The Right Fidelity: Representations That Speed Up Innovation Processes

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Introduction

Innovation, by its nature, is a social activity that requires a range of collaborating actors, each having their expertise. At an interpersonal level, it is hard to share knowledge and develop knowledge (Smulders and Bakker, 2012). Boundary objects are objects that have the capability, in teams and organizations, to transfer, translate, and transform knowledge across difficult barriers such as there are between specialists, departments, or disciplinary functions (Carlile, 2002, 2004; Star and Griesemer, 1989). Consider, for example, a planning board: Even when people do not see each other or communicate, they can still decide what they have to do and when and interact. The term "boundary object"proved to be particularly valuable in the context of new product development (NPD) (Bechky, 2003; Bucciarelli, 1994; Carlile, 2002, 2004; Cook and Brown, 1999; Leonard-Barton, 1995; Levina and Vaast, 2005). Boundary objects for NPD can be sketches, engineering drawings, models, abstract notions, timelines, charts, spreadsheets, and so on.

Lately, there has been much interest in the notion of boundary objects. Despite the scholarly interest, there are many unanswered questions about boundary objects. What objects may become boundary objects? Why, and when? How can these objects be improved in terms of their boundary-spanning capabilities? How can boundary objects be developed and managed explicitly? The current state of the knowledge leaves practitioners and managers in NPD teams empty-handed when it comes to developing effective boundary objects.

The specific kinds of objects we are interested in are representations of the product or service an NPD team is developing. These enable specialists to learn about what they are developing together. In a six-year participatory study of NPD teams in the wild, these representations were omnipresent, ranging from text documents, such as requirements and business cases, to integrated prototypes. The difference between these representations is their fidelity: the degree to which a representation corresponds to the eventual real product. The representations proved to be of particular importance to facilitating collaboration in the teams we studied (see Figure 1). In this article, we explore these representations to understand and predict which kinds of representations become boundary objects and in what context.

Theory: boundary objects

While developing complex products, specialists create something none of them could conceive beforehand, as these products require too much knowledge to be developed by a single person (Schrage, 1995). However, collaboration is not simple. Each specialist has his or her own practice, made up of his or her occupational and educational background, jargon, tools, models, and the like. In short, specialists have different object worlds (Bucciarelli, 1994). That means specialists will have trouble understanding each other's practices, and boundaries can be observed (Carlile, 2002; Doughtery, 1992) imaginary/felt demarcations between specialists, departments, or disciplinary functional units. Boundaries are known to stifle innovation (e.g., Dougherty, 1992) but also to incite innovation (e.g., Fiol, 1995). Spanning boundaries is crucial for organizations that develop complex products or services—not only to enhance their innovative capabilities, but also to reduce costly errors and iterations as a result of poor cross-disciplinary collaboration. Several mechanisms are known to span these boundaries, such as assigning someone the role of boundary spanner and using tools such as wikis. It has been found that some objects used in teams also have boundary-spanning capabilities.

Figure 1. An emotional discussion alongside sketches of a user interface. The project leader on the left discovered from the sketches that there was disagreement about the functionality of the product. It shows how objects are critical for multidisciplinary collaborative knowledge work.

The term "boundary objects" (Star and Griesemer, 1989) refers to a wide range of artifacts, observable by many actors, that are robust enough to maintain a common identity across the diverse practices, yet are flexible enough to adapt to distinctive practices. Although the name suggests that boundary objects are at the edges of practices, Star and Griesemer (1989) described them differently. Boundary objects "sit amidst" all practices; that is, they are part of the practices of many specialists. For example, an intergrated prototype is designed, built and used by all specialists. So it is part of all their individual practices. Thus, boundary objects should be conceived as nodes in a network, where practices become joint practices.

Carlile (2002, 2004) developed extensive theories to explain why some objects enable boundary spanning. He found that knowledge within NPD teams is structured differently across functions that are dependent on each other. In addition, this knowledge is embedded in practices and cannot be articulated. Carlile identified four categories of boundary objects: repositories, standardized forms or methods, objects/models, and maps. The importance of Carlile's writings is that he showed that there is a relation between the kind of boundary and the kind of object that can be used to span it. Repositories (e.g., specification databases) and standardized forms are good for transferring and translating knowledge across boundaries, but they have limited value in cases where, for instance, contradictory aims exist and knowledge has to be transformed: when something new has to be invented.

Ewenstein and Whyte (2009) studied visual representations in architecture, such as drawings and sketches. They highlight that these representations are characterized by a lack or an incompleteness that precipitates unfolding. In time, the objects change, the meanings shift, and layers of information are added. The drawings serve as boundary objects but are in flux, continuously adapted and never complete. These drawings have an "unfolding ontology" (Knorr Cetina, 2001) and are essentially mutable. This insight opposes the view that boundary objects are relatively stable, a view that is implicit in many publications on the subject.

What is lacking in the literature is insight into the way these boundary objects themselves are expressed. For example, it has been observed that sketches are boundary spanning (Ewenstein and Whyte, 2009; Henderson, 1999), but what kind of sketches? Are they back-of-the-napkin kind of sketches or well-crafted and precise sketches? Do they need to convey beauty and elegance, or does a clumsy sketch also have boundary-spanning capabilities? In this paper, the research question we explore is: What representations have boundary-spanning capabilities, how, why, and when? The focus is on representations of the final product or service in NPD.

Method

This article uses the data and analyses from a larger PhD study conducted from 2006 to 2012 in the Netherlands. The aim of the larger study (Stompff, 2012) was to understand what designers contribute to multidisciplinary teams and organizations. This article uses the same data and shifts the empirical lens from designers to representations used in the design process, to reflect on the boundary-spanning capabilities inherent in some of these representations.

Method and context

The study concerned understanding designing in multidisciplinary teams. There is a large body of literature on design, but design *teams* in the wild are rarely discussed. Similarly, there is an even larger body of literature on innovation, but designers are remarkably absent from these studies (Hobday, Boddington, and Grantham, 2011). A large multinational high-tech company served as the context. The company produces printers, software, and services developed by a research and development (R&D) organization of 2,000+ employees based in nine countries around the world. A topic was chosen that represents multidisciplinary NPD teamwork well: operator recoverable errors (ORE). ORE is concerned with enabling printer users to solve errors such as paper jams. In the company at hand, ORE is known to be a notoriously complex topic that touches on the work of many developers, including mechanical, software, and electrical engineers; product and interaction designers; and quality assurance specialists.

The study was set up according to Deweyan inquiry, a method based on Dewey's pragmatist logic (1938). The study consisted of roughly two stages. First, an analytical stage induced insights from observations in the everyday practice, to understand the constituents and the relations. This theory-building stage was intended to lead to new or revised theories and associated hypotheses. Data gathering for the first stage lasted two years and included 29 interviews, 30 hours of filmed team meetings, and many photos and scans of objects, sketches, models, and so on. In addition, observations by the participating designer were recorded in a journal. Analysis was done in five distinctive studies (triangulation of methods) and together with seven co-researchers who varied across studies (triangulation of evaluators).

The second stage consisted of a range of guided experiments in the same practice to validate or falsify the propositions. Three guided experiments were done in the wild in the company at hand. The data from these stages consist of participatory observations recorded in a journal, plus photos and sketches of objects, sketches, the environment, and the like.

One set of findings from the larger study is the subject of this article and concerns the role of representations in discussions and reflections on activities of specialists within and across their practices (Stompff, 2012; Stompff and Smulders, 2013). These representations seem to provide a platform that serves as common language for the specialists to relate their activities to those of others and in that way facilitate cross-boundary discussions.

Representations as boundary objects

A range of distinctive representations was observed, from simple sketches to beautifully crafted and expressive representations as models. Several of the experiments in the second stage of the study were geared toward developing and using these representations to span boundaries inside the organization at hand. Some of the boundaries that were included in the experiments were known to be problematic in the company, such as between R&D and marketing. The experiments done during the studies showed mixed results: Some were successful, others less so. Consequently, a question arose: What kind of representations can span boundaries and in which situations?

Informed by the methodical principle underlying grounded theory (Glaser and Straus, 2009), we moved back and forth between analyzing and collecting data. While keeping our focus on the research question at hand, we worked inductively to distill ideas for a framework until "theoretical saturation" was obtained (Glaser and Straus, 2009). The framework we looked for needed to combine representations and design situations. We categorized the representations and reflected on their contribution to the social processes in the design situation. A striking observation was that the fidelity of the representations seemed to be highly relevant for the situation and process an NPD team was in.

Findings

The continuous refinement of our findings enabled us to obtain a fine-grained perspective on representations and design situations. Below, we present and describe four categories of representations, with varying fidelity.

Category 1: When every detail counts

The first category concerns representations in which every detail seems to be of importance for the specialists involved. Consider, for example, an integrated prototype or integrated computer-aided design (CAD) model that represents the work of a group of specialists (see Figure 2). Things that could not be observed, such as software code, were explained in depth by the specialists in meetings. The photo of the integrated prototype shows that the team collectively did experiments with the prototype, interacting heavily with it. They took care that all steps for the experiments were done correctly. They closely

Figure 2. On the left (1), a team is meeting and experimenting with an integrated prototype. On the right (2), a team is holding a review behind a computer-aided design station. In both situations, interactions and (sensory) experiences were important for boundary spanning.

scrutinized whatever happened. Discussions, proposals, experiments, and reflections were cross-disciplinary.

Interestingly, the interactions with the object itself seemed of particular value. Or, more precisely, the sensory experiences they had while interacting were also important. The team members took parts in their hands to feel the robustness, sat on their knees to access specific situations, listened to the sound of a motor gearing up, and so on. They felt an internal part being stuck, understood that a motor ran too hot due to the smell of ozone, or heard how something broke down. Consequently, the fidelity of the representations needed to be as high as possible. Any abstraction was considered a nuisance or was mistrusted. Only a detailed prototype allows one to experience the situation at hand in real time. If no prototype was available, a CAD model that depicts the current situation as best as possible was used instead. Category 1 representations, therefore, are not solely abstract boundary objects that represent something; the *interactions* with the object also proved to be meaningful and enabled boundary spanning.

Looking at situations in which a detailed object fulfilled its boundary-spanning contributions, we see the following. In these meetings, specialists were discussing problems that were not well understood, reviewing work that was new to others, or discussing situations where the team members disagreed about whether or not something was a problem, or whether or not a proposal would solve a problem. Often, ambiguity prevailed and team members had different explanations for and interpretations of what they observed. They tried to make sense of the ambiguous situation they found themselves in. The many questions, discussions, and interactions with the object were focused on how to interpret the situation at hand; this lasted until the actors agreed upon what brought them there. Put differently, these situations concern a social process of problem setting and making sense of the situation at hand. Sensemaking is devising plausible explanations of the situation a team faces, retrospectively (Weick, 1995). Once the problem was set, the detailed representations seemed to lose their value as boundary objects in the discourse and objects of other fidelity levels entered the situation, as the next category illustrates.

Category 2: "A little sketch will do"

The second category opposes the first group in almost every conceivable way. This category contains crude sketches or maps, drawn on paper or on the whiteboard—or "cardboard prototypes" that a mechanical engineer made every now and then, as was observed. He made those within a few hours to show, for instance, a cover or subframe. He subsequently invited others to have a look, which sparked animated discussion and new ideas. These models were the three-dimensional equivalent of quick sketches and clearly served as boundary objects.

Actual sketches usually included some words, arrows, or circles to highlight a specific part and typically had very low fidelity. Involved team members were sometimes amazed what the impact of such sketches could be. In an interview, a project leader of a software product explained this quite expressively:

> *We had all these discussions . . . resulting in a project description of at least 60 pages. All specs, all market information, neatly categorized in excel sheets. . .. everything was important, nothing could be skipped. Nobody had a clue what we had to make, what the story was. Then the designer made some nice looking sketches on a Monday afternoon (. . .) and . . . Bang (slams hand on table)! Finally, we had the discussion on what on earth we had to make.*

In Figure 3, one example is shown, including what it evolved into in time. These sketches are so rudimentary that they have hardly any meaning for those not involved in the meeting where they were created, and only make sense for those who were part of the social activity. As an interviewee explained: "You know, in these situations a little sketch will do." For example, the sketched map depicted in Figure 3 has some vertical boxes on the left that have no

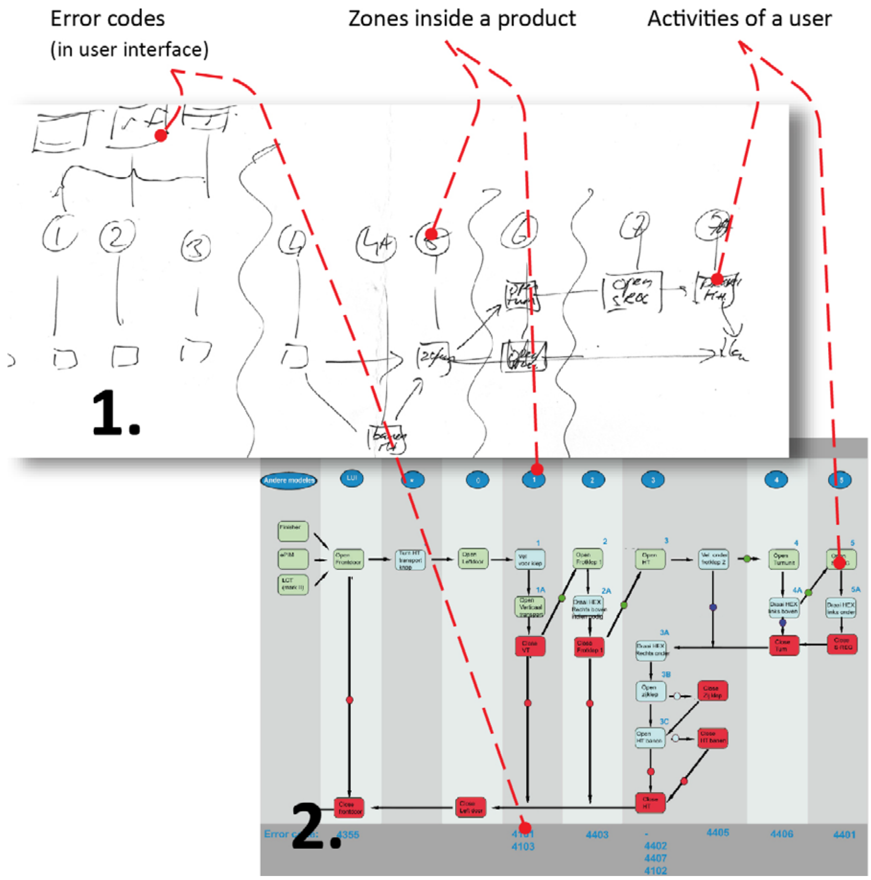

Figure 3. On top (1), a sketch of a map that was used in a multidisciplinary team meeting. It provided the means to swiftly sketch ideas for cross-disciplinary problem solving. The language developed proved fruitful, as the team stuck to these kinds of maps, eventually developing them into a large map (2) that depicted the relations between physical zones inside the product, software code for specific error scenarios, and the user activities.

words in them, whereas the boxes on the right do. The boxes with no text had already been discussed and sketched before, so in this sketch just a hint sufficed for the team members to grasp what was depicted. More information was added later in the meeting, adding another layer of meaning to the sketch. The vertical curly lines were added to group some of the boxes together, which was done at a later time.

These kinds of representations are created quickly in multidisciplinary team meetings when collaboration is ongoing. Say two or more specialists need to develop something together to solve some problem that has impact on both their work. They have to find ways to express to other disciplines what their ideas are and what enables development of and reflection on these ideas. While doing so, they develop a way to express their collective work in a sketchy way and develop a common vocabulary and discourse. It is the essence of designing: to put forward an idea by means of a sketch and to reflect on it (Schön, 1983). In this process, the sketches are changed, thrown away, drawn again, and elaborated on—the same way a designer working alone would be sketching, but now in a multidisciplinary setting. To show this progression, Figure 3 also depicts the final map that evolved from these crude sketches a few months later. It is not hard to recognize the initial sketches in this map, although the map is much more detailed and layered. The map enabled the team to show and reflect on the relations between their activities.

The map developed and matured over time, but it remained open ended until the end of the meeting. The in-between sketches and digitally drawn versions of the map had white spots that still needed to be filled in, areas that were still subject to debate. Put differently, the map was an essentially mutable object that was continuously adapted to new insights and had to be co-created. It was a boundary object par excellence, sitting amidst practices, but not static, as the object came into being while insights progressed. These sketches, with their low fidelity, have an "unfolding ontology" (Knorr Cetina, 2001): The objects are never fully accomplished but rather "continually 'explode' and 'mutate' into something else, and that are as much defined by what they are not (but will, at some point have become) than by what they are" (Knorr Cetina, 2001, p. 182).

As becomes clear from the situational descriptions above, these sketchy boundary objects prove their value mainly when the various specialists are actively involved in a multidisciplinary design process with the aim of identifying solutions to the problem at hand.

Category 3: The essence of an idea

The third category resembles the previous one, as it concerns representations that have low fidelity and can be quite abstract. Consider hand-drawn and computer-drawn sketches that are deliberately stylized or even iconified or three-dimensional models that depict a similar abstraction (see Figure 4) like a mock-up. However, these representations lack the open-ended nature of the previous category. Rather, they represent the essence of the outcome of a team decision after considerable discussion. Despite the similar abstraction and low fidelity, the aim of these representations differs from that of the crude sketches in category 2. Category 3 sketches and models represent the essential idea a team agreed on—and nothing else. A project leader was highly aware of this and commented in an interview:

> *We are still learning what the project is about. We need to have a mock-up as soon as possible, so that we can invite everybody around it, so that everybody knows what we are doing in the first place.*

These representations show the frame for subsequent design and engineering activities, a frame that often needs to be approved by others. The representations depict what everybody agrees on across practices and are very to the point. In a way, these representations are a visual summary of what happened in the meeting. At the same time, these representations leave ample open space for individual specialists to develop their lines of action within their own disciplinary practice. Even though these sketches close a multidisciplinary discussion at the team level, they leave ample open space for individuals to maneuver.

Despite the apparent lack of details and the low fidelity, every detail is meaningful. A lot of information is deliberately omitted, so the remaining details are obviously relevant. For example, the center figure in Figure 4 shows an iconified drawing. Behind the man, there is a clock. There is hardly any information in the drawing, so time is very relevant. These kinds of representations not only summarize, but also attempt to prevent misinterpretations. They serve as boundary objects over time, establishing a jointly constructed frame for future

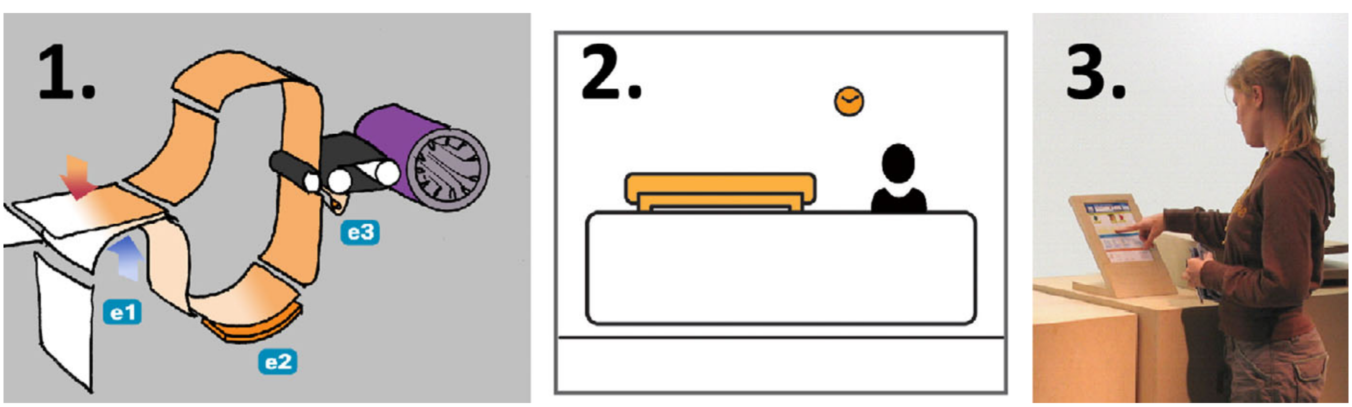

Figure 4. Three examples of representations that were created to summarize the essence of an idea the team agreed on. The one on the left (1) was hand-drawn and stylized later, erasing unnecessary details. In the middle, a highly iconified picture is shown, and on the right (3), a photo is shown that was used to explain what was decided about the position of a user interface.

Figure 5. Three examples of highly stylized representations of possible future products. On the left (1), an idea is demonstrated to have one user interface across a range of products. In the middle (2), a proposal for a new package design is shown, which leverages the brand. On the right, (3) a proposal for a new design language is demonstrated. When these representations were made, none of the products they refer to were planned for.

activities. These sketches come about in a social process that was termed "future framing" (Smulders and Brehmer, 2011), a design process in which the actors aim to develop a satisfactory frame representing the future outcome of their combined work as well as the solution space for their upcoming individual design and engineering activities.

These representations were also used to communicate with others, for example, management stakeholders. By presenting the core of an idea and nothing else, it is clear what had been chosen and what was still open. Category 3 representations have a persuasive force and appeal that ensure commitment. They invite people to participate, as much is left to the imagination. We observed that these representations incite open dialogues and space to explore new aspects. As such, somewhat paradoxically, the representations of this category represent both the end of one discussion and the beginning of another, in separate tracks.

Category 4: Even better than the real thing

The final category concerns extremely well-crafted representations and models that are aesthetically pleasing. Consider photographic renderings of a product, real-life models, scale models that are almost artistic, short movies or animations, and so on (see Figure 5). These representations bring to mind the concept cars that are presented at car shows to show possible future models. Buijs (2012) referred to these concept cars as "projecta's," a way to demonstrate future technological and cultural options. These representations are made with great care and displayed in ways that are deliberately chosen, providing a kind of future reality of how the object should be seen. For example, the lineup of products in Figure 5-1 highlights that the products will share the same user interface, which was considered a unique selling point (USP) for the firm involved. The representations have extremely high fidelity and often look better than the real thing they refer to, namely, the future product.

Just as in the previous category, these visuals and models point toward the future. Here, they represent a very detailed end result of the design and development process.

Category 1	Category 2	Category 3	Category 4
When every detail counts	*A little sketch will do*	*The essence of an idea*	*Even better than the real thing*
High fidelity	Low fidelity	Very low fidelity	High fidelity
No abstraction allowed	Sketchy	Iconic	Carefully crafted and expressive
Preoccupation with failure	Preoccupation with problem solving	Preoccupation with converging	Preoccupation with commitment
Sensemaking	Designing	Future framing	Gaining commitment.

Table 1. Comparing the four categories of representations of the intended product that serve as boundary objects.

These representations serve a different goal than the ones in category 3. Rather than summarizing what has been decided, category 4 representations are aimed at getting commitment from others, such as resources and budget. This category of representations is compelling, clarifying, elegant, coherent, aesthetically pleasing, and thought-provoking—in short, seductive and perhaps even persuasive. All means are employed to ensure that others become convinced something is a good idea. It is not about explaining an idea; it is about ensuring the idea is framed in a particular preferred way. As such, these representations are basically selling ideas to actors outside the team in social processes that aim to persuade actors from other disciplines or within other roles.

Summarizing the findings

We discerned four categories of representations that each have contributions as boundary objects in a dynamic social setting of actors, within and outside of teams. The fidelity of these objects varies across these settings. Consequently, we distilled that the right fidelity of a representation is situationally dependent, and the situation is formed by the involved boundaries and the aim of the social interactions. In Table 1, we present an overview of our findings.

High-fidelity category 1 representations such as integrated prototypes are used inside the team when the team experiences doubt or uncertainty as a result of an unexpected situation. Such events initiate processes in which teams resort to those representations that best show their collective work at that moment in time and that hardly show any abstraction. While assessing the situation, the specialists have a preoccupation with failure, looking for clues that hint at problems or may provide explanations for why something does not work. This is known as setting the problem.

Of interest is that the representations preeminently refer to *past activities*. For example, a prototype represents what all team members did in the past, those past design decisions that brought them to the situation they are in. The social cognitive process can aptly be named a sensemaking process: the "retrospective development of plausible images that rationalize what we are doing" (Weick, Sutcliffe, and Obstfeld, 2005). The boundaries that are spanned are disciplinary boundaries inside the team.

In contrast, category 2 representations such as back-of-the-napkin sketches are used when a problem is well understood and the team is engaging in solving it. The low fidelity of the representations is needed because the team needs to invent, explore, and adapt solutions swiftly, reflect on them, and—if necessary—dismiss them. The representations need to be understood by all and are often abstract and refer to both past activities (e.g., existing parts) and future activities (e.g., new parts that need to be developed). Representations serve as boundary objects among the disciplines, are in flux, and are continuously being adapted to the latest insights and ideas. Layers of information are added. This category of representations is closely related to the findings of Ewenstein and Whyte (2009) and Knorr Cetina (2001) on the unfolding ontology of epistemic objects. These representations are deployed when a team is in the process of developing a solution for a problem, that is, when the team is designing. The boundary that is spanned is disciplinary, just like category 1 representations.

Category 3 representations are suited for processes in which the robustness of possible lines of action is tested. These representations of the intended product summarize and capture the core of the idea and consequently provide an agreed-upon frame for future activities. The process of summarizing is somewhat different from the design process, as the focus shifts from developing solutions to expressing "what we agreed on creating." Of interest is that these representations capture the essence and nothing more; they have what Weick named the "charm of the skeleton" (2004, p. 43). The skeleton of a good idea has a vigor and a charm that is persuasive, so that individuals can commit themselves.

It also leaves sufficient space for individuals to explore solutions and is sufficiently constrained so that everybody knows the generic line of thought. This class of representations embodies a frame for future activities without explicitly spelling out what individuals need to do. We see this social process as future framing (Smulders and Brehmer, 2011), rationalizing current and future activities. The boundaries that are spanned are somewhat different than with the two previous categories. These representations concern spanning boundaries with managers, stakeholders, investors, other organizations, and the like—that is, people who are quintessentially outside the team, and the boundaries are not merely disciplinary but also organizational and political.

Category 4 representations seem to have much overlap with the previous category, as these expressive representations also provide a future frame and are the outcome of a design process. However, the aims for these representations are very different. The persuasive representations are geared toward gaining the commitment of people who are not part of the team, for example, management stakeholders who provide budget and resources or sales and marketing actors or potential future clients. Even though the idea may be premature, it is shown as if it is fully developed so that others can commit themselves. A language is used that is easily grasped by all involved. It is

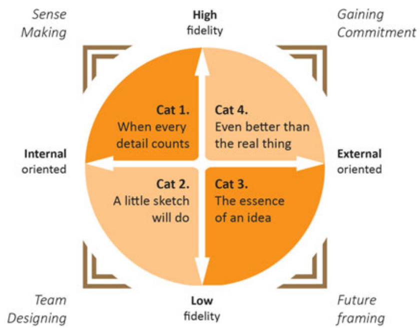

Figure 6. An organizing framework. The vertical axis plots the fidelity of a representation. The horizontal axis depicts whether a representation is preeminently used inside or outside the team. Each of the four categories is related to observed team processes.

harder to explain and reflect on the added value of, for example, a project description of 100 pages, compared to an expressive picture that says it all.

A framework and conclusions

The research question we explored in this article is: What representations have boundary-spanning capabilities, how, and when? We focused on representations of the intended product. Our findings show that boundary objects are a fruitful concept for studying and explaining knowledge work, at least in NPD. What we added to the existing body of literature is that the fidelity of representations that serve as boundary objects is related to the social process a team is in.

We observed that the many representations used throughout multidisciplinary product development have varying fidelity. We categorized these and present a convenient organizing framework (Figure 6). The vertical axis depicts the fidelity of the representation: the degree to which a representation corresponds to the intended final product. The horizontal axis depicts whether a representation is preeminently used within the team, for example, to span boundaries between specialists, or outside the team, for example, to span boundaries with stakeholders or other teams. We projected the four categories onto this map, showing (1) that the fidelity of representations that serve as boundary objects can vary considerably and (2) that this variation can be observed for representations used inside and outside the team. Consequently, there is no silver bullet, no representation category that serves boundary-spanning goals independent of its context.

The process a team is in is an indicator for what kinds of representations are useful to the team members. Consequently, the right fidelity is the appropriate fidelity for the social process a team is in:

- If teams are in doubt, experience ambiguity, or need to review parts or modules they hardly know, they need to make sense of the situation. The team engages in problem setting. The best representations for this process get as close as possible to the eventual product, providing detail that team members can interact with.

- If teams are solving problems (i.e., designing), representations need to have low fidelity and be highly abstract. The key reason for this is that specialists must be able to make swift cross-disciplinary proposals that are continuously improved upon, changed, and reflected on. These representations unfold in time.
- If teams know where they are heading, they need to converge and explain to each other and others what they will do in the future. We call that future framing: constructing a guiding frame for all subsequent activities. Representations need to capture the core of an idea and nothing more. They should be robust enough to maintain a common identity, yet flexible enough to adapt to distinctive specializations.
- If teams need to gain the commitment of others, representations are needed that are compelling, self-explaining, seductive, and even persuasive.

A representation of an intended product does not merely translate a preconceived idea into an appealing visual, but co-shapes what the outcome will be. The message a representation conveys cannot be seen apart from the way it is expressed. Thus, the right fidelity depends on the goals and the process a team is in.

The implication of these findings for practitioners in NPD teams, such as managers, designers, engineers, and so on, is that they first need to become aware of the impact representations can have on team processes. Much attention is given to communication by means of text documents, spreadsheets, planning, and the like. This study demonstrates that other representations are just as important and need to be managed well.

Second, practitioners need awareness of the impact of fidelity of their visuals on these processes. If a problem needs to be solved cross-disciplinarily, flashy renderings of the intended product will not help at all. People who have the skills to produce such flashy visuals need to restrain themselves in order to facilitate team processes and stick to rapidly drawn sketches with a low fidelity. The other way around, back-of-the-napkin sketches that make sense to the team members involved may look incomprehensible, awkward, and unprofessional to outsiders, such as managers or other stakeholders. It will pay off to condense the results into one appealing visual that captures the essence.

Third, representations only have value if they can be observed by others. Sensemaking and design processes come to a standstill when representations are not shared among all involved. Consequently, practitioners must have an inclination to share their ideas visually and to share these, even if these are drawn clumsily or are representing half-baked ideas.

To conclude, in literature on innovation processes, representations are often overlooked. Instead, communication, planning, and formal processes get considerable attention. Scholars such as Carlile (2002) drew attention to the boundary-spanning capabilities of objects and representations. The contribution of this article is that it shows that the fidelity of representations constitutes team processes. There is a right fidelity for the representations for different processes and boundaries.

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