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Formality in design communication

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Abstract

How designers communicate within design teams, and with users, suppliers, and customers, differs in formality both between industries and between different situations within one project. This paper identifies three layers of structure in design communication, each of which can be more or less formal: the design process, the interaction between participants, and the representations of design information that are constructed and used. These layers can be formal across a spectrum from explicit rules to habitual conventions. The paper draws on a range of contrasting case studies in mechanical engineering and knitwear design, as well as a larger corpus of cases comparing design domains more generally, to analyze how formality affects design interaction in different situations and process contexts. Mismatches in the understanding of formality can lead to misunderstandings, in particular across expertise boundaries and between designers and their clients or customers. Formality can be modulated in the mannerism of communication, the rhetoric employed, and how representations are constructed, to make communication more effective. The effort and skill put into modulating formality is greater in domains where designers work with end users, like architecture, than it is in companies where designers interact mainly with other professionals.

Keywords: Ambiguity; Design Communication; Design Process; Formality; Interaction; Representation

1. INTRODUCTION: A COMPARATIVE PERSPECTIVE

Designing is a social process, where designers communicate with other designers as well as nondesigners inside and outside the design process. However, communication in many design processes is riddled with difficulties and misunderstandings (see, e.g., Kleinsmann & Valkenburg, 2008). To improve design communication and eliminate problems, we need to understand the causes and contributory factors of misunderstandings and failures to communicate in a timely and effective manner. This paper argues that some of these factors can best be understood in terms of *formality*: formality of the design process in which communication takes place, formality of the interactions between the participants, and formality of the representations that mediate the communication.

This paper addresses how formality affects design communication episodes, such as meetings, unplanned encounters, or exchanges of messages, which comprise a large part of most design processes. It describes a range of situations from different design domains that illustrate the influence of real and apparent formality on how designing is done and describes how some designers modulate the formality of their behavior and the graphic representations they use to achieve the communication they want. The paper builds on our analysis of formality in sketching (Eckert, Blackwell, et al., 2012), which concluded that divergent interpretations of the formality of sketches create significant communication problems in design processes.

This paper takes a broader approach than the many detailed studies of design communication in particular design episodes. For instance, Cross et al. (1996) and McDonnell and Lloyd (2009) presented a range of different approaches to analyzing the same design episodes. How designers argue and communicate with and through graphic representations has been extensively studied (by, e.g., Minneman, 1991). Design communication has also been studied from the viewpoint of assessing (Maier et al., 2006) and understanding the challenges and opportunities for communication to assure that design processes work effectively (Kleinsmann & Valkenburg, 2008).

1.1. The research approach: Patterns and differences between design domains

This analysis of what formality consists in and how it influences design practice is based on comparisons between design pro-

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cesses encompassing a wide spectrum of activities in different domains. Our working hypothesis is that each design domain has its own particular patterns of behavior to deal with the demands of its tasks, with significant similarities between quite diverse fields as well as significant differences between industries producing relatively similar products. Sometimes design processes are remarkably consistent across an industry (e.g., knitwear design; see Eckert & Stacey, 2003; Eckert, 2006); in other industries corporate idiosyncrasies are influential. We are concerned to identify the causal drivers of these patterns. Different fields have their own approaches to design methodology, with different strengths and weaknesses: critical thinking and process management effort is focused on mitigating the prevailing risks in each industry (Eckert et al., 2005). Behavior that is highly visible in one field is often found in other domains when the same drivers occur but in a less conspicuous form. For example, knitwear designers have a culture of constantly looking for sources of inspiration and talking freely about them, to be able to produce hundreds of designs every season (see, e.g., Eckert & Stacey, 2003). Product designers, engineers, and architects engage in similar behavior although it often does not figure largely in how they describe their processes (Goldschmidt, 1998; Lawson, 2004; Bonnardel & Marmèche, 2005). By looking across domains, we can observe recurring behavior, which leads to understanding of design practice, discovering ways to improve it and to transfer best practice between domains (Stacey et al., 2002). In contrast, other comparative research has sought to identify characteristics and construct theories that apply to all designing and, in some sense, define what design is (see Reymen, 2001; Love, 2002).

1.2. Case studies and comparative analysis

Our case study research has covered design and modification of complex engineering products (Eckert & Clarkson, 2010) and buildings (Eckert, Stacey, et al., 2012). These studies, each based on between 15 and 40 interviews, provided analyses of process that were validated by presenting them to the designers again. Further studies that we draw on in this paper include diesel engine design (Flanagan et al., 2007; Eckert, Stacey, et al., 2012) and an ethnographic study of design processes and communication in the knitwear industry (Eckert & Stacey, 2000, 2003; Eckert, 2001). In addition, we conducted a research project (the Across Design project) to compare design practice across different domains, in which 20 designers presented witness accounts of the practices in their fields (for a discussion of the methodology, see Blackwell et al., 2009; for a summary of the results, see Eckert et al., 2010). Some points we make in this paper are illustrated by the practices of the graphic designer and the architects who took part.

2. ASPECTS OF FORMALITY IN DESIGN COMMUNICATION

We start with the hypothesis that how people communicate in design processes and collectively create plans for products may be influenced by a number of disparate factors that may be more or less "formal." These include not only the purposes of the communication acts themselves and the intended information about the design itself, as well as the representational forms they use, but also the formality of the surrounding social structures and interactions, and the participants' perceptions of formality. Here we briefly outline a view of the concept of formality that is intended to provide a common framework for understanding these different influences on how people communicate.

2.1. A working definition of formality

The standard commonsense use of the word *formal* is to mean "strictly adhering to rules or conventions." This points to the essence of formality, but it misses the subtleties that emerge whenever scholars have examined the notion of formality seriously. For instance, MacFarlane (2000) explored how philosophers and logicians have used different notions and sometimes conflated different issues. Heylighen (1999), considering formal expressions of scientific information, argued that the degree of formality is the degree to which statements are *independent of context*; while formal (context-independent) expressions are highly desirable in some circumstances, context can never be eliminated, so formality can never be total, and formality depends on who is interpreting the expressions.

We view formality as being *strictness of entailment*: how tightly situations determine the appropriate interpretations and subsequent actions. Context independence is one aspect of this. This view is articulated in more detail in a parallel study on formality in sketching (Eckert, Blackwell, et al., 2012).

2.2. Levels of formality

Formality as adherence to rules, or as strictness of entailment, operates at two levels, which we occasionally need to distinguish. The first is how a set of rules governs interpretation and action, which we term *first-order formality*. The second is how free readers or participants are to modify or break away from the rules, to give a different interpretation, or to act outside the scope of normal convention, which we term *metaformality*. Degree of formality is ordinarily *perceived* rather than explicitly inferred in a systematic manner. It might be useful to distinguish between perceived formality and inferred formality, but we do not make use of this distinction in this paper.

2.3. Explicit and implicit formality

Interpretations and actions can be guided by the conscious application of explicit rules or by tacitly learned conventions. Complex human behavior is largely driven by the recognition of situations and associated actions that are appropriate in the context, often without reflection or conscious choice (see Suchman, 1987; Clancey, 1997). While there is an important distinction between explicit and tacit rules, we note that habitual procedures can be as tight as explicit procedures and as dependent on assigning individuals, objects, or situations to categories. These habitual procedures can be oblivious of individual detail or context. We discuss designers' use of stereotyped procedures in Section 5.2.

2.4. Distinguishing formality from clarity, certainty, and commitment

Formality, especially in representations of design information, is closely related to the *clarity* of the information, the *certainty* about the exactness and correctness of the information, and the strength of *commitment* to the decisions embodied in the information. Moreover, formality influences clarity, exactness, and implied commitment. In particular, the use of formal systems of notation serves to help eliminate *ambiguity*. This can be an advantage in handover scenarios, but it is a limitation when developing creative ideas through reinterpreting marks and symbols. In design, relatively formal representations can suggest greater certainty and commitment than is actually intended by their creators, especially to people unfamiliar with their working practices (see Eckert, Blackwell, et al., 2012).

3. FORMALITY OF ORGANIZATIONS AND INTERACTIONS

Organizations have structures and institutional orders: requirements and conventions for how to behave within the organization. These frame social behavior and influence interactions. The influence is bidirectional: organizations are socially constructed (Berger & Luckmann, 1966) out of the recurrent patterns of the face-to-face behavior of the participants (e.g., Silverman, 1971; Ranson et al., 1980). Goffman (1983) presented the notion of interaction order, a set of conventions for how to behave that are generated by the actors sharing common situations, so that they maintain their sense of self through interaction. Behavior following interaction orders constitutes social behavior. For Goffman, interaction orders were interpersonal rather than individual or institutional (see Rawls, 1987). The requirements of institutional orders and interaction orders can conflict (see Rawls, 2010).

Morand (1995) saw formality and informality in interactions between people as two distinct types of interaction order, commenting that Goffman favored the terms *tightness* and *looseness*, that is, "how disciplined the individual is obliged to be in connection with the several ways in which respect for the gathering and its social occasion can be expressed" (in other words, how strictly the requirements of the gathering entail what is the appropriate next action). Morand made the point that different styles are appropriate to different types of work. Companies dependent on creative design in unstable environments need flexibility, willingness to argue for ideas, and strong personal relationships, fostered by an informalistic interaction order. By contrast, organizations concerned with the fair and dispassionate implementation of procedures gain from a formalistic interaction order that fosters what Weber (1947) termed *impersonality*, a disconnection of personal feelings from working behavior. (*Formalistic* is Morand's term; we take it to mean having the surface appearance and connotation of formality.)

Formalistic interaction orders, as discussed by Morand (1995), differ from informalistic ones in two key ways. They not only have tighter rules for what are allowable actions and topics for conversation but also create the feeling of needing to consciously adjust ones behavior in the direction of impersonality, treating others by category, as actors performing particular roles, rather than as individual human beings one knows personally: this is what we experience as "formal." This phenomenological experience of formality does not map exactly to a view of formality as the tightness with which legitimate inferences and actions are defined. Rawls (2010) made the point that informalistic orders can be more rather than less tight than formalistic orders. The rule that one always uses first names is just as precise as title plus surname (high first-order formality), even if deviant behavior might be treated with more tolerance (possibly lower metaformality, according to the culture of the particular organization). The degree of freedom one has to break rules and adapt codes for rational reasons is important to one's subjective experience of formality. Moreover, some interactions, such as some between designers and clients, can be pseudoinformal in that they need to maintain the surface appearance of informality while people are consciously aware of tight requirements on how they need to behave.

The relationship between interaction orders and the content of communication is subtle. Organizational culture, which includes the institutional order as well as how the organization is structured, influences which interactions happen and what issues get raised by whom. However, the content of discussions within the rules of formalistic interaction orders can be free and fluid, whereas more informalistic interactions can be quite formulaic.

4. DESIGN COMMUNICATION: PROCESSES, INTERACTION EPISODES, AND REPRESENTATIONS

Designing creates *representations of artifacts* (see Visser, 2006). Through a coordinated process, designers develop partial, skeletal, and provisional representations of different aspects of artifacts, along with descriptions of requirements, constraints, and other aspects of the design context, leading eventually to a full specification of the final product (see Boujut & Blanco, 2003).

4.1. Speech acts and diagramming acts transmitting information

We see communication essentially as the exchange of information encoded in words, gestures, and information artifacts such as sketches, with each mode disambiguating the others (Tang, 1989; Minneman, 1991; Neilson & Lee, 1994).

Sketches and other information artifacts also convey information between designers working apart, as well as across time and space when their creators return to them. Notes, sketches, diagrams, and so on are created for four different audiences: the creators themselves; their professional colleagues within a community of practice, who share the concepts, problem-solving methods, and diagram-reading skills, which comprise what Bucciarelli (1994) termed an *object world*; design colleagues with different training and knowledge; and outsiders. The same diagram may be seen by all of these and interpreted differently.

Designers' individual speech acts and changes to graphic representations are seldom encoded or decoded in isolation. They seldom form a simple linear sequence and often refer to each other as well as to the context. Essential aspects of meaning are often indicated by context, or signaled by means other than the ostensible content of the message. Communication depends on correctly recognizing the elements of conversations as *speech acts* in which speakers convey their attitude to the content of the message (see Searle, 1962). Moreover, speakers are sensitive to nonverbal signals from their hearers that help regulate turn taking, as well as conveying attitude and degree of understanding. Conversation can be viewed as a sequence of *contributions*; making a single contribution to a conversation is an interactive process of establishing shared awareness of what the contribution is (Clark & Schaefer, 1989).

4.2. Design communication is structured top-down and bottom-up

The meetings and unscheduled conversations designers choose to have, the messages they choose to send, and the representations of design information they construct, store, and look up, embody a complex structure. Designers organize their activities including their communication efforts according to the tasks they see themselves as performing to achieve particular goals. The organization of designers' interaction episodes and message passing comes from two directions. One is the set of process plans and standard procedures they use to guide their activities, and the requirements to produce particular types of information that they need to conform to. (We consider the formality of plans and process models and unstated tacit procedures in Section 5.4.) The other is designers' dynamic situation-specific responses to problems and information needs as they arise.

4.3. A hierarchical model of the structure of design communication

Figure 1 presents a model of the structure of communication in design. Tasks (the gray rectilinear polygons) are embedded in organizational culture and constrained by task, product, process, and organizational constraints. Within tasks, designers either work on their own or with others creating design artifacts and discussing them. The interaction between tasks occurs through these artifacts or through meetings, which might make use of design artifacts, as well as through the information carried in the participants' memories. This model only includes some aspects of design communication. The different issues covered by a wide range of communication models were reviewed by Crilly et al. (2008), whose analysis focused on how designers communicate with customers through completed artifacts.

4.4. Dimensions of formality in design communication

Corresponding to these levels of structure we distinguish three dimensions of formality along which design communication can vary: process formality, interaction formality, and representation formality. For each of these the levels we can distinguish between first-order formality and metaformality. The relationship among the three is subtle. For example, a formally planned process might be managed through unscheduled informal chats in small organizations. In engineering, informal and speculative discussions might employ highly formal exact computational models, whereas in more artistic fields decision-making meetings essential to the structure of the process might employ loose and suggestive descriptions of the product, which are often moodboards in product design and fashion.

5. FORMALITY OF PROCESSES, INTERACTIONS, AND REPRESENTATIONS

Processes, interactions, and representations differ according to the complexity of the designs to be produced and the requirements the designs must meet, as well as on company culture.

5.1. Larger processes lead to more formal communication

Scale in terms of team size and number and variety of tasks is a key influence on formality in process, interaction, and representation. Large-scale processes, for example, diesel engines or buildings, are carried out by teams of specialists, who communicate informally within a team but follow formal processes when communicating to designers outside their field of expertise or to customers and clients. In small-scale processes, designers tend to be less specialized and carry out tasks across a spectrum or specialize according to preferences. For example, architects in small teams comment that while they might all work on a project, one person works on building up a relationship with clients. Graphic designers might work alone carrying out all tasks.

Both culture and physical proximity are important to the rapid exchange of information through a network of connections. However, there is limited time to spend on communication, in particular informal communication, and in consequence this is

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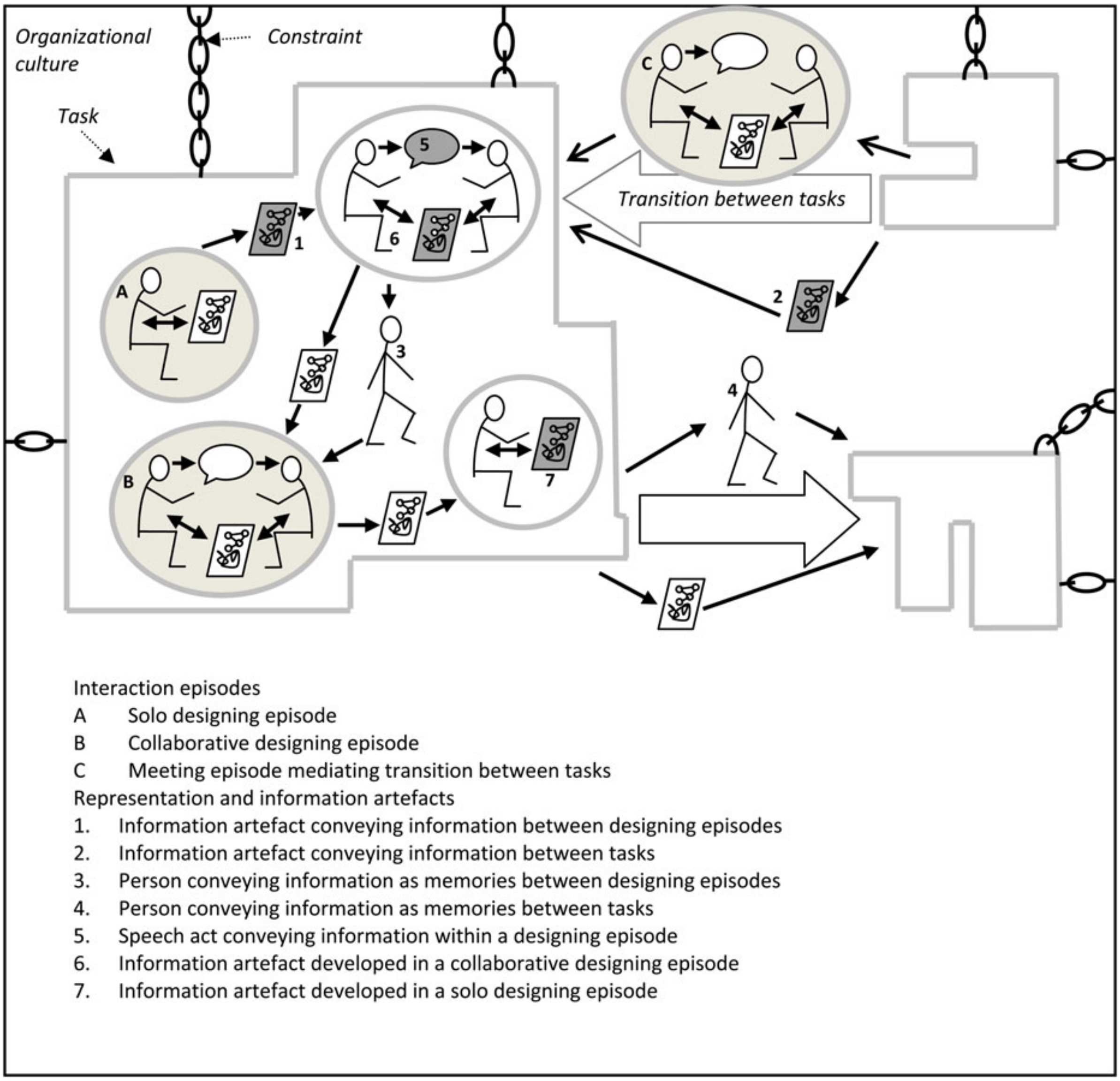

Fig. 1. The communication model of a design process. This model leaves out information transfer between design processes. [A color version of this figure can be viewed online at http://journals.cambridge.org/aie]

limited to a small circle. Flanagan et al. (2007) argued that a step change in the effort involved in communication occurs when processes or organizations become so complex that individuals no longer know the roles and tasks of everyone who is affected by what they do.

5.2. Structuring organizations to foster informal processes

Many design-driven companies take active steps to facilitate efficient as-needed information gathering and communication, mitigating the effects of organization and process size. One way is by arranging the working environment so that people frequently meet colleagues they need to communicate with, as for instance at the BMW Development Centre in Munich.

Another approach is to engineer the corporate culture to encourage informal interaction. Contrasting organic organizations with bureaucratic organizations, Morand (1995) argued that organizations characterized by relatively informal interactions tend to have rather different structures and organizational cultures than organizations where interactions are more formal: They tend to have flatter hierarchies and lower power distance between colleagues working together in meetings and much more flexibility in the patterns of communication. Morand stressed the importance of informalistic interaction orders to innovative technology companies such as Cray and Microsoft, noting the combination of corporate cultures deliberately fostering direct personal interactions with working environments physically set up to facilitate them (see, e.g., Peters & Waterman, 1982; Kanter, 1983, 1989; Aguilar, 1984).

5.3. Customers, clients, and users

Big differences between design processes arise from the relationship between the project designers and their clients, users, or customers. Different types of customer require different degrees of formality in customer interaction: whether in the process of interaction, how the interaction is set up, or what design information makes up the interaction. Customers may explicitly impose a particular process or tacitly expect a particular process. Alternatively, the designers know that some kinds of clients benefit from particular kinds of interactions.

Designers' modes of interaction with their clients and the users of their products vary widely. Designers may directly interact with the users of the product, as architects might do, or the product may be delivered through intermediaries, such as buyers, who purchase from manufacturers on behalf of retailers (e.g., fashion knitwear) or commissioners of products for others to use, such as a brochure. Professional purchasers have strong expectations for how providers of designs will interact with them (high process formality, often relatively high interaction formality), and in many industries they enforce these through explicit formal procedures that require particular information in particular formats (with relatively high representation formality, particularly high metaformality). Part of the motivation for this is that these intermediaries are accountable either to end users or bosses, and need process formality to be seen to be doing their jobs properly.

Inexperienced customers or clients do not bring their own processes for buying but rely on their suppliers to educate them and develop processes with them. This is the part of the process most vulnerable to misunderstandings of formality and commitment, because the rules of engagement are not clear to both parties and expectations might diverge without any understanding that this might be the case. The architects who participated in the Across Design project commented on needing a lot of informal interactions with clients to explore ideas and needs. This involved little in the way of formal process or formality of interaction beyond professional good manners.

5.4. Formal versus habitual processes

People use plans as guides to the actions they select dynamically according to situation and context. People plan to the level of detail where they expect to recognize what to do or figure it out when they need to (see Suchman, 1987; Clancey, 1997). Within the steps prescribed by their plans, what designers do can be very reflective and responsive to the idiosyncratic features of the problem, or can be very formulaic.

Formal processes are an important part of designing in particular in engineering and software, where they are applied both to the entire product development process, especially stage-gate processes in engineering and methodologies in software, and to specific detailed activities, such as testing protocols. Formal high-level process models do not prescribe the entire process in detail; rather, they require that particular actions have been carried out at particular points in the process for the process to continue. This is often a requirement for quality accreditation procedures like ISO 9000, which are by nature formal. Companies often develop more formal procedures for more detailed processes as well, but they find these harder to enforce because they not part of auditing requirements.

Complex processes in engineering, software, or construction are planned, structured, managed, and recorded through process models. Processes can be modeled and conceptualized in many different ways (for a comprehensive review, see Browning & Ramses, 2007). These process models are relatively formal descriptions in that they both have a role to play in the design process, which is often an essential and explicitly specified role, and employ a well-understood formalism to specify exactly an idealized structure that can be checked against reality. Plans and process models influence how designers divide work into tasks and how they conceptualize the structure of the process, as well as what information they need to produce and communicate (Eckert & Clarkson, 2004). What communication does or should occur can be inferred to some extent from these models, but the true richness of interaction is never captured because even detailed process models do not describe all that designers do. Many engineers generate their own informal or ad hoc models that describe their habitual processes or supplement official processes by focusing on what needs to be done beyond routine tasks.

In engineering design, it is hard to predict and describe in detail the actual activities that are carried out, because they are subject to many uncertainties (Earl et al., 2005; de Weck et al., 2007). Engineering design thus tends to be situation driven and responsive underneath the formally specified stage-gate structure. Problems and shifting requirements can throw companies into a firefighting mode, in which they concentrate on one problem to the exclusion of others (Repenning, 2001). Firefighting processes are not particularly formal or preplanned.

Designers in artistic domains, such as knitwear design or graphic design, often do not plan their activities as such, but follow habitual processes that they repeat from season to season or assignment to assignment. These are not explicit or written down, but they are entirely clear as process steps to the participants. While these designers can deviate from their processes, they typically would not; thus, they have high first-order process formality even if metaformality is low. For instance, the graphic designer reporting in the Across Design project described her processes as a series of activities she would typically follow, which systematically limited the search space by imposing a somewhat artificial decision order on the process. For example, she selected the colors before she selected fonts. Eckert (2006) reported on a detailed model of the knitwear design process that fitted the practices followed in 25 companies, none of which had a formal process description. The variation was in the duration of tasks and the probability of iteration.

In contrast to engineering, the rhetoric of artistic design is around free and unconstrained creative processes. In their own narratives of their processes, artistic designers often highlight insight and serendipity rather than systematic activities; however, when the designers are questioned about how they work, a habitual product-category-driven task structure is revealed.

5.5. Intrinsic formality of representations

The choice of representation influences design processes (such as computer-aided design models versus paper sketching or technical drawing, see Henderson, 1999). Mathematical representations and associated analysis tools, such as stress analysis, have a degree of formality that is intrinsic. These representations are not valid or meaningful unless they follow rules and meet criteria. However, the way that representations are used by designers is also driven by convenience. This can involve treating representations containing design information as either more formal or less formal than they might appear to be or were created to be. For example, the diesel engine designers take mathematical models based on past designs along to early meetings to illustrate the range of performance they might obtain through modifications or through adopting new solution principles. Here we observe that a formal representation can have an informal process role of providing evidence in an informal interaction in the same way as a sketch or a prototype might do in another domain.

Conversely, informal representations can also be deployed in formal process roles; for instance, the sketch part of a technical sketch in knitwear is an essential part of a handover document. For communication to succeed, it is important that the degree of implied formality and thus the commitment to what is expressed is understood by the different parties in a similar way. For example, it would not be obvious to an outsider that the technical sketches in knitwear are formal handover documents.

Another example of objects that can play a surprisingly formal role are moodboards, which are assemblies of design sketches with other images and objects to indicate the appearance of a new design, the aesthetic effects and connotations it should have, and how it should feel to interact with the design. They are widely used in the fashion industry, by graphic designers and by product designers, including the contributors to the Across Design workshops. While moodboards can be put together casually for internal use, they are often beautifully presented when shown to outsiders, such as fashion buyers in the case of the knitwear companies we observed. They appear artistic and suggestive, and function partly through the connotations of images not directly related to the design. However, a moodboard is also the most formal and complete description artistic designers can generate of design intent. Moodboards are extensional descriptions with fuzzy boundaries for what might be included, but they typically provide a relatively tight description of the designs that constitute the center of the space of possibilities. Although moodboards appear informal, they employ standard conventions to communicate particular types of information and so are dependent on learned interpretation skills; they are a central part of quite formal processes for product selection and purchase.

6. INTERACTION SCENARIOS

Designers interact with their colleagues, users, and customers in a variety of situations that place different demands on both how they behave and how they use representations of design information. We contrast interactions in several scenarios.

6.1. Collaboration versus handover

Team members can collaborate either in a codesign mode or though a sequential handover. In codesign they are working together on a solution and therefore communicate in order to develop that aspect of the design. For example, in diesel engine design, engine block and piston designers work together on their common interface. These interactions are typically among people who know each other and can be informal. However, codesigning activities often end at formal approval points and handovers. In a handover interaction, a design is passed over to another designer for work on a separate aspect. For example, knitwear designers hand over their designs formally to technicians for prototyping through technical sketches. Other handovers occur when engineering designs are released to manufacturing, an architect hands a design over to a construction specialist, or programmers receive a system specification. These are formal interactions in terms of the requirements of the process although the processes may be habitual.

6.2. Conversation versus asynchronous message passing

Asynchronous design communication, when people are sent messages or look up documents created earlier, has very different task demands from conversation. In general, the consequences of ambiguity in representations are very different when documents are interpreted away from the people who generated them, compared with the rapid disambiguation and negotiation of shared understanding characteristic of codesigning (see Tang, 1989; Minneman, 1991; Neilson & Lee, 1994). The recipients of asynchronous communications generally have a greater need for representations that avoid ambiguity and that are clear about both the precision of design proposals and the degree of commitment (see Stacey & Eckert, 2003). More formal descriptions, whether using more formal notations or the same notations used more carefully, are likely to be needed. However, in engineering and software development, representations that are formal enough to be unambiguous may always be used for particular types of information; conversely, Eckert (2001) found that knitwear designers' technical sketches were unclear and ambiguous in practice, but pro-

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ducing them carefully enough to avoid problems did not seem cost effective.

6.3. Communication across expertise boundaries

Large-scale processes like engine design require designers to communicate within their organization and to suppliers across boundaries of expertise. In multidisciplinary teams, designers often work with a wide range of specialists who use different processes, representations, and ways of interacting. Thus, communication within a technical specialism and with others in the same organization can be markedly different, although they are likely to share a common engineering professional and organizational culture. Interaction with customers and clients may involve nondesigners, that is, people who may not understand design processes or how to read representations of designs. A consequence is that it can be difficult for participants in design processes to distinguish between issues arising from specific interactions and problems that are inherent in using particular representations or following particular procedures. Eckert (2001) observed this in knitwear design.

Communication and handover across expertise boundaries takes place through *boundary objects*. A boundary object is a representation, typically a sketch or a diagram, that designers in different object worlds can interpret in different ways relevant to themselves and that acts as a medium of communication between them (Star & Griesemer, 1989; see Bucciarelli, 1994; Henderson, 1999; Boujut & Blanco, 2003). Such boundary objects can be seen as more or less formal when designers with different specialisms work out their implications for their own areas of concern. However, they can also misinterpret the degree of formality, and with it, the scope of permitted interpretation, intended by their colleagues. Designers may try to interpret them on their own, only seeking out colleagues when they can anticipate a problem.

Other designers construct and distribute representations so as to compel their colleagues to act in particular ways. They function as what Henderson (1991, 1999) terms *conscription devices*. Eckert (2001) discussed this with knitwear designers who wrote deliberately incomplete technical sketches so as to force knitwear technicians to discuss them. The knitwear technicians work their way through the specifications provided in the designers' technical sketches as far as they can, away from the designers, and then meet with the designers for clarification.

Engineers generate significant numbers of written documents as part of their daily activities, which they circulate across the organization and across expertise boundaries. These can be official documents, such as design specifications, or more informal memos. The diesel engine company, for example, also produces a large number of mathematical and numerical models, such as performance models, generated in dedicated analysis code or in spreadsheets, which are used in informal interactions as well as more formal interactions that constitute elements of decision-making processes. In this case, there is a preference for numerical models in both formal and informal interactions; we have observed little evidence of sketching in diesel engine concept development.

Artistic design domains tend not to have formal processes that require communication at a specific point in the process but follow habitual processes with established types of representation for standard communication activities. Many artistic designers work alone or in small teams with people who have different expertise. For example, fashion designers work with pattern cutters, and knitwear designers work with knitting machine technicians. Product designers work with model makers, as well as ergonomics experts, who advise on the human–product interaction, and engineers working on the technical side of the products, using a variety of different representations. Pei et al. (2011) presented a taxonomy of 32 types, arguing that a better understanding of their different properties would enhance communication. In small teams there is a considerable amount of informal communication, both in mannerism and in representation. However, although the processes are not formally described, team members can have very clear roles that they enact.

Many designers, in particular in artistic domains, make extensive use of sketches or rough models that allow them to express their ideas to themselves and to each other. However, this is not universal: We have encountered knitwear designers who never sketched and others who only sketched to document or communicate. Schön and Wiggins (1992) and others have made the point that the ambiguity that is afforded by these representations facilitates idea generation in artistic design domains.

In large organizations, distinguishing the effects of scale from the effects of expertise boundaries can be difficult. For example, in a jet engine company, which has been the subject of extensive case studies (Eckert et al., 2008), the mechanical engineers work with each other closely and in spite of the high degree of specialization have an understanding of the issues that concern their colleagues. They also work with computer scientists and electrical engineers, who work on the embedded software, but have little direct interaction with them. The mechanical engineers invoke formal procedures by issuing formal change requests to colleagues across the boundaries of their expertise in situations where they would wander down the corridor to discuss options with their peer group (Kilpinen, 2008). However, it is significant that the functional groups are housed in different buildings. We have observed the same behavior at a car company, where communication across expertise boundaries was more formal, involving prearranged meetings (more formal procedures and interaction order) and written specifications (more formal representations); in that case, the main driver appeared to be geography (Eckert & Clarkson, 2004).

6.4. Negotiating requirements and deals

Interactions between designers and customers for requirements analysis are typically fairly informal in both interaction order and the representation of ideas, though they can involve elements of structured process. In contrast, meetings to agree on deals are ordinarily more formal in process, interaction order, and representation, since precision is needed both about the creation of social facts (that deals have been agreed) and the legal and technological details in the agreement.

To illustrate these differences between negotiating requirements and deals, we consider the case of the diesel engine company. They invite representatives of the key customers (avoiding clashes among competitors) to requirements workshops at the beginning of a new product development cycle. This is a fairly informal event, where engineers from both sides take part to discuss potential design ideas for the engines. In the workshops ideas are exchanged quite freely and informally by engineers separately from commercial negotiations over cost, which take place outside of the design environment. The designers make fundamental design decisions according to the requirements elicited from the workshops, working out how to meet as many individual customer needs as possible with a well worked-out option package. Once the new engine is under way, talks will begin with customers who might buy engines from the option package. An application engineer conducts technical, but fairly informal discussions, helping a customer to find an existing engine that meets their particular needs. Financial negotiations, which are more formal interactions, are carried out separately by a sales team.

7. MODULATING THE FORMALITY OF INTERACTION EPISODES

Every interaction episode has a degree of formality, which is derived from the process context in which it takes place; however, the participants are not necessarily conscious of the formality or in agreement about the formality. Formality is situated and is the result of an intertwining of process, interaction, and representation. The expression and perception of formality depends on both mannerism and rhetoric. In some cases, this is a conscious modulation, and in others, it is a subtle response to a slightly changing context.

Many designers are adept at tailoring the formality of their collaborations with others at the process, interaction, and representation levels to fit the needs of others and their own goals. However, misunderstandings and confusions can arise from mismatches in formality. This is likely in cases where neither side has sufficient experience and where people do not get rapid enough and complete enough feedback on what their communication has achieved.

7.1. Interaction orders: Mannerism and content

As Morand (1995) pointed out, informality in mannerism and process fosters lower power distance in interactions and an atmosphere of openness that allows designers to explore their ideas, in both artistic and technical spheres. The openness and low power distance is needed to employ informal representations conveying rough and tentative ideas. At decision points, with a more formal process and often a more formalistic interaction order and a greater power distance, more formal representations are needed to express more complete and carefully worked-out designs, indicating more exactly the range of possible interpretations and the scope for further change.

Meetings with relatively formalistic interaction orders with strong emphasis on role and status can involve quite free exchanges of information, with informal procedures and representations; thus, an impression of stuffiness in some engineering companies does not translate to stiffness in the development of ideas. Formal situations afford a degree of freedom in that designers do not need to invest mental effort in modulating the formality of the interaction. In the design of complex or safety-critical products, decisions need to be logged with people taking responsibility for them, which contributes to the formal structure of many meetings and the formal roles they play in design processes, even if the atmosphere and the mannerisms in them are open and informal. Conversely, interactions between designers and buyers in more artistic industries may be a lot more formal in process and representation, and have a much tighter interaction order than a superficial air of informality would suggest.

7.2. Formality in designers' rhetoric and self-presentation

The rhetoric of formality is different in different domains, but it does not have a direct relationship to how formal or structured their design processes really are. Artistic designers like to give an impression of informality, of effortlessly flowing creative processes, while engineers like the appearance of formality to signal structured and well-running processes. Formality is an important part of the rhetoric of different design domains, in particular around creativity and risk. Artistic designers want to stress their creativity because it promises novel and exciting designs to a customer. The scope of interpretation afforded by informality allows scope for changes to a design and therefore provides an opportunity for new ideas to arise, or at least to signal that they could. Formal processes indicate that the processes have clear steps and repeatable outcomes. The artistic process rhetoric hides this in favor of the creative ideas and inspirations of the individual designer. By contrast, by highlighting formal processes, engineering designers' rhetoric signals that they design reliable and thoroughly validated products, thus reducing the risk for the customer associated with using the product. A formal process and the rhetoric that goes with it reassures them.

Mannerism and projecting an image through body language and appearance also plays an important part in communication within a team and outside. This is particularly an issue in more artistic design domains where the designers personally are the guarantors for the quality and relevance of the design. The image projected by the designers is one of the ways by which clients can be attracted and reassured. Moreover, an informalistic interaction order is important to artistic designers' sense of themselves as creative.

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7.3. Modulating formality of representations

Design communication is diverse and contingent on requirements and circumstances. Designers can adapt the intended and apparent formality of representations through the care and exactness with which they draw, speak, and gesture. Designers also possess specialist skills in domain-specific graphical conventions, modeling techniques, and diagramming notations. These possess intrinsic formality, inherent in the rules accepted by a community of practice. Designers can modulate this intrinsic formality by signaling how formal they intend the representations to be, to bias the strictness of the recipients' interpretation of content and connotation. This requires metainformation, conveyed easily enough by varying the pragmatics of interaction: words, gestures, and tone of voice. It is much harder to do in noninteractive situations when representations of design information must be read in isolation.

This is evident in architectural design. The architects we studied for the Across Design project put considerable effort into managing client and user interactions and create specific representations for the different groups with whom they interact. General-purpose representations are tailored for special purposes by adapting their formality. Special-purpose representations have different degrees of formality that are central to their functioning. This is very notable in architectural sketches for the public, which suggest the range of suitable activities in a space.

Levels and types of formality are used to highlight or to hide information as well as to indicate what is necessary (as direct entailment) and what is possible (in a range of consistent entailments). The architects who contributed to the Across Design project carefully modulated the formality of representations of their designs to convey degrees of completeness, commitment, and exactness, thus the scope for further modification, to people without the training or experience to interpret graphic representations in the ways architects would. For example, one of the Across Design architects reported on the renovation of a school theater: She had created representations for the customers, that is, teachers, as well as more impressionist sketches for other users, for example, pupils. Similarly, the diesel engine company modulates perceived formality in presentations to customers, avoiding sketches and using pieces of previous engines in CAD models. These served as placeholders for yet to be designed parts of new designs, to create the desired impression of completeness and scope for further change. The company aims to minimize novelty internally, but customers can also be unsettled by it, because off-highway engines must be extremely robust and reliable. In this case, they are using perceived formality as a means to reassure their customers.

7.4. Modulating formality of interactions

Formality in itself is a neutral concept, but increasing formality can change an interaction episode by signaling that a message or a design change has more significance or a greater degree of commitment. Modulating formality to communicate expectations about processes, representations, and interactions assists in determining appropriate modes of communication for different interactions between designers and with other stakeholders, and consequent shared commitment to the goals of a design task, whether at the level of a whole project or a design detail. The interpretation of the formality of the process, the interaction, and the representations is derived implicitly from the context, according to each participant's knowledge of the conventions of the domain. What can be problematic, though, is a mismatch between different parties in interpreting formality in an interaction episode. Both more and less formality than expected can be an issue. If one party treats a meeting as formal, say, with a formal meeting room and formal clothes, they signal that this meeting is important and that decisions made in it might have long-term consequences. This can place one party, who was planning a frank exchange of ideas, ill at ease. In contrast, a meeting that is billed as more casual might signal that it will not produce results with serious consequences. There is a strong element of personal style in how these interaction episodes are conducted, with some preferring formal meetings and others a more exploratory, informal style. During frequent interactions it is possible to adjust for these factors and see the role of individual interactions in the context of a wider process. However, this becomes more difficult without frequent interactions, for example, in a remote collaboration, in a supply chain, or across cultural or domain boundaries. Perceptions of formality need to be handled carefully in the interaction with end users who have no experience of the culture of a particular design process and therefore can't correctly infer the degree of commitment from perceived formality.

7.5. Mismatches of formality as a source of misunderstandings

Mismatches between perceived degrees of formality, in process, interaction, and representation, can seriously affect the effectiveness of design communication. As a design progresses through stages that involve different interactions and different representations, changes to formality can indicate potentially abrupt shifts in the nature of design communication. Such shifts are characteristic of a changing perspective, an opening up or closing down of exploration either from a client's or a designer's perspective.

Mismatches between the degrees of formality expected by designers, clients, or users, and those actually used, can weaken effective communication. While explicit shifts can create new perspectives, mismatches of expectations of formality can cause a transient disruption to communication. For example, expectations of a high level of formality in a process containing well-defined tasks when others expect a low level of formality are likely to lead to confusion and dissatisfaction, as well as narrower interpretations of the scope for variation implied by representations.

Relatively informal representations of design information that suggest scope for negotiation and a range of possibilities for further development are useful for exploratory activities but look like inadequate preparation for decision-making activities requiring more precisely defined proposals. This is often a practical problem in processes that require formal activities at particular points but allow freedom at others. For example, many engineering processes involve formal stage gates, where the state of the design is formally assessed according to a number of criteria and decisions are made about the future of the project. Some managers or companies run these as very formal meetings that involve a predefined set of documents to be shared or created, while others might conduct a gateway review as part of other meetings or as informal meetings. However, informal mannerisms or venues do not detract from the formal role of the event in the structure of the process. Conversely, if expectations of formality are confirmed, then confidence rises in the other participants' shared understanding and commitment to joint proposals. Although shared expectations are generally beneficial to effective communication, we cannot discount the potential for creative benefits of mismatches in expectations through disruptions to habitual communication.

8. CONCLUSIONS

This paper has argued that formality and in particular the perception of formality is one of the factors that adds to the complexity of design communication and is sometimes a cause of major difficulties. We view formality as strictness of entailment, that is, how tightly what is required and what is possible in a given situation is determined by the application of a set of rules; the rules may be explicitly stated or tacitly learned through social interaction. Designing can be more or less formal at the level of the *process*, the *interaction* between people, and the *representation* in which design information is expressed. The rules and expectations governing these different levels at which participants in design processes structure their communication both create possibilities for how designers and clients envisage the design and their own possible future actions and restrict those possibilities. The tightness or flexibility of the rules biases these possibilities, with tighter rules providing more clarity and precision at the cost or benefit of narrowing the range of possibilities. The relationship among these levels is subtle and not all that close, as is the relationship between the superficial appearance of formality and how tightly interpretation and behavior is actually constrained. This paper has focused on interaction episodes and communication acts and the representations they employ; since formal processes play a particularly important role in the design of complex products in domains like engineering and architecture, an important project for future research is how different ways of conceptualizing, specifying, and enacting processes affect the outcomes of those processes.

In most design processes, there is a mixture of more formal and more informal communication, as formal interactions, such as formal team meetings, are followed up by informal interactions, for example, in unscheduled face-to-face conversations. The informal activities often fill the gap between the formal steps. They are no less important. Conversely, informal activities and interactions are often concluded, recorded, or summarized in a formal manner to create information that plays an explicit role within the design process. Our observations of communication difficulties in large-scale design processes reinforce the familiar point that easy, spontaneous informal interactions with colleagues to gain information or negotiate solutions are essential for the smooth running of design processes and that facilitating them is an important part of design management. Enabling easy communication across boundaries of expertise or geography is sometimes neglected.

Understanding the intended formality of an interaction event or a representation is important for achieving effective communication and avoiding misunderstandings. Controlling the formality can enable participants to manipulate a situation, for example, by making another person uncomfortable through formal mannerism or to close off debate, and also to encourage other stakeholders to participate or indicate openness for negotiations. The appropriate degree and types of formality in the manner of communication and the representations used is not always self-evident to the contributors. It sometimes needs to be explained or negotiated. A shared understanding of formality can be deduced from a shared understanding of the context; however, when designers communicate across boundaries of expertise or national culture this cannot be taken for granted. Agreeing on appropriate degrees of formality for different situations and purposes could usefully become a part of setting up and maintaining communication within large projects.

Design practitioners in some domains, notably architects, are very good at modulating the formality of the representations and modes of interactions they are using to suit the different types of stakeholders in their projects, but others seem less aware of the need to manage expectations. Mismatches in expectations of formality are a potential source of poor communication. Understanding how formality affects a process is a necessary precursor to the analysis of effective modes of design communication, especially in uncovering the subtleties of mismatch, disruption, and control, which lie in the path to effective communication. Exactly how creating expectations about the formality of communication can be used to control, manipulate, and ultimately improve interaction episodes and the transmission of information is an important next step in this research. In industrial practice, explicit reflection over the rules that govern the formality of interaction in design and the consequences for communication would benefit designers in all fields and at every stage in developing designs.

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