem at hand?

   The purpose of this question was to remind us to watch for the extent to which the collaborative nature of the toolkit might produce "groupthink," where individual perspectives were drowned out in the need to create a common structure. We observed in this respect the usual group dynamics, where a leader might emerge

who either had an idea or else wanted to create a consensus, but we also observed instances where the group developed a shared conviction in the need for creating a structure that recognized multiple perspectives.

One group of participants, in fact, working with the most complex conversation (the transcript), using the most complex model (the magnetic panels) created a structure that not only modeled the viewpoints of the people in the interview transcript, but also modeled the viewpoints of the study participants, resulting in a complex understanding of the permutations of interpretation, where each participant might have a different idea, not about a central consensus of understanding, but instead about the viewpoint of each speaker. One participant explained that it started when someone held a pair of cubes up to their face as though they were eyeglasses, saying that each of them could use the model to see the content from a different lens.

4. Does the process augment communication of ideas between the people involved?

   The quality of communication mediated by the model is different than in an ordinary conversation. It is more ordered, structured, self-reflecting. Every time the session is conducted there must be a certain agreement about the "rules of the game", the meaning of elements, the ways of expressing ideas. Every time people are involved in creating a model, they become more aware of the ambiguity of the language we are using in everyday life.

   Within the teams, we observed that the models were often used by the participants as physical demonstrations of ideas: "these are barriers, but they are also open".

5. Can the result serve for transmitting the findings in meaningful ways to those not involved in the process?

   We need to differentiate, however, between augmenting communication among the analysis team and supporting communication of the results of the analysis. The new possibilities and constraints of three dimensional real construction do influence the process of idea-generation, but much of the thinking process is still not readily apparent in the final object. By including labels and even text snippets on the various components, participants did attempt to provide third parties with enough information to make the models understandable. However, in most instances it was also necessary to provide a quick précis of what the structure was intended to show and what was learned, using the models as a reference during the conversations.

   In the sessions where participants were explicitly asked to create a model that could be understood by an uninformed third party, it became clear that the need for subsequent communication interfered with the primary task of analyzing content. One team, in an extreme case, carried out their analysis on the white board, then built a model that attempted to communicate the conclusions. This model was noticeably simpler than those typically produced by other teams.

6. What kind of a common language (both verbal and visual) is established as a shared platform to exchange ideas and to make understanding between the involved parties easier?

If we think of the toolkit as a language for developing boundary objects, this research question is actually asking what kind of objects the participants created. Perhaps not surprisingly, many of the aspects of the models created drew on previous forms of mediation, such as texts and drawings.

After the first 2 workshops, we also developed a protocol for the use of the kit, which we thought would allow participants to get more quickly up to speed on carrying out the analytical tasks. Instead, none of the subsequent workshop teams adopted the suggested protocol, preferring instead to develop their own emergent language for what it means, for example, to stack elements, set them beside each other, leave them open or closed, use colour or lights, and so on. Because the model is physical, some of these emergent conventions were not necessarily fully verbalized by the team, but are communicated instead by demonstrating the idea. We also saw evidence of the kinds of visual representations that are used in diagrams: boxes and arrows, different thicknesses of lines, little figures of people, and so on.

7. In what way does the model integrate multiple modes of information representation to facilitate the processes of understanding, memorizing, communicating, and creating new concepts?

   Somewhat surprisingly, the model does not seem to encourage a high degree of expressivity in terms of text and drawing. We had originally anticipated that the model would fade into the background to a certain extent, like a white board or chalkboard, where the medium is not making a significant contribution to the content of the discussion. This was true for the first 2 prototypes, before the tool became complex enough in its own right to allow participants to create structures that had meaning beyond grouping.

   However, as the structural opportunities increased, they became of central interest to the teams, so that explanations of the analyses for the final workshops tended to rely more heavily on the shapes of the models and what those meant.

Conclusions

Although much work remains to be done (see below), the results to this point have been encouraging. As we increased the complexity of the models, they became more useful in acting as boundary objects that the participants could use to discuss their sometimes conflicting ideas and opinions, both at the level of the analysis and also in terms of the meta-discussion of what it means to be doing an analysis.

We have found that participants are interested in increasingly complex 3D models that provide a wide range of expressive affordances such as shape, color, and light. The physical nature of the task activates additional forms of intelligence (spatial and kinesthetic); the collaborative aspect does not seem to overwhelm individual thinking, but instead appears to suggest that multiple interpretations should be accommodated.

A further, non-trivial aspect of the models is that they are fun to use, which results in a higher level of engagement than in simply verbal conversation; we observed this in all the

workshops, where participants who were reluctant at first and had been quiet until the point of working with the model were lively and noisy before long.

Our results suggest that this kind of system is useful for these types of facilitation, and that it is possible to modify the affordances of the system to increase its power. Further, we observed that such models result in a tendency for participants to recognize multiple perspectives in the material, and to express the understanding that divergent valid interpretations are possible. This serendipitous finding appears to be emergent from the nature of working with other people on a 3D analytical model; it also aligns nicely with one of our larger programs of research, which is to find how design can reduce the human tendency to find and defend a single perspective, to the exclusion of other alternatives.

Further Research

It is important to stress that this study is just a first step in our exploration of the relationship between quality of thinking and representations of the outcomes of thinking processes in the form of 3D conversational models.

A reflection upon the way that students in particular are actively involved in co-creating mutual understanding could be of interest for educators in design and other disciplines. From that point of view the value of the modeling process still needs to be explored, perhaps through a comparative evaluation of a control group that does not have the model and an experimental group that does.

We also need to do further investigation of the introduction of the activity. Since this is a mode of knowledge production not commonly experienced, it is important to decide how much initial instruction needs to be given, and how it should vary based on the composition of the teams, their previous experience with the model, and the nature of the task.

In terms of the morphology of the model, one of the current difficulties is the time and expense involved in fixing magnets around the periphery of the transparent panels. Our next version will replace the magnets with strips of a Velcro-like material, which will bring back the idea of colorful frames, while at the same time expanding the construction affordances. With the magnets, it is only possible to connect the panels in specific ways; using Velcro, participants will be able to attach one panel to another at any point around the periphery.

Finally, we have begun experimenting with techniques that will allow us to capture a virtual representation of the physical model.

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