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Structured Methods in Product Development*

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We adopt the perspective that product design is a social activity: the outcome of an organized human effort to transform a set of requirements into a reality. It requires the collaboration of a wide range of individuals and stakeholders, each with different competencies, knowledge, responsibility and interests. Our focus is on the structured methods developed within the engineering design community to manage the product design and development process. Empirical observations of the product development process within a design consultancy show how they are used, patterned and shaped by participants in many different ways, with an array of intangible as well as tangible benefits.

INTRODUCTION

WE ADOPT the perspective that product design is a social activity: the outcome of an organized human effort to transform a set of requirements into a reality. It requires the collaboration of a wide range of individuals and stakeholders, each with different competencies, knowledge, responsibilities and interests. In the design of a fictional widget for instance, we may observe the interchange of ideas and data between industrial designers, mechanical engineers, marketing and sales personnel. The process can be contentious, difficult and often demands close attention to the interactions between participants, management and the external environment.

Yet, engineering design is often represented as a purely technical activity: the fabrication of products in a systematic and orderly way. Early management writings consistently espoused a view of product design as 'simply one of technical optimization'. Problem-solving theories introduced by Simon provided a logical framework in which design was seen as a 'rational problem solving exercise' [1]. This rational approach to design assumed a stable definition of the problem, which defined the 'solution space' that had to be surveyed.

A radically different paradigm was proposed by Schön who described product design as a 'process of reflection in action' [2]. This alternative epistemology of practice is based on a constructionist view of human perception and thought processes. Each design problem is perceived to be unique ('a universe of one') and solvable through the 'professional knowledge and artistry' of experienced designers. Design in this context is a 'reflective conversation with the situation' where problems are actively 'framed' by designers who 'make moves toward a solution' whilst continuously reflecting on those moves. Schon asserted that product design was not describable or generalizable in any meaningful way by the prevalent analytic frameworks.

In recent years, researchers have expanded on this alternative view of product design. Bucciarelli uses the notion of 'object worlds' to frame the individual and self-created working environments of design participants [3]. By referring to the 'ecology' of design, as well as its social nature, Bucciarelli recognizes the organic (dynamic, vital and reciprocal) components of what otherwise might be construed as a linear, deterministic process.

THE STRUCTURED APPROACH TO DESIGN

Our focus here is on the methods developed within the engineering design community to manage the product design and development process. Organizations of all sorts rely upon what we call 'structured methods' to guide and control this dynamic and uncertain process. We broadly define a structured method as an explicit, formulaic, written-down-somewhere, way of doing things: a template to be filled in by participants, for generating concepts, for deciding among alternatives, for laying out paths for the transfer of information, resources, knowledge and even people. A structured method can be a formal project plan spread over time (such as a milestone chart) or a method intended to capture user needs in the early stages of design. They are rule-like in that use of the method calls for a step-by-step progression of interactions until the result is achieved.

Practitioners believe that structured methods are valuable for three reasons [4]. They make the

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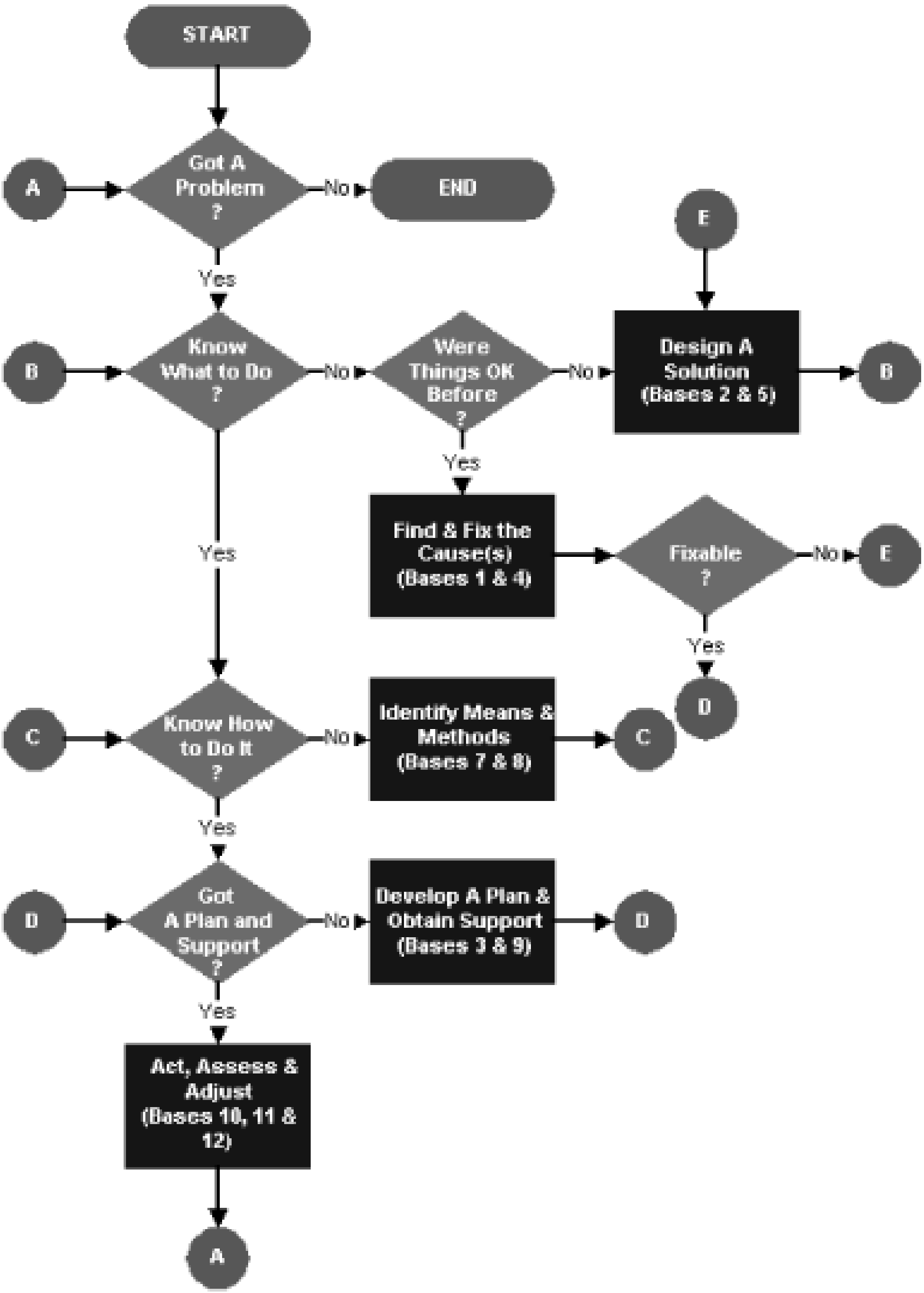

Fig 1. Rational approach to designing.

decision process explicit, allowing everyone on the team to understand decision rationale. They act as checklists to key steps in the development activity, maintaining quality across project approaches. In the process of executing the method the team creates a record of the decision-making process for future reference and for educating newcomers.

For the purpose of this thesis, the structured method is represented as a procedural framework in product development that defines a sequence of operational tasks. Participants adhere to a series of working steps in the design process, to translate and transform their work as individuals into a coherent design. Structured methods are used in almost all commercial design and development activities and as such, are inherently dynamic and cross functional.

> 'It is not exaggerating to say that there are no well structured problems, only ill-structured problems that have been formalized for problem solvers' [5].

Despite the functional clarity of structured methods, empirical observations of the product development process suggest they are used, patterned and shaped by participants in many different ways, with an array of intangible as well as tangible benefits.

> 'They (structured methods) provide a common structure, shared by all participants across object worlds, for patterning explanations and fixing what counts as an explanation of consequence and what is relegated as background noise' [3].

Throughout this study we were concerned with the divergence between the theoretical and practical applications of structured methods in product development. We have attempted to understand their meaning as revealed in use, observing first hand how they are manipulated, amended and recast in an ongoing product development project. Our objective is to separate fact from fiction—to understand better the true value of structured methods, their limitations as well as power, so that they might be better construed and employed more effectively.

We argue that structured methods serve most effectively as an interface between the boundaries of domain knowledge, facilitating knowledge creation and exchange among different participants within each firm, each with different responsibilities, competencies and interests but all engaged in the same effort. They act as an artifact that is used by more than one distinct group and provide some degree of translation between groups. The content requires consensus and is flexible enough to allow the object to stretch across multiple domains, serving multiple groups. Structured methods allow the framing and stabilization of public concepts, while simultaneously providing an opening into other worlds [6]. They are weakly structured in common use, and become strongly structured in individual use. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation.

The use of boundary objects

Structured methods can be viewed as 'boundary objects'—a concept developed by Star in [7] to describe objects that were shared across different problem solving contexts by different stakeholders and actors in product design. Boundary objects embody particular details of stakeholder interests and help individuals express and understand cross-functional design challenges.

Boundary objects can be repositories (i.e. cost databases, parts libraries, etc.), which supply a common reference point of data or a shared format for solving problems across different functional settings (i.e. FMEA forms, ISO certification, engineering change forms). They can be the representation of a physical object in its current or future form (i.e. mock-ups, assembly drawings, sketches or simulations) or they can yield a snapshot of shared boundaries and dependencies that exist between functional settings (i.e. Ganttt Charts, Milestone Charts, Product Development Methodologies and Work Flow Charts). In this way, boundary objects possess boundary-spanning capabilities and serve as interaction spaces in the product development process.

The use of historic work methods

We claim also that structured methods are more than a methodological template or tool in product development, if only in the way they are conceived. For they provide a means to bring prior experience into current activity. Whether the designer acts alone or in collaboration with peers, the use of structured methods enlists the historic involvement of others engaged in prior activities. These methods change with time, from project to project; they are themselves continually redesigned, a product of trial and error, a hybrid of methods used and redeveloped by past practitioners. The appropriation of historic work practices shapes the present context. In this way structured methods stand as a pragmatic testament to the notion of design as a social process.

This defines the dialectic nature of structured methods. They do not merely facilitate mental processes that would otherwise exist but fundamentally shape and transform them [8]. Structured methods, like any type of tool, shape the consciousness of those who use them. They establish the fundamental modes of activity involving productive labor. The tools themselves were conceived by conscious agents engaged in practical activity. The tool molds the wielder who molds the tool, ad infinitum. We see a self-and-species transformation through the use of tools [9]. There exists a logical relationship between consciousness, the social organization of productive forces and the structured methods that emerge out of practical activity. Each has the power to transform the other in a continuing, evolutionary cycle.

The ethnographic approach to product development

To establish the value of structured methods as a tool in product development, we must observe how it mediates human intention, how well it can 'share' a work load, and how effectively it shifts focus away from itself toward the object of the activity [10]. So we go into the firm to study first hand the product development process.

The research was conducted with an ethnographic approach: an attempt to understand and describe product design from the perspective of those who work in the field. The findings of the study were typical of ethnographic output; qualitative, diffuse, unstructured, highly interrelated, voluminous and slow to emerge. Its value resides in the ability to provide a highly detailed account of situated behaviors and beliefs in the product development process.

FIELD OBSERVATIONS

Research focus: creative works

Creative Works Group (CW) is a medium sized East Coast product design and development

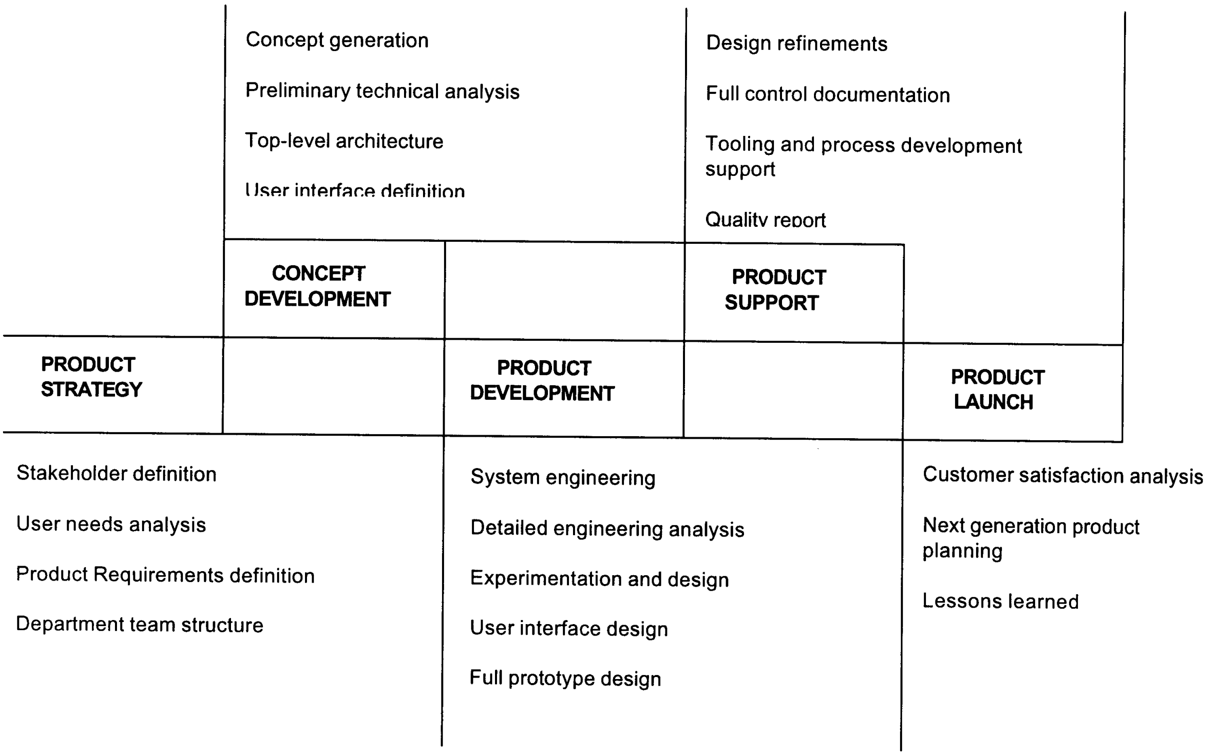

Fig 2. Product development methodology for Creative Works.

consultancy founded in 1985. Within the product design community, it had developed a reputation for superior project management with 98% of projects being completed on time and within budgetary constraints. Over the years it had become particularly adept in the design of innovative electromechanical devices for the healthcare sector. CW had a multi-disciplinary workforce comprised of mechanical, electrical, software and manufacturing engineers, in addition to industrial designers and business analysts.

CW attributed much of its success to its own in-house product development 'template': a variant on the Ulrich and Eppinger method.

Essentially, the template separates the design process into a series of steps and sub-routines performed by different practices and functional groups within the company. The methodology breaks down product development into five key stages: product strategy review, concept development, product development, product support and product launch. Each stage is a generic description of a 'family' of operations.

CW was contacted by a dental equipment manufacturer (DenSys) to aid in the development of a new product for the endodontic systems market. DenSys also designed and manufactured dental implant surgery items, oral surgery systems and an ever-widening range of portable dental equipment in the dental asepsis market.

DenSys was only a 'minor player' in the oral surgery suite of products having previously focused on supplying laboratory disposables such as syringes, rubber dams and surgical handpieces. It had not looked to take advantage of this presence to leverage broader opportunities in the endodontic market.

DenSys's position in the suite was challenged by a competitor with a new endodontic injector (the main operational piece of equipment used in oral surgery) that did not rely on the disposable interfaces or syringes made by DenSys. Although the products made by DenSys were not the primary competitive target, they were collaterally affected by this development. After carefully reviewing the scenario, DenSys executives decided that the growth opportunities created by developing a superior endodontic injector far exceeded any defensive response towards the existing disposable systems product line.

The overriding objective was to develop a product in the oral surgery market that would 'substantially leapfrog' the competitor's offering within a time to market of two years or less. DenSys had decided to out-source the product design and development to overcome its own institutionalized 'mindset'. The challenge facing CW was to have defined and validated the need and opportunity for a new product and to have developed an innovative concept targeted at meeting this objective within six months.

DenSys had also contracted a market research firm, Science Survey Inc. (SS) to conduct field research and to define user needs. Both firms aimed to lead the project at different times according to their competencies: SS during the early stages to develop an understanding of market demands and CW during the engineering

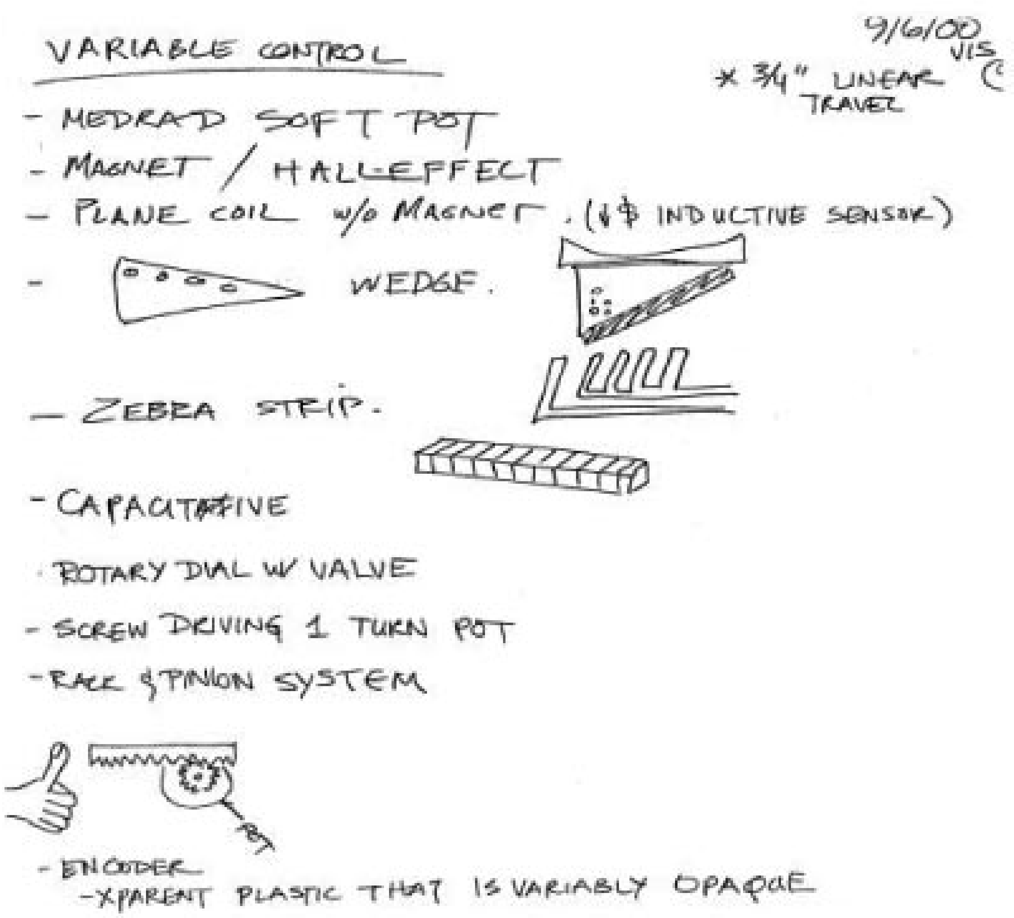

Fig. 3. Brainstorming sketches.

design process. They were expected to work collaboratively for the duration of the project, whilst DenSys 'shadowed' the entire process.

Conflicting structured methods

At the project inception ('kick-off' meeting) there was widespread disagreement over the division of labor and the timing of work activities. Each party had constructed its own project plan (Gantt chart) with varying degrees of commonality between them.

The negotiations were contentious partly because there was no standardized format for representing the project over time. Participants had difficulty understanding and modifying each other's project work schedules.

Yet despite disagreement amidst misunderstandings, ambiguity and uncertainty, the lack of a shared language (in the narrow sense), the various renditions of a project plan served as boundary objects. We see that structured methods are not rigid and binding like physical laws: participants showed they could interpret, advance and augment instructions. They utilized these plans in different ways whilst providing a permanent communications framework. By creating ways for participants to interject opinions, convey decisions, object and negotiate, structured methods generate design conventions and establish accepted 'ways of doing things'.

When structured methods articulate various kinds of stakeholder knowledge and are modifiable by those involved in the design process, they prove to be effective boundary objects. By spanning functional boundaries, structured methods make it easier for dynamically formed, cross-functional teams to work together.

The importance of context

In theory, structured methods standardize the product development process to ensure consistency across project approaches. Empirical observations suggest that there are many tangible and intangible benefits to this. In particular, structured methods allow for a much quicker process of assimilation for newcomers to the project. Through the use of Gantt charts and project timelines, their work can be 'itemized' and their role in the project can be more clearly defined.

However, standardization of the product development process does have its shortcomings. The project strategy used by all three companies in design review meetings contained task descriptions that were highly general and broadly applicable to any design project. Terms such as 'top level system concept generation', 'preliminary product architecture' and 'concept risk analysis' were generic descriptions of work activities within the process of creative engineering design. Establishing the balance between process generality and project specificity was important in the creation and use of structured methods.

It became clear that CW did not base their in-house product development strategy on a series of high-level checklists, although these checklists (accompanied by a narrative of events) were valuable in conveying the generic design process to outsiders or newcomers.

> *CW engineer:* 'I'd like to describe the design effort over the last few months for DenSys and anyone else unfamiliar with the approach. As you can see from the methodology, we began the field research in October followed by brainstorming in January and a review of essential claims in April.'
>
> *DenSys engineer:* 'Did you get everything you wanted to find out from users the first time around?'
>
> *CW engineer:* 'No, we were faced with missing information on the market—specifically user preferences—we had a to conduct a 'conjoint analysis' in March. A major conclusion from that study was that the hardware cost was a big concern to users.'

Structured methods need context to be valuable tools in product development. This is partially achieved through the use of narrative to bridge the gap between what is implied and what is shown. The challenge for managers is how to achieve context with a globally distributed (and functionally diversified) design team.

The use of narrative or 'story telling' played a critical role in enhancing the boundary spanning capabilities of structured methods, by fashioning context and providing a means by which design participants could articulate tacit design ideas.

Designers involved in brainstorming sessions would often use narrative to embellish product descriptions:

> *CW employee:* 'Last night I was playing with my son's computer and I noticed that he had a game which required a password. When you typed in the password, the game made a "typewriter" sound with each keystroke. Now, I'm not very good with keyboards in general—my fingers go everywhere—it's just not intuitive to me, but when I typed that password in and heard the typing sounds, it suddenly made me much more comfortable with the keypad. Maybe that's what we should try to do with the design of this device—an audio-visual combination that enhances the user experience—the "computer game" effect.'

From this narrative came the expression 'computer game effect' to describe the responsiveness of the hand controller. This expression would serve as a linguistic prompt to design participants in future discussions on the sensitivity of the hand controller.

The 'language' invented and used also had the potential to exclude participants from the design discourse as much as it could include them. Team members that were absent when a linguistic term was coined were faced with uncertainty over its meaning and would often feel inhibited to resolve the impasse. As one participant confided:

> *CW engineer:* 'You can't stand still too long in this place, they (management) invent a new term for everything and I sometimes find it hard to understand what exactly is being said.'

I returned from a temporary break from my research at CW to find they had invented an array of terms to describe new product features. 'Ride the wave', and 'spring touch' described the feedback on the hand controller while the expression 'plug and play' had been adopted to describe the ease with which the product could be modularized.

Context was not just provided by language but also by other media: sketches and physical objects. This was well illustrated by an examination of brainstorming sessions.

Methodologies for brainstorming were used throughout the project as a creative tool for the generation of concept ideas. The brainstorming sessions were typically 'led' by a team member whose ideas provided the direction and critical focus for the subsequent discussions. Brainstorming sessions provided a forum for the clarification of project constraints and the interchange of information between design participants. The room often contained product prototypes or component parts as a means of providing physical context to the discussion.

It was clear from the field observations that the generation of ideas was not localized around specific points in the design process. Creative engineering design was an ongoing process, either 'formally' (during brainstorming) or 'informally' (during impromptu meetings). In the development of original products, the notion that creative thought can be subject to spatial or temporal constraints is misguided.

Participants would often brainstorm during car journeys, on the plane to a client meeting or during work dinners. These sessions lacked depth but allowed a wide range of ideas to be explored, which were most effectively communicated by drawings and white-board illustrations. Brainstorming was a tumultuous affair: dueling marker pens and aggressively wielded board rubbers were the weapons of choice, as team members vied for the right to express their design ideas. What emerged was often symbolic of the event itself: lists of design features in untidy handwriting, scattered designs with scant and illegible descriptions.

As the design process continued the decisions gained more structure and a level of formality was somewhere transcended: the indecipherable notes of the brainstorming world would evolve into the formalized jargon of the world of evaluative matrices. On occasion, features of the two 'worlds' would be juxtaposed in a single methodology.

Decision matrices could only partially describe the concepts generated in brainstorming sessions and participants were much more responsive to the sketches which they had made and annotated. As with the use of phrases and expressions ('plug and play', 'computer game effect', etc.), the use of sketches provided context for the structured method at hand (i.e. the decision matrix).

Choosing the appropriate methodology

Design is viewed as an evolutionary convergence between problem understanding and solution definition [22]. Aspects of a solution are explored in conjunction with the emerging problem: the designer's perception of both is continually reformulated over time. The use of structured methods is an attempt to manage the dynamic interchange of information between the design 'problem' and 'solution'.

> *DenSys:* 'Initially we thought feedback on the hand controller was important to users—it was a general claim based on what we had read—also, designing a true feedback system was proving difficult and expensive. After the conjoint analysis a few weeks later we were able to identify specific details about user needs. We found out that feedback was only a minor consideration to users—so we settled on a much simpler system—basically a plunger connected to a spring to simulate feedback'.

The clarity of the design step: how well defined the constraints, guidelines and requirements appear to be, is an important factor in the selection and use of structured methods. Design steps such as concept selection, which can be reduced to a set of well-defined rules, are clearly represented by formal methods. The decision matrix compiled by CW as a means of communicating the choice of product features to participants from DenSys and SS, is a case in point. The matrix provided an explicit means to evaluate several proposed features for the new product and was used to explicate the decision rationale.

The decision matrix allowed different features of the hand controller to be evaluated using the same criterion with preferences being articulated in a way that could be understood and modified by all participants in this design stage.

Design steps that are characterized by incomplete information or evolving product specifications cannot be subject to the same rules and guidelines of the decision matrix. The early stages of the design were characterized by a high degree of uncertainty—unreliable field research of limited breadth and scope. Under these circumstances, rigid (inelastic) structured methods were largely ineffective. These ill-defined design steps require formal methods that reflect on the complexity of the situation and manage uncertainty.

In product design, many of the critical issues are 'semi-structured': containing both structured and unstructured sub-processes [11]. Semi-structured problems are not limited by what can be explicitly articulated, leading to some decision making without symbolic representation. The choice of which product features to evaluate in the decision matrix is a semi-structured process. While the relative attributes of the product features are ranked by explicit criterion, the choice of this criterion is subjective and often favors a particular feature going into the analysis. Moreover, many of the features evaluated in the matrix were excluded from the product development strategy (a record of design events), showing a degree of implicit decision making in the construction of structured methods. As we abstract from the structured evaluations of product detail to the semi-structured representations of product strategy, we consciously and sub-consciously obscure the decision rationale.

Imposing structure on an ill defined or 'semi structured' design scenario through the use of inappropriate structured methods is at best, redundant and at worst, misguiding. Yet it was a common approach taken by Creative Works in the early stages of the project, when attempts were made to fashion the project strategy in the form of pre-existing product development templates. There seemed to be a low tolerance for uncertainty among engineers in the design team: a type of institutionalized risk-aversion. By representing the design process schematically, by inventing language and by assigning concrete terms to ill-defined concepts, we engender a sense of control of the process. Superficially, structured methods would provide order to an otherwise risky and unpredictable process.

Compatibility of different approaches to design

The involvement of DS early on, brought about many unorthodox approaches to designing.

> *DenSys manager:* 'The product development effort so far is a slight departure from the usual process. We've been forced to rely on data supplied to us by DS whereas we'd normally conduct the research ourselves.'

As non-engineers they frequently relied on qualitative observations and audio-visual recordings to try to capture user needs. This placed them at odds with the quantitative style favored by Creative Works and DenSys.

> *DenSys manager:* 'Once we've collected the data on user needs we can present it to you in a number of formats. We recommend placing all the information: the interviews, the audio recordings, the video recordings, etc., on a CD-ROM. It makes the information easily accessible.'

> *Creative works manager:* 'I would feel more comfortable having the information in a paper format.'

> *DenSys manager:* 'I feel the same but maybe you could supply both.'

The most innovative and creative concept ideas for the orthodontic injector came in the early stages of the project when each group had different perceptions of the design problem and alternative approaches to tackling it. This was also a time when the progress was agonizingly slow and there were frequent breakdowns in communication between the participants.

The most efficient stages came later in the project during prototyping when DS were no longer involved (hence the number of participants was smaller) and there was a shared understanding of goals and objectives.

There was a clear trade-off between intersubjectivity (shared meaning of design goals) and the exploration of design alternatives: if group members possessed too much common ground, they communicated more efficiently but there was less of a tendency to explore alternative courses of action.

There is clearly no single right or wrong methodology to designing. It is less important what structured methods are used, than how they are managed. Approaches that encourage creativity and innovativeness must be balanced by analytical rigor in the engineering and business fundamentals of designing. The project suffered from a lack of direction early on with too many participants contracted to undertake ill-defined design tasks. The consequence of this was that the first step of the product development template ('stakeholder definition and market analysis') was not completed satisfactorily. Eighteen months after the 'kick-off' meeting began, the project was eventually axed owing to the uncertain market demand for a product that was overpriced and undifferentiated from its competitors.

DISCUSSION

Structured methods in context

Structured methods are 'an appeal to the general, not the particular' [12] and as such promote tension between what a designer thinks they should do and what, in actual fact, they do.

Designers do not plan actions which are followed through without reflection, but are guided by partial plans which are locally contingent upon the context of activities and material conditions involved in the problem situation [13]. Lave and Wenger [14] argue that design is situated in an organizational context: abstract representations of a solution are meaningless unless they can be made specific to the concept at hand.

This theory is supported by our observation of design, which indicate that designers solve novel problems by generalizing from a similar problem, or by reframing the problem to fit partial solutions which are already available to them from their own (or colleagues') experience [18, 20, 22].

There is an element of constructionism in the use of structured methods in product development. They are not just 'constructed' in the material sense. They have a context: a meaning that is dependent on and shaped by the design environment.

Structured methods need context to be truly valuable. Narrative or 'story telling' generates context by creating new 'language' to serve as linguistic markers for previously articulated design ideas.

Storytelling introduces a description of events that link people over time. It is characterized by a unique terminology ('computer game effect'), multiple viewpoints (it can be interpreted or 'read') and a definite ending (it has a sense of closure). As an explanation of design or, to be more accurate, how the designer communicates the design process to others, structured methods are incomplete without narration. It provides a way in which an engineer can explain a *specific* action. Whereas a formal method provides a rhetorical structure, a story evidences personnel detail.

There is an economy of language associated with the use of narrative in product design. Structured methods are presented, understood socially and then reconstructed using familiar 'language'. Context is encapsulated by a word or phrase that can be used repeatedly to validate the formal method at hand.

While narrative provides an efficient way to convey meaning among design participants, attention has to be paid to the dissemination of new language among 'globally' distributed design teams. Being unfamiliar with new terms and expressions can reduce the effectiveness of structured methods: if a designer cannot understand what is being said in a Brainstorming session then she cannot be expected to contribute to the generation of new ideas. This dual function of structured methods—they are simultaneously inclusive and exclusive—has a direct effect on the team, group and organizational culture. The more specialist the design issue, the more exclusive the sub-culture becomes.

Creating a working environment that encourages participants to question unfamiliar 'frameworks' or 'language' is an obvious (though not always practical) solution to this problem. Establishing and maintaining a project glossary to detail design terms and expressions would also improve the effectiveness of structured methods.

Structured methods as adaptive artifacts

An experimental study by Rugs and Kaplan [15] stressed the importance of goal congruence (i.e. intersubjectively-held goals) in group decision-making. As might be expected group (shared) goals facilitated greater normative influence upon decision-making (based upon social relations) and task goals facilitated greater informational influence (based upon evidence about reality). The implications for design teams are that effective consideration of organizational design requirements is only possible when there is a high degree of divergence between individuals' approaches to designing, whereas effective synthesis of solutions requires much higher levels of intersubjectivity. In the early stages of design, members of a design-team are likely to hold diverging models of design requirements and thus cannot effectively synthesize solutions; during later stages, levels of intersubjectivity may be higher and so solution synthesis can proceed more effectively.

The challenge designers face is how best to use structured methods in view of these findings. When the design problem is ill defined and the level of intersubjectivity between participants is low (typically in the early stages), 'elastic' structured methods that support the divergent approaches to designing and opaque design constraints are more likely to be effective. By the term 'elastic' we mean structured methods that are interpretable and encourage reflective reasoning on the part of the designer. When the design problem is well defined and the level of intersubjectivity between participants is high (i.e. the later stages), formal methods with greater structure are appropriate.

Structured methods as boundary objects

The groups were able to co-operate despite having diverse goals, time horizons, and constraints. They could successfully work together while employing different units of analysis, methods of aggregating data, and different abstractions of data. The activities were coordinated and supported by structured methods which acted as 'boundary objects' that could be adapted locally to needs and constraints while maintaining a global identity.

No one actor held a complete model of the situation, but individual actors held both partial models of the solution and a process model which enabled them to coordinate other actors' partial models to reach a complete solution. Hutchins [16] studied how the social organization of distributed cognition affects the cognitive properties of groups in a study of how communities arrived at shared versus differing understandings. He concluded that cognition in this type of situation is shared among agents in organizationally-prescribed roles and also among the methods used, such as work-procedures, charts, plans and routines for route-calculation. The models of how a situation may be handled are embodied in the structured methods used to expedite its handling. This echoes the work of the actor-network theorists (e.g. [17, 19, 21]), in treating structured methods as 'non-human actors' in the analysis of the 'web' of distributed interactions in organizational decision-making.

Lifecycle of structured methods

By defining the term 'lifecycle' we are able to understand how structured methods change over time and how they are disseminated. I hypothesize that structured methods 'evolve' by iterating between the general and specific details of a design problem.

A process that has been successfully pioneered within the design community is generalized. The structured method which results is effective as a boundary object: understandable at the intra and inter firm levels. When we realize that it inadequately describes what actually happens at a local level, we supplement it in some way (through the use of narrative, impromptu sketches, language etc.). The structured method becomes localized at the intra firm level and is much less effective as a boundary object. When we need to broaden the scope of the methodology a gradual process of standardization ensues and the cycle repeats.

Methods are actionable at the local level (where they are context dependent) but are disseminated more effectively between organizations at the general level (where they operate as powerful boundary objects).

In all of this we see that what on the surface appears as a machinery, or formulae for the conduct of design, is in fact, in the everyday practice of product design and development, a social artifice, shaped and manipulated to meet the often conflicting interests of participants.

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