Framing innovation: negotiating shared frames during early design phases

Jonathan H.G. Hey*

University of California,
Berkeley Institute of Design,
281 Hearst Memorial Mining Building #1764,
Berkeley, CA 94720-1764, USA
E-mail: jono@berkeley.edu
*Corresponding author

Caneel K. Joyce and Sara L. Beckman

University of California,
Haas School of Business,
545 Student Services #1900,
Berkeley, CA 94720-1900, USA
E-mail: joyce@haas.berkeley.edu
E-mail: beckman@haas.berkeley.edu

Abstract: Members of newly formed design teams have different *frames* – implicit values, goals and assumptions – each of them hold about what problems are important and how they are best addressed. In the early, informal phases of design projects, these frames, and the degree to which they are shared within the team, have substantial consequences. However, little is known about the interactions and activities that reveal frames and support frame sharing in teams. Our study follows 22 newly-formed multi-disciplinary teams through the early phases of the design process in a New Product Development course. We used a mixed method, interdisciplinary approach to understand the dynamic process through which design frames are socially negotiated and shared. We identified core framing activities of design teams and propose a framing cycle of pseudo-frame setting, making individuals' frames explicit, making frame conflicts salient, and building a common frame.

Keywords: design team; early phases; framing; innovation; user-centred.

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Bibliographical notes: Jonathan Hey is a Doctoral Student in Design Theory at UC Berkeley. He holds a Masters degree in Innovation and Engineering Design from the University of Bath, UK. He is fascinated by framing in new product development and how designers learn to understand people and behaviour to ultimately make the world a better place. He has spent time in innovation consulting at both Jump Associates in the US, and at CREAX in Belgium and India. He is also an avid underwater hockey player.

Caneel Joyce is a Doctoral Student of Organisational Behaviour at the Haas School of Business, University of California, Berkeley. Her dissertation focuses on the effects of constraint on creative processes, outcomes and cognition, asking "When do freedom and choice limit creativity?" Her background in the arts informs her research which looks at how people form judgements and make decisions about how to solve problems using new ideas. Her current empirical and experimental work focuses on the role of leaders in innovation and design, and the effects of constraint on idea generation and idea selection. She assists in teaching leadership, negotiations and creativity to MBAs, and has consulted for the high-tech and entertainment industries.

Sara Beckman has taught New Product Development and Operations Management at the University of California's Haas School of Business since 1987. She developed, institutionalised and directed the School's Management of Technology Programme, initiated new courses on design, entrepreneurship in biotechnology, new product development, and work and workspace design, won four awards from MBA students for excellence in teaching, and received the Berkeley campus Distinguished Teaching Award. She has also taught for the Stanford University's Department of Industrial Engineering and Engineering Management, and been a visiting faculty member at MIT during 1994 and 1999, where she taught in the Leaders for Manufacturing (LFM) Programme. Her present research interests lie in the general area of innovation management with specific explorations of the role of design in business, environmental supply management and development of operations strategy.

1 Introduction

The innovation process, and more specifically the New Product Development (NPD) process, is well understood as a series of divergence–convergence cycles through which the members of the innovation team iterate to arrive at a final result (Boehm, 1988; Ulrich and Eppinger, 2005). The earliest stages of the process, or those in the fuzzy front end, require the widest divergence as the teams gather information to make decisions about business objectives, technologies, target markets, capabilities development and general product or service features. Lack of complete information for making many of these decisions creates both uncertainty and ambiguity for the team (Eisenhardt and Tabrizi, 1995; Iansiti, 1995), yet the decisions made have a large effect on project outcomes (Cooper, 1998).

Responsibility for executing the fuzzy front end is typically given to a multi-disciplinary team that provides the diversity necessary for thoughtful group decision-making (Tetlock et al., 1992), and creativity (Chatman et al., 1998; Nemeth et al., 2004). Teams drawing from a range of disciplines – engineering, industrial design, marketing and operations – ensure a diversity of perspectives, languages, bodies of knowledge, values and goals. This diverse team executes fuzzy front end activities through a process of argumentation and discussion to decide what form the project should take, what audience or user group it should target, its hierarchy of objectives and goals, and the means to achieve them.

In general, however, much of the research on fuzzy front end activities (e.g. Khurana and Rosenthal, 1997; Bhattacharya, Krishnan and Mahajan, 1998) is normative and assumes highly rational team practices. It identifies optimal design processes and tools,

but does little to address cognitive and social limitations on the adoption and effectiveness of the tools. This paper starts to address that gap by leveraging theory and findings from organisational behaviour and social psychology that focus on understanding non-rational processes of judgment and decision-making in groups (e.g. Janis, 1982; Kahneman and Tversky, 1984; Kerr and Tindale, 2004).

Specifically, we use the theoretical notion of framing to study the fuzzy front end of the innovation process. Through an in-depth examination comparing the early stages of design in 22 teams, we develop a model for understanding how the frames individuals hold are brought together through social interactions to create a shared frame. Our findings emphasise the conflict inherent in successfully negotiating shared frames, and the importance of raw user data in generating productive conflict.

1.1 Defining frames

Each member of a team arrives at the early phases of design with his or her own set of assumptions, or *frame*, that guides his or her interpretations and actions. While there are few precise definitions (Stumpf and McDonnell, 2002), frames are 'underlying structures of belief, perception and appreciation' (Schön, 1994), comprised of implicit assumptions about what issues are relevant, what values and goals are important, and what criteria can be used to evaluate success. Designers' frames work in concert with their professional knowledge to influence the decisions they make and the actions they take (Schön, 1983). Frames form the basis upon which the designers pair problems with solutions (Schön, 1983; Valkenburg and Dorst, 1998; Dorst and Cross, 2001): the selection (or assumption) of a desired end state or goal implicitly includes the identification of a problem or need and conversely, the identification of a problem or need implies some desired end state or goal.

Because most definitions emphasise the tacit 'underlying' nature of frames, studying frames and their evolution is a challenge. We propose an operational definition that allows frames to be identified and tracked throughout the design process including the following constituents:

1 a desired end state or goal

2 relative importance and relevance of features (prioritisation of designers' attentions)

3 boundaries to the design situation (problem scope, solution scope, resource constraints)

4 criteria for evaluation (of new information, features and possible solution concepts).

1.2 Distinguishing individual and team frames

Frames are cognitive and thus are held implicitly by individuals. Even though they are not readily observable by others, frames can be more or less *shared* as a team frame to the extent to which the individual members' frames overlap or align. Because frames are shaped by an individual's unique combination of prior experiences and cultural backgrounds, divergence between members' frames may be greatest in interdisciplinary teams, where diverse backgrounds result in conflicting sets of goals, assumptions and attentional foci.

Prior studies of framing within design teams have employed a range of analytical methods, although no single method has been able to reliably tease apart individual frames from team frames, or to examine the differences between individual members' frames. Stumpf (2001) studied how design teams negotiate before settling upon a shared frame. Team transcripts, coded for argumentation, reliably identified broad frame shifts throughout the early conceptual stages of design. However, the authors speak to the difficulty of identifying different 'levels of frames' – frames at different levels of abstraction – between members using this methodology. Rather than using a rigorous coding scheme, Schön (1984) used a form of narrative analysis to analyse the contrasting frames a student designer and his mentor brought to a design review and how they interacted to produce the final design. However, it is difficult to extrapolate these dyadic findings to the team-level.

Our study aims to better understand how individual frames diverge from one another, while maintaining the distinction between individual and team frames. To do so, we examine a collection of 22 NPD project teams as they execute design activities, framing and reframing over time. Our comparative, multi-method perspective provides rich data for rigorous theory development, enabling us to observe team-level framing processes while understanding fine-grained differences between individuals' frames.

1.3 Negotiating shared frames

The notion of negotiating shared frames helps to resolve a conundrum in the literature on team performance. While diversity in teams has been shown to have costs such a conflict, inefficiency and failure to share non-redundant knowledge, it also has benefits including creativity, complex thought and thoughtful decision-making (Stasser and Titus, 1985; Nemeth, 1986; Ancona and Caldwell, 1992; Dougherty, 1992; Chatman et al., 1998; Reagans and Zuckerman, 2001). This dichotomy is most informative when applied to the dimensions of diversity that remain stable over time (e.g. race, gender and age). However others, like frames, change over time via social interaction. To understand the effects of these deeper dimensions of diversity, research uses a framework of temporal dynamics.

For example, empirical evidence suggests that the more time an individual spends defining and framing a problem, the 'better he/she was able to achieve a creative result' (Christiaans, 1992). More broadly for NPD, Song, Dong and Agogino (2003) show that successful teams cycle through periods of high and low shared understanding towards high shared understanding in the later stages of product development. In management, top performing teams exhibit high cognitive diversity (in terms of their interpretations of a project) early in the project, but later converge on a common understanding (Kilduff, Angelmar and Mehra, 2000). This undulating pattern of shared and unshared understanding may reflect the development of a common frame. It seems that early conflict between individual frames does not prevent, but rather *enables* the negotiation of shared frames, as long as the conflicts are made explicit.

Like the documents analysed in these studies, mission statements and project proposals represent thin slices of time in a team's life-cycle. However, the prior creation of team design documents alone does not necessarily guarantee that all team members subsequently share a common frame, rather, each member's frame evolves as the project progresses, so mission statements and other explicit artefacts formulated by the team at the onset of a project may grow increasingly inaccurate relative to the members' current understanding about the situation, unless regularly updated. Because individual members'

frames are implicit, constantly evolving and often diverging from each other, reaching a common frame is challenging, and may never be achieved.

Even though the negotiation of a shared frame is vital to the outcomes of team design processes (Whelton, 2004), little is known about the activities involved in the negotiation of shared frames. From this theoretical motivation, we ask:

1 What activities support the negotiation of shared frames during the informal early phases of design?

2 What recommendations can be made to designers about identifying and addressing problems in coming to shared frames?

The paper proceeds as follows. First, we describe the research setting and the rich range of qualitative data required to reliably study the implicit processes such as framing. Secondly, we present our findings and a model of the framing cycle resulting from the present research. Finally, we discuss the contribution of our research and present the practical implications for designers.

2 Research setting and methods

Data for this paper were gathered from a graduate class at the University of California at Berkeley that focuses on teaching students the innovation process through the lens of user-centred design. Material covered in the class broadly follows the textbook *Product Design and Development* (Ulrich and Eppinger, 2005) supplemented by readings and lectures on user-focused design and ethnographic research methods. The students also 'learn by doing' through a team project – with project areas such as: more blood donors; reducing obesity in the young and healthy meals for schools – that spans the 15-week semester. Each team is interdisciplinary with some mix of business, engineering (mechanical, electrical, chemical and industrial), information management and industrial design (California College of the Arts) students. Each team is coached by the three course faculty members as well as by a local design professional and evaluated at the end of the semester on how well they have undertaken the process as well as on their final prototype. Faculty and judges from well-known product development and design firms do the evaluation.

Two researchers and research assistants collected data throughout the semester. Three faculty members, with a combined experience of teaching the class of over 30 years, validated our interpretations regarding team performance and provide additional insights. We collected a wide variety of data including:

- *Initial project proposals*. We captured both the written project proposal from each student as well as a videotape of his or her presentation of that proposal to the class. This provides us with the first description of each project, and thus a base from which to measure its adaptation over time.
- *Short free-response survey*. Several weeks into the semester, we asked in a voluntary free-response survey for students to tell us the goals of their projects, the strongest points of consensus on their team about its mission, the most significant issues about which the team members were not in agreement, and how they thought their team's mission statement had changed in the past week.

- *Observations of in-class team meetings*. We observed and took notes on six in-class sessions in which teams were working on their projects alone as well as with faculty coaches.
- *Interviews and observation of meetings outside class*. One researcher met with each design team to observe and audiotape the meeting for between 30 and 150 minutes. Near the end of the meeting, we conducted a short structured interview of approximately 25 minutes to gather inputs about the customer research performed, mission statement development, challenges they faced or imagined facing on the project, the number of times they had met to date, and the amount of work they had been able to contribute to the project. For each observation, we have field notes and transcriptions of the audiotapes.
- *Informal interviews with class instructors*. We met regularly with class instructors to collect their thoughts on how well the teams were doing, and their thoughts on team dynamics.
- *Mid-semester team evaluation*. Halfway through the project, we asked students to complete a comprehensive survey about their team's performance and the performance of each of the individuals on the team. In that survey, we asked for free-response answers to these questions:
    a What was important to you and your team in terms of evaluating new ideas and making decisions about the direction of your project?
    b Please describe briefly what you learned about the NPD process and working on a cross-disciplinary team during this assignment.
    c Please write a brief description of any problems or conflicts you encountered in working with your team and how they were resolved.
    d Please provide any thoughts on the product development tools provided to you in lectures and how useful/not useful they proved for your project.
    e If there is anything else you would like to communicate to the faculty or anonymously to your team you may write it here.
- These free-response questions provided an opportunity for team members who were less likely to speak out during the collective team interviews to provide their opinions.
- *Design documents produced and exchanged by the teams*. We accessed the design documents produced and shared within the teams as well as the class deliverables. These documents, together with an early stage presentation to their peers, provided a public viewpoint of the teams' understandings of their projects.

Even with this multitude of data, finding framing is challenging: frames are cognitive, often implicit, and reside in the minds of individuals. For teams to negotiate a shared frame, an individual's frame must be shared explicitly or otherwise suggested through interactions and behaviours. Furthermore, it is possible for a team to ignore the frame of an individual member and continue its activities without that member's buy-in to the project direction.

Thus in our observations, we looked for activities and interactions that either:

1 revealed an individual's implicit frame to others

2 made discrepancies between individuals' frames visible or salient, or

3 engaged the team in explicitly negotiating among individual frames and constructing a shared frame.

Each of these activities concerned a change in one or more of the key frame constituents: overall goals, selection of important or unimportant features, setting boundaries to the situation and selecting, though often unconsciously, evaluation criteria.

Through our observations, we identified several key frame-setting activities:

1 writing a project proposal or problem statement
   - for example, decomposing the situation by time, key phases or types of users

2 developing a mission statement, both collectively and individually, including:
   - product description
   - goals
   - stakeholders and selection of primary and secondary markets
   - assumptions/constraints
   - defining relevant terms and concepts within a team

3 selection of research areas
   - which types of users to interview
   - choice of interview content – what questions to ask
   - choice of competitive products or services
   - criteria for evaluation of competitive products or services

4 digestion and analysis of user data
   - selecting categories or clusters for user needs and interview data
   - developing 2×2 matrices
   - developing consistent naming for needs
   - what is dismissed or selected for attention

5 setting categories in ideation and brainstorming.

Each of these activities and decisions were framing activities in themselves. Section 3 provides examples of each framing activity drawn from the teams and projects studied.

3 Findings

3.1 Project proposal rescoping

Both teams starting with solution-focused proposals and those with project champions often engaged in reframing, but with different levels of encouragement and difficulty. The team working on 'Child Floating Clothing' – a suit that would protect children in the event of falling into a pool – smoothly morphed into 'Child Swimming Pool Safety' as the team explored other solutions, such as fences around pools, to fulfil the need set forth in the initial proposal. They returned to a wearable device after exploring the wider set of options. On the other hand, the 'website for connecting grads' project launched with a proposal to create a website to connect graduate students across the campus. With the instructor's pressure, team members grudgingly stepped back and broadened their scope, but only briefly:

> "Is it ok to go back and say we're not doing a site? It's what we started with."

Stepping back, particularly for the team member who proposes the project, requires a change of frame. While other members of the team may not enter the project with strong ideas about a particular solution, the person proposing the project often does. These project champions engage in reframing as a result of discussion with other team members, collection of research data or, intervention by faculty or design coaches.

3.2 Mission statement – process rather than artefact

The process of creating and iterating the mission statement provided value to all design teams. As two team members suggest, the iteration process was more beneficial than the artefact itself:

> "To resolve a discussion we never said 'let's check the mission statement'. It was something that, after the discussion, we just kind of kept the core project goals in mind. The core concept kept us on track."

> "I feel I viscerally know what our mission is and don't need to refer to it, and that we all agree. But we do need to revise it."

Discussion of the goals of the project elicits team member opinions about those goals thus revealing their frames. When team members take the time to discuss and select a shared goal, they adapt their frames accordingly, creating a common reference for both discussion and evaluation of possible project directions.

However, even with a semi-formal agreement within the team, it was not always clear to all members what decision had been made and whether all team members fully bought into the new frame:

> "Did we agree that we're going to focus on [x]"

> "Yeah"

> "We're on the same page."

> "What page?"

And:

> "We had a really hard time deciding on an area to focus on. We had a lot of discussion and as a group we thought we had reached a decision and then one member decided that we should change the focus the next day. The rest of the group basically went along with the idea since we needed to move on."

And:

> "Concept idea convergence is difficult, especially when the overall mission & goals are not well defined or fully accepted by all the team members."
>
> "One member of the team doesn't seem to 'get it', meaning the purpose and emerging design of our product."

In these examples, some members of the teams reframed their project goals, while others had yet to do so. The differences in individual frames clearly caused confusion as to how to proceed. In some cases, it was possible for teams to agree to disagree and come to a shared frame by seeing one another's perspective:

> "In at least one case we had all but one person of the team agreeing on something. Although the last person did not agree, he understood where other people were coming from and we tried to understand his viewpoint. Eventually we had to settle on the majority, but he was very graceful about working with the team even though he obviously felt strongly about his idea."

Strong and open communication facilitated this result. In other groups, lack of a shared frame resulted in tensions and conflicting ideas without an effort to 'see where they were coming from.'

Mission statements that were written at a high enough level of abstraction served as guiding visions for the teams, and required less iteration throughout the project. The 'Healthy Meals for Schools' team, for example, started with each member writing his or her own statement and found that they were remarkably similar and forged a joint statement that remained the same throughout the project. The team attributed this coherence to the mission acting more like a guiding vision that reflected the team's values of providing a socially responsible solution.

As in this case, when the overall project vision was clear, conflict regarding the direction of the project shifted to a lower level of abstraction (e.g. choosing categories of solutions, selecting means of achieving the team's goal). Having a strongly shared higher-level goal that coincides with team members' core values provides clear criteria to evaluate decisions and suggestions. Shared 'higher level' mission statements also resulted in, as an instructor put it, 'less mission statement churn'. There was less iteration seen in the mission statements than in the past years when initial mission statements were narrower. This exemplifies the difficulty, highlighted by Stumpf and McDonnell (2002), of identifying 'levels of frames'. In this case, the team shared the same high level frame as defined by their shared values, yet differed on more pragmatic aspects of the project.

Discussion of the subtle meanings and nuances of individual words or phrases in the mission statement surfaced information about individual frames. Through the discussion of keywords and goals, team members expressed their opinions and shared their values revealing individual differences in understanding and interpretation. These 'defining' activities were revealed when even apparently simple terms were put up for definition:

> "Can you define 'to be interested'?"
>
> "We have to be careful what we mean."

> "Our terms were so vague and so broad that we kind of forgot what they meant."

> "That term 'appeal' is bothering me. Is it bothering anyone else?"

> "Let's make sure we're all on board with the last one."

Teams that do not take the time to ensure similar interpretations for words risk a false sense of shared frame. On the surface, they appear to have buy-in from all members, but deeper probing reveals differences in interpretation from member to member. In these cases, unstated assumptions and ideas influence team member decisions and actions throughout the early stages of the project, but the reasoning behind their actions is unclear to other team members.

> "The project focus came out of 'language learning' and it became clear that we all had different conceptions of 'language learning'."

Discussions of the mission statement sometimes reveal member's implicit assumptions about the possible directions of their project:

> "Usability and eco-friendliness are not necessarily in line with each other".

In this example, one team member saw the two factors as somewhat conflicting. Statements like these both reveal the frame of the speaker and subtly influence the frames of team members. While the statement may provoke open discussion of differing opinions, it may also lead others to adopt the speaker's frame without questioning it.

Iteration of the mission statement occurs naturally in the early phases of NPD. To some students:

> "Sometimes it seems like the product development is driving the mission statement, rather than the other way around."

> "So maybe we need to revise our mission statement based on what we want to do? We need version 3.0."

> "We were having trouble refocusing our mission statement since some of us felt we did not have a perfect understanding of the problem. We interviewed more people and as we got more data, we were able to find trends and patterns that allowed us to focus."

A student on the 'Child Swimming Pool Safety' team highlighted the conceptual difficulty of the paradox of a mission statement driving product development, in turn driving your mission statement:

> "There are already a lot of good products on the market (fences, pool covers…) that prevent children from drowning. We could choose a product that the child has to wear but [then] it is not prevention anymore."

A student on the broadly-scoped 'improving the supermarket experience' team explained how they viewed the concurrent evolution of their mission statement with their evolving understanding of their project:

> "We have been cycling through broad missions to more refined missions and then back out again."

3.3 Frames drive research

The initial frames that the members hold for their project strongly influence the research directions they choose. Discussion of what types of primary and secondary market research to do provided a useful forum for members to share project frames. Several teams chose research directions that coincided with their initial views and assumptions about the likely direction of the project. A member of the 'More Blood Donors' team – a team formed to increase the numbers of first-time and returning blood donors – explained:

> "We all had in mind some kind of solution based around a needle or a chair."

Similarly, a member of the 'Childhood Poisoning' team – addressing the issue of reducing the number of kids poisoned by ingesting toxic household substances – told us:

> "Research moved us towards childhood poisoning risks in the home because it was a much larger issue and something that we thought we could actually improve."

> "We all came into the project thinking it was going to be about making locks on cupboards."

Eventually, both teams learned that their initial assumptions were not correct – the actual process of giving blood was not what was hindering donors, and physical access to cupboards was not the key issue in childhood poisoning. Teams also made early assumptions and judgments about feasibility, even in the face of uncertain information. By explicity seeking "a problem we could readily address", or "something we could actually improve" reveals the application of assumptions about what is possible and likely.

Conducting and learning from initial research is difficult when the initial frame is too broad. A member of the 'Safer Stove' team – which sought to improve safety of household ovens for the blind, the elderly and the disabled – commented:

> "I have realized that we have to be much more specific in defining the problem and demographic. I shied away from this at first, not wanting to miss some issue that might present itself during an ethnography that covered a broad scope, but I have come to understand that due to time constraints we need to be more focused."

As team members argued about the breadth and depth of the research they should conduct, their individual frames were revealed. Some members wanted to stay open to the needs from a wide range of target markets, while others were anxious to converge on a single target market. The team struggled for some time before focusing on a single user group, but then it was able to make headway as they had surfaced differing frames. Other teams did not engage in as much research, and thus did not learn about one another's frames:

> "I think that we haven't explored things enough to really have large disagreements."

3.4 Digestion and analysis of user data

The presentation of user research itself provides clues to the team members' frames as individuals distil and prioritise what they share. Team members select what they believe

to be important to the rest of the team and exclude what they feel is unimportant. Team members may genuinely see only 'what they were prepared to see', but information is lost in the distillation process. Other team members observing the raw data might well glean different information. Team members' individual frames may shift as they learn more about their users. They may focus on different user needs or may become sensitive to different details and nuances of behaviour previously unnoticed. As they modify their frames, they need to share this information with other team members.

Sometimes distillation of needs was done too quickly without sufficient consideration of the frames applied. For example, these teams immediately filtered user needs based on the assumptions about the feasibility of meeting those needs:

> "apart from marrying them, I don't know how to address that 'they don't feel settled down' [issue]"

> "I don't think we can expand on that in a product." "No, that's something we can't do. But we could…"

Here, team members' implicit assumptions regarding team capabilities and the possible direction of the project limited the potential solutions the team could produce. The most common implicit criteria that we observed related to feasibility. In these two examples, filtering was made explicit through brief discussion. However, more subtle and damaging errors are made by neglecting those needs that never leave the researcher's mind having been prefiltered by their assumptions.

Sharing research information, often visually, played a key role in the satisfaction and progress of the design teams. Sharing information from user interviews, secondary research and observations can become a bottleneck. In the short meeting times available, it seemed nearly impossible to sufficiently share the learning of each team member with the others:

> "We sometimes spent so much time collecting data that we had a hard time to synthesize and share the data as a team."

> "I feel like we have so much information, let's just put it all out there."

Yet it is difficult, if not impossible, to convey the richness of an observation experience or a user interview with an important stakeholder to those who were not there. Greater richness in sharing by standard methods, such as discussion and sharing of notes comes only with significant time investment. Teams that took the time to discuss their research experiences in-depth allowing room for interpretations and clarifications benefited. When research information is not adequately shared, team members' frames diverge as they incorporate the needs of different users making group decision-making more difficult. A group exploring the possibilities of mobile handheld education experienced this problem when using e-mail to share the information:

> "We used to email stuff to each other and then tried to converge. Converging was fine for the most part but sometimes we thought we agreed but didn't…Things became apparent when we sat down together in person."

However, there were examples of effective information sharing including discussions based around photos of observations, visits and interviewees. Personas and user scenarios (see, e.g. Beyer and Holtzblatt, 1997; Constantine and Lockwood, 1999; Cooper, 1999), when built around real people, proved a highly effective facilitator of rich sharing. Real people, supported by their actual words in quotes and photographs, bring to life what can

otherwise become dry and abstract. These techniques helped several teams towards a shared perspective based upon real users.

Information sharing was enhanced by effective use of tools and space such as plenty of whitespace on whiteboards or paper to share findings visibly with the whole team. Laptop displays facilitated sharing visual information such as photos of people, places and behaviour. That sketching can make conflicting frames and assumptions visible is well documented (Akin, 1978), which our observations supported. One team member commented:

> "I think being able to visualize what the other person is talking about is a problem we need to overcome. Talking a lot and sometimes drawing out ideas help tremendously in communication."

Sharing user research using the exact words and behaviour of interviewees helps in the development of a shared team frame. Keeping exact quotes of the users and recounting research experiences as stories resulted in team members 'imposing' less of their own frames on the data. Instead, they let the users to speak for themselves. Some teams explicitly chose to use quotes from their users to identify needs and others adopted the user perspective sharing and answering questions as if they were the user:

> "They said it – that's not my opinion."
>
> "It seemed, when I talked to women, that they…"
>
> "Because she didn't want to…"
>
> "It makes Rachel feel…" "She feels…" "She doesn't like…"
>
> "He's on the extreme of independence and not letting anything stop him."

Making the user data explicit helped the team members to adapt their frames around shared information. Teams that had less time to perform user research did more information sharing based on personal experience. Their sentences would often start with 'I':

> "I think the average user's not going to want…"

Relating information based on personal experience alone is significantly less likely to lead to the team successfully addressing the issues of real users, except in cases where the students themselves are potential users. Relying on personal experience and information also leaves more assumptions, goals and criteria left implicit, which can lead to a conflict later in the process.

Teams that actively sought out real user data – in the form of interviews, observations and market research – negotiated a shared frame among team members more easily than those who relied upon their own frames and viewpoints. Some design teams allowed the user research to inform and shape their projects while others used it to confirm their own frames. The user data helped the teams in two ways. First, it provided a concrete reference to an external source of information, forcing individuals to test their own assumptions. Secondly, it illuminated conflicts among individual members' frames that were otherwise hidden. By grounding the team's conversations in concrete data from an external source, ideas could be evaluated with a common frame of reference while minimising hurt feelings. The following examples show teams relying on user data over and above their own assumptions:

> "None of our interviews have led us to that conclusion – so we might just have to strike it."
>
> "Did that appear in our interviews anywhere?"
>
> "I want to go to [collect data at] more schools." "Now it's just conjecture."
>
> "It's tough to not jump to thinking of solutions and we keep reminding each other to keep it problem-based and not limit ourselves or constrain our thinking too narrowly."

Organising user needs is a framing activity. The teams followed several prescribed methods of understanding, categorising and prioritising user needs. Categorisation of needs was often performed individually and then as a team; the frames of individual team members invariably resulted in different categorisations of the same needs:

> "We already categorized our own." "Doesn't mean they're the right ones – I mean they're individual ones."
>
> "I separated mine into four groups. How should we do this as a team?"

The categorisation of the needs themselves was seen as an ambiguous and uncertain process with multiple, if not infinite, possibilities. Many teams lacked a coherent story around which to select categories. Often a process of enlightened trial and error based on personal experience and intuition resulted in the final categorisation.

Naming of needs is also performed from the personal frame of each designer. Teams struggled to collect and aggregate user needs, as team members often did not understand the categorisation of a need or what the abbreviated version of the need (e.g. as represented on a post-it note) meant. Clarifying questions together with patient explanations helped to develop shared understanding. In some cases a precise definition could not be found, however discussion itself resulted in a shared understanding of the concept:

> "Put 'mental structure'. It's a word that's familiar to our group even though we struggle to define it."

Those in charge of the 'meeting tools' for user needs data collection – spreadsheet, whiteboard, flipchart – wielded power as an executive filter over others. The 'pen carrier' who wrote down the needs and categories of the team often exercised liberty in naming the needs that sometimes lost the richness of the initial meaning. The process of aggregating the needs risked losing specificity – losing the core of some of the needs – that might have led to a greater depth of understanding.

3.5 Ideation and brainstorming

At the concept generation stage, team members often still held strongly different frames of how they understood the project.

> "Ideas are still coming in which greatly disrupt the consensus formed in the team."
>
> "…even though [the idea] might not fall under any of these [focus areas] that we decided upon…"

One team we observed conducted an entire meeting carefully discussing the user needs and user research before one member pulled out three completed concept sketches

unrelated to what they had been talking about. The team member participated in the discussion, but was not open to change due to his excitement over the concepts he had developed. Allegiance to his initial frame influenced the way he interpreted new information in the meeting.

Other teams struggled to balance solutions and needs from the outset. The initial frames held by the team members contained strong enough goals, criteria and bounds that several types of solutions presented them automatically. These teams found themselves working backward from solutions to customer needs

> "I think it would be more useful to come up with solutions and then classify solutions [rather than needs]."
>
> "In the beginning we started with solutions rather than actual customer needs and we are beginning to refine our work in terms of customer needs statements."
>
> "We kind of worked backwards from our concepts, to which needs they addressed."

Teams often iterated through several rounds of concept generation building off promising concepts to create new ones. One team used multi-voting to select ideas for further development, but did not ensure that they shared the same definition of each concept. Two people may be voting on what outwardly appears to be the same concept – as represented by a sketch, a sentence or a post-it – but they may see it developing very differently. The frames the members hold based on their understanding of the concept as represented, and their assumptions as to what is possible, are what drives their decision. Therefore, the team members are making their decisions based on different criteria, often leading to conflict.

4 Discussion and conclusions

We have discussed our findings about the role of framing and reframing throughout the early stages of the product development process including development of the initial proposal, creating and refining the mission statement, conducting user research, digesting the data collected, and creating categories of ideas for concept generation. We have identified ways in which teams were successful in eliciting information about individual frames and synthesising shared frames throughout this process, and ways in which they were less successful. In this section, we pull together what we have learned to describe four phases of framing (Figure 1) through which we observed the teams cycle. We close with a discussion of the contribution and limitations of our research.

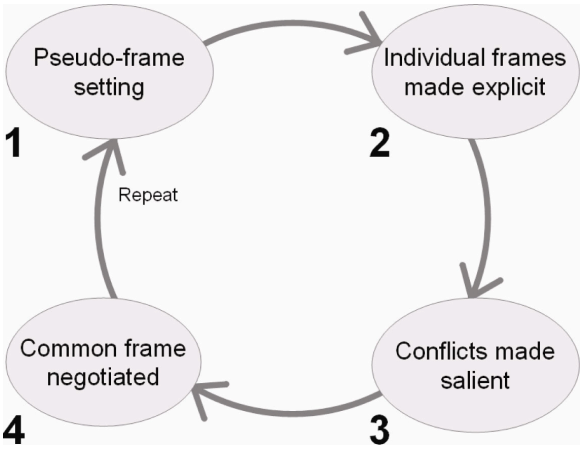
4.1 The four phases of the framing cycle

4.1.1 Pseudo-frame setting

Pseudo-frame setting creates an initial understanding of the design situation, the goals, important features, boundaries and evaluation criteria, in this case upon the initial presentation of the project proposal to the class. The proposal sets boundaries around the problem and solution domains and, in some cases, implies strong solution directions. Potential team members listening to the proposals bring preconceived ideas as to possible

directions based on their repertoire of past experience, personal opinions and assumptions. Their frames are often very broad, although some may assume specific needs and features relevant to real users.

Figure 1 The four phases of the framing cycle



The presentation of an explicitly agreed-upon artefact, like a team name, proposal, or mission statement, appears to be frame setting. The use of broad, abstract language leads members to believe that they are on the same page. However, the vague nature of these initial agreements can mask deep-level disagreements in goals, assumptions, values and understandings. Individual frames are still hidden.

4.1.2 Individual frames made explicit

The process of interacting with and collecting data from users breaks down designers' preconceptions by informing their point of view and challenging their assumptions. While this notion is the primary driver of the user-centred design movement, we demonstrate that user data serves additional valuable functions.

During a team project, designers interact and make decisions about research directions, ideation emphases, and so on. In the process of making these decisions, members often discover their own implicit ideas regarding the project. The consequent sharing of expectations through team interaction makes each member's implicit frame more explicit, and thus tractable material for discussion and debate.

4.1.3 Conflicts among individual frames made salient

Several activities make individual frames explicit, and thus conflicts among them salient, e.g. building a group vocabulary through defining terms, writing mission statements and other textual artefacts, labelling user needs and other concepts, prioritising user needs, categorising ideas and dimensioning users. Once conflicts between individuals' frames are made salient, common frames can begin to be negotiated.

4.1.4 Common frame negotiated

Teams that made individual frame conflict salient used a combination of user data, discussion and listening to negotiate a shared frame. Dedication of the team to the user-centred design gives the team a common anchor against which to tether constantly evolving individual frames, thus enabling the eventual arrival at a shared frame. For example, team members on the 'Healthy Meals for Schools' project did not hold strong frames at the onset of the project and were able to build a shared frame directly from user data without significant conflict.

Other teams did not gather sufficient user data to find and address conflicts between individual frames. In the case of the 'In Touch in the Developing World' team, the team struggled to find potential users to interview and so never reached the stage of frame conflict. Another team disagreed about the values of the team members, which led to difficulties in negotiating a shared frame despite frame conflicts becoming apparent.

It was useful for teams to perform a full iteration of the framing cycle early in the project. The sooner the team was able to 'get on the same page', as many students described it, the sooner they were able to focus on addressing the needs of their users without differences in understanding and assumptions getting in the way.

4.2 Contribution

We have highlighted the important and pervasive influence of both individual and shared frames throughout the early stages of NPD. We identified the activities that support the negotiation of shared frames and provided real examples of effective and less-effective means of carrying out these activities. In particular, we highlighted the role that concrete user data, effectively shared, played in the formation of a shared frame.

The paradoxical nature of user research is that teams seek out information they predict to be important before knowing what is important, and yet the information they gather in part determines what ends up becoming important. That user research serves to illuminate hidden frames helps to explain why teams experience such difficulties in narrowing their focus towards user needs. This finding contributes to the sociological and organisational behaviour literatures on the latent functions of social activities. Like other design activities such as brainstorming, user research serves additional, less obvious, functions than are conventionally intended (Sutton and Hargadon, 1996). An emphasis on the real user data serves not only to guide the team towards effectively addressing user needs, but also to assist in the effective negotiation of a shared team frame.

We also provide a model of an iterative cycle teams execute to develop shared frames that contributes a new level of understanding to a robust body of work on team processes, including Tuckman's (1965) forming, storming, norming and performing model of group development, Schön's (1983) naming, framing, moving, reflecting model of reflective practice, and Nonaka and Takeuchi's (1995) SECI model of Socialisation, Externalisation, Combination and Internalisation. However, each is different in important aspects from the Framing Cycle proposed herein.

Tuckman's model focuses primarily on interpersonal relations among team members. When the storming phase, for example, resembles the stage of 'Conflicts made salient' of the framing cycle, it refers not to a clarification of project frames, but to interpersonal conflicts. A group that transitions through Tuckman's stages may still lack a shared frame about the design situation.

Schön's model is well validated (see, e.g. Valkenburg and Dorst, 1998) but does not distinguish between framing at the individual and team levels. When Schön's model assumes that as group norms are developed, individual frames merge, our cycle acknowledges that individual frames need not converge to form a shared frame. Conversely, the framing cycle allows each individual team member to retain his/her own evolving frame, and 'agree to disagree' even as the team makes decisions using the team frame as their guide.

Nonaka and Takeuchi's spiral model of the knowledge-creating process (SECI) outlines four successive modes of knowledge conversion: tacit to tacit, tacit to explicit, explicit to explicit, and explicit back to tacit once again. The framing cycle differs from this model in that it focuses on the cognitive dimension of tacit knowledge, and the evolution thereof. This dimension, which we have referred to as a frame, is made up of "mental models, beliefs and perspectives…" (Nonaka, 1991). The framing cycle differs in its emphasis on non-rational processes of intra- and inter-individual frame conflict, i.e. individuals may not be aware of their own implicit assumptions until they are met with conflicting perspectives, either from external data or other team members. When conflicts between members' frames are made salient, the team is forced to negotiate before they can develop a shared frame. This contrasts with the more rational SECI model, where each stage takes place in a more deliberately constructive fashion. Furthermore, while the SECI model spirals to a higher level of knowledge creation, towards the company level, the framing cycle repeats at a more micro-level. Subsequent cycles enable the team to make ever more detailed decisions about specific attributes and features of their product based on their larger shared understanding.

Given these the key differences from previous models, the framing cycle makes an important contribution in illuminating the evolution of shared frames in design teams.

4.3 Limitations and future research

Some aspects of this research may limit its generalisability. First, the classroom-based research setting is more protected from environmental and market constraints than real world design teams, while at the same time is more constrained by lack of technological resources and human capital. A similar research protocol should be conducted in industry to clarify the applicability of these findings.

This paper is part of a larger research effort on the social and psychological dynamics of framing, idea generation and selection, and problem setting in innovative teams. Future research will examine the trajectory of front end frame conflict and frame formation on final outcomes like team satisfaction, unresolved conflict and performance. We are also examining how different cognitive styles (Belbin, 1981; Kirton, 1989; Kruglanski and Webster, 1996) help or hinder the framing process in teams.

4.4 Implications

Several practical recommendations result from these findings. First, we encourage design teams to focus on raw user data to guide their activities in the early phases of NPD. Through user research, team members discover not only how to provide a solution to genuine user needs, but also bring artefacts into the team that reveal latent disagreements between individual members' implicit frames. Sharing raw data, such as quotes, videos and photos, helps to make frames explicit in a contextually-rich way. Thus, we encourage

the development of tools and guidelines to assist teams in organising and discussing this data in its raw form, before meaning is attached to it and its ability to reveal assumptions is weakened.

Secondly, we encourage design teams to consciously perform multiple iterations of the framing cycle early in the process. Doing so reveals divergence between individual members' evolving frames, allows deeper layers of implicit assumptions to be challenged and revealed, and facilitates construction of more coherent shared frames.

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