

Crafting interpretation in ambiguous contexts: Conceptual modularity and the evolution of novel product concepts

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ABSTRACT

When individuals in organizations are faced with ambiguous situations in which to coordinate action, the use of a shared concept is regarded as important in providing an interpretive framework, but the process by which concepts are collectively crafted and managed is little understood in detail. Using an inductive case study method of six novel product development projects across three industries, the process by which development teams defined, altered, and ultimately realized novel product concepts was examined. The empirical results suggest that rather than using singular focal points, individuals in such organizations employ conceptual modularity when dealing with such ambiguity. In such contexts, concepts are composed of components—elements such as stories, metaphors, and prototypes—which have modular properties of substitution and interdependence, the assemblage of components is evolved over time, and these components are distinct from the corresponding physical components most commonly considered in innovation studies. Common practices employed in working with concept components are described. In addition to providing decision-logics by which to coordinate action, modular concept components may also provide other functions, including organizational identity and temporal markers within organizations.

Individuals in organizations at times need to cope with high levels of ambiguity and to coordinate their actions in such situations (Weick 1993). One prime example is the case of developing new directions for innovation, where individuals are faced with novel combinations of technologies where they have few templates for how decisions should be made (Dougherty 1990; Hargadon and Sutton 1997; Henderson and Clark 1990). Coordinating such activity in such ambiguous contexts can be challenging, as goals can be unclear and changing, few existing organizational practices may be relevant, and many individuals may be involved—each with some effect over a subset of a design that must function as a whole (Dougherty 1992). Practices related to describing and interpreting a novel concept may be especially important in these ambiguous contexts (Brown and Eisenhardt 1995; Burchill and Fine 1997). In such settings the individuals involved in development draw upon cognitive models to guide what they may regard as appropriate action under a limited set of organizational routines. While potentially of great importance in these ambiguous settings, an understanding of the process by which individuals collectively manage this conceptual process has been lacking (Shane and Ulrich 2004).

This research set out to inductively understand how novel concepts are constructed and evolved within organizations. A focus on novel concepts brings a more cognitive and interpretive perspective to the study of coordination in ambiguous contexts, in contrast to behavioral and political approaches (Normann 1971). This study builds on the tradition of studies of how product concepts evolve within systems of producers and users (Clark 1985; Rosa et al. 1999), but it differs by taking a focused look within the organization, at the practices employed among team members to craft and modify conceptual goals prior to market launch.

An inductive perspective was employed where the underlying concept components were catalogued at various points in the process; this approach illustrates how conceptual modularity is employed by individuals dealing with an evolving and ambiguous conceptual landscape. The approach will be shown to provide a surprisingly similar process across very diverse organizations, from small start-ups to large multinationals. Although the representation of goals embodied in concepts can form an

important coordination device as a form of “focal point” among members (Schelling 1960), concepts were found to be composed of components that reflect more varied activities of the organization.

NOVEL PRODUCT CONCEPTS

Individuals coordinating their activity in organizations can be viewed to work across three organizational sub-systems: the task subsystem defining actions, the political subsystem describing the locus of control, and the cognitive subsystem involved in sensemaking (Normann 1971). Comprehensive reviews of the product development literature (e.g. Brown and Eisenhardt 1995) have described what is known about the characteristics of the task system, such as how events are sequenced or emphasized within development, and the political system, such as the level of control exercised by central authority versus that by work teams. In line with earlier contingency studies of innovation (e.g. Woodward 1958), each subsystem may need to be adapted to the novel innovation context. Indeed, studies focused on more ambiguous or “radical” settings describe modifications that may be beneficial to these systems, such as increased overlap in stages (MacCormack et al. 2001), delaying decisions (Thomke and Fujimoto 2000), or focusing control within project teams (Cardinal 2001). While all major reviews note conceptual issues as important, they also note that much less is understood about the concept development process (Brown and Eisenhardt 1995; Shane and Ulrich 2004).

The ‘product concept’ can be viewed as representing the goals of the development process for a new product (Crawford and Di Benedetto 2003)—such as an expression of what is going to be changed from existing artifacts and how customers will gain from the innovation. The potential importance of concepts in coordinated product development is supported by studies by Clark and Fujimoto (1991) in the automotive industry, where easily-communicated concepts were associated with successful projects. Burchill and Fine (1997) used causal-loop systems modeling applied to cases of product innovation to demonstrate how design objective credibility and concept commitment would be important to the concept

development process. The importance of concepts was emphasized in such studies, but the specific process of creating and modifying concepts, however, remained a question.

A glimpse of the underlying process of working with concepts is provided by Bacon, Beckman, Mowery, and Wilson (1994) in their pilot study of twelve paired projects. They found that “priority criteria lists,” summaries of the main characteristics of the product, were recalled differently among members of a project, and they noted that the changing nature of the product definition should be considered in future research. The case study of Polaroid conducted by Tripsas and Gavetti (2000) demonstrated the firm’s failure to adopt to technological shift toward digital imaging, noting that managerial cognition, such as understandings of certain business models or technological functions, could restrict search in product development activities. Indeed, as one of the features of management is the management of attention (March and Simon 1958), in times of technological ambiguity the focusing of attention through novel cognitive models may be especially important. Such focus may be difficult for individuals in the realm of products, especially when ideas stray from those that serve as familiar templates (Goldenberg et al. 2001). While it appears the process by which the concept is created and is changed will be important, the specific process of managing novel concepts could be better understood, and so an inductive study was undertaken.

METHODS

Case studies are particularly effective in exploratory areas of organizational inquiry where organizational context is significant (Yin 1994) and the range of factors that may be important to process outcomes are not yet known (Eisenhardt 1989). In the area of product development, using case studies has been noted as particularly appropriate (Montoya-Weiss and Calantone 1994). The approach of this study is to develop middle-range process theory (Merton 1957) that helps to explain how novel product concepts are managed through to the outcome of release to the market.

Case Selection

Heeding the guidance provided by Downs and Mohr (1976) to select innovation variables based on primary attributes that are fixed across all cases, cases were selected where the innovation was new to both the market and the organization. To assess a market novelty, mention in *The New York Times* or *The Wall Street Journal* was used, as these national newspapers have sections that cover the three industries under study and would be expected to provide coverage for only the most innovative products. A second indicator of market novelty was the receipt of national innovation awards or significant testimonial. Each case name was disguised but termed to provide a helpful indication of the product. Organizational novelty was assessed through preliminary interviews; examples of the assessment of novelty across cases is summarized in Table 1. To preserve confidentiality, some descriptions of concepts have been slightly altered in this study, while still preserving a sense of the themes for illustrative purposes.

All of the novel concepts were launched and sold in the market as new product innovations, the outcome of interest for this study. As developing innovations is subject to multiple barriers (Dougherty 1992) and a large proportion of radical innovation projects are never launched (McGrath 1999), the fact that each product was produced for consumers is a measure of successful, if painful, navigation through a radical development process.

--Insert Table 1 about here--

Breadth in industries selected was desired so that the results could be generalizable across industry contexts. Two cases of novel concept development projects were drawn from consumer electronics. *eBook* was one of the first hand-held dedicated electronic book reader announced and was one of the first generation of products to define the emerging category of electronic book reader. *PDAPhone* was one of the first products launched to integrate personal digital assistant (PDA) and mobile

phone functions as well as related communication abilities such as e-mail and web access, a novel functional combination at the time.

Two cases, termed *RadCross* and *Flextruck* were drawn from different divisions of the same automotive firm. *RadCross* was the first "crossover" vehicle for its firm, seeking to incorporate a novel mix of product platform attributes not before seen on the market. *FlexTruck* was a new truck with an innovative flexible cargo area design.

The final two cases were drawn from the medical / sports therapy market. *BodyCool* provided body cooling based on technology targeted toward serious medical applications, but the first actual application was for athletes. *JointCool* was designed to cool specific joints using a novel combination of therapies.

The cases were based on novel concept development projects that had ended within one year of the commencement of data collection. Across the six cases, the development contexts differed from small start-up environments to large multidivisional firms. The formal product development task systems differed among cases, ranging from a highly unstructured process for the electronic book to very formalized development processes with long histories for the automotive projects.

Data Analysis

Primary data was gathered through fifty-one interviews across the six projects, where the focus of interest in interviews was how the concept was specified at various points during the project. A minimum of five roles were included: executive leader (the CEO in smaller firms or the executive champion in larger firms), project leader (person responsible for project coordination), engineering manager (person responsible for a team of engineers), marketing manager, and engineer. Extra interviews of additional engineers and product designers were also included; a summary of the total number of interviews for each case is included in Table 2.

-- Insert Table 2 about here --

Interviews were augmented with archival data which provided reference to written and visual descriptions of the concept and also listed key milestones. All interviews were audiotaped when permitted, which included all but three informants. Transcripts were transcribed, and upon completion of the interviews six case studies were developed that provided a narrative of the concept development process for each project.

Concept components were cataloged through the development of the cases. An example of a concept component was the verbal description that the JointCool product was to be “sleek and sporty, like a BMW.” A further component could be a physical model that described a key feature of use. These components are not to be confused with the actual physical components that make up the product to be manufactured, but the labeling of these elements “components” will be seen to reflect their use in the conceptual domain and follows generalized modular approaches that range across physical and social systems (Baldwin and Clark 2000; Schilling 2000). The practices involved in the definition and use of these concept components became a central focus of the study, and in total over sixty concept components were noted among the six cases. Through considering the common elements under which product concepts were crafted and managed across the six cases, an appreciation of the process emerged.

RESULTS AND INDUCTIVE PERSPECTIVE

From the empirical evidence, managing novel product concepts is found to take place within a process involving four phases within an evolutionary interpretive context. The four phases consist of: *conceptual system definition*, establishing an initial set of concept components and relationships; *concept elaboration*, where new concept components are introduced and fitness-tested; *concept shifting*, where some components are seen to no longer apply and a new conceptual system is established; and *concept execution*, the period when the concept is frozen and final design decisions are made. The process takes

place within an evolutionary interpretive context, linking a conceptual system of ideas to a technical system of physical artifacts.

Conceptual System Definition

The first common element of novel product development is a phase of *conceptual system definition*, practices related to the definition of both components and relationships.

Definition of initial components The common first set of practices in novel concept development all served to define initial concept components. There was surprising uniformity in practices that were used, even if supported to differing degrees. The practices generated concept components were the generation of 1) a “concept genesis story” of how the concept came about 2) an initial concept vocabulary of terms applied to the concept and 3) an initial physical form. Examples, focused on the case of the eBook, are given in Table 3.

--Insert Table 3 about here--

In all cases, informants spoke of a story that was related to them about how the concept originally came to be, a story that at least initially defined what was considered a key component of the concept. Table 3 provides an overview of the strength of the evidence of this practice in each case. Perhaps the most vivid of the genesis stories was told by the executive of the firm that developed the eBook, relating the initial need driving the novel concept:

“[I was] flying from San Francisco to Hong Kong, with all of the electronic information I had printed out, but it was loose sheets of paper sitting by my printer, really important stuff, ‘read some day,’ but impractical to carry on an airplane and very heavy: that much paper is incredibly heavy. And I finished my book with 12 hours to go. So, foolish mistake. I thought, ‘I need something...Once I get down maybe I’ll find one in Hong Kong and buy it.’ But there wasn’t anything remotely close to it, which really surprised me.”—eBook Executive Leader

In the case of the eBook, this story appeared well known by designers in the organization, one of whom shared his understanding of the story:

“The original problem as I heard [it is that] on an airplane, you have a ton of paperwork, or a ton books that you would like to get through, why couldn't you...just download what you wanted in one place?”—eBook designer

In addition to a concept genesis story, in each case leaders introduced verbal elements that constituted the vocabulary for the product concept. The extent of the vocabulary varied within the cases, with eBook perhaps providing the most vivid case of the introduction of a full range of vocabulary elements, in this case describing the need to think of the design in terms of book-like elements. As a core element, the project leader introduced a broad metaphor as a statement to be reinforced:

“And so that statement was ‘It's a book!’ ...[we] pushed our engineering team to be very careful with the vocabulary that we used, because in some ways, it's the language we use that implicitly defines what it is that we're working on. And so I worked hard at making sure that instead of using ‘download a book,’ you'd be like, ‘transfer a book,’ and instead of looking at how large a book is in terms of how much ‘K’ [kilobytes] it took, it's like, ‘No, it's how many *pages* this book is.’”—eBook Project Leader

Engineers working on the eBook also noted the use of this use of vocabulary. For example the engineering manager recounted that, “The book metaphor was very strong for us...”, and described how it had influenced design decisions. In the case of PDAPhone, the use of terms such as “Smartphone” and “Facilitator” were introduced to distinguish the new product goal from their historic product focus on PDAs. In only one of the cases, RadCross, was the introduction of new vocabulary specified as part of the formal development (task) system.

In addition to verbal descriptions of the concept, in each case there was also an initial physical mock-up of the concept. The executive of the firm designing the PDAPhone for example used a crude wooden mock-up of the product, and the engineering manager summarized the process succinctly as: “You build a model. It gets carried around, it gets talked about, it gets refined.”

A further common concept element at this stage in the process was the development of minimal project documentation. Often these written records were in the form of an executive summary sketch of

the product proposed, as in the case of FlexTruck where they had prepared just a simple twelve-page overview, even though larger documents were expected in a large automotive company.

Together, the processes invoked are surprising in their consistency but can be understood in relation to existing theory. Information theory suggests that in times of greater uncertainty or ambiguity (Daft and Lengel 1984), greater emphasis at building means for communication will be needed (Galbraith 1974) and managers will strive to form a shared grammar (Weick 1979). The telling of stories within organizations has been discussed in the context of how they serve to guide identity and sense of purpose for participants (Martin 1982), provide a dynamic interpretive context (Boje 1991), or to convey information on how to get work done (Orr 1996). Stories serve in this case to provide an easily-conveyed sense of one or more attributes of the concept to be developed, in a form that may be modified with time. The use of metaphor presents an effective short-hand for introducing ideas into dialogue and simplifying cognitive operations (Lakoff and Johnson 1980; Schön 1993) and are particularly salient to individuals, especially when combined with additional imagery (Paivio and Walsh 1993). The use of crude prototypes provides an early boundary object (Carlile 2002) by which participant can at an early stage question aspects of the new concept and an early visual artifact that may relate especially well to an engineering audience (Henderson 1995). The existence of minimal documentation may also signal that the project has begun, even if providing documentation is only symbolic managerial action (Pfeffer 1991) and little-referenced. The wide array of concept components at this stage helps to establish the elements of a conceptual system—a system of language, form, and written artifacts—which can provide a basis for common understanding when there is much ambiguity. The above discussion also points to the range of functions these early elements have. Not only do they provide some decision-logic about how to coordinate action, they may also provide some identity to individuals in an organization (such as that one works on the new domain of eBooks, not PDAs) and a source of temporal information (that the process has begun, as the concept has several components including an early prototype).

Establishing comparative relationships The initial conceptual system requires not only components but also relationships between these components and other known domains. There were two

common practices of establishing comparative relationships: 1) comparing to other concepts and technologies, and 2) assigning a new concept category.

At the time the novel concept is first being defined, there are products in use that provide a comparative reference point for the novel concept proposed. The case of the eBook provided a good illustration of how such comparisons are made. At the time, there were no stand-alone hardware readers for electronic content, but there were personal-computer (PC) based readers for viewing content on a computer, and there were PDA (personal digital assistant) readers with small screens that could be used to read some material electronically. The leadership team of the eBook made comparisons to both types of product as they laid the groundwork for their product.

An additional practice was in assigning a new concept category. In the case of the eBook, the marketing manager explained that rather than consider the eBook a type of PDA or a portable version of a computer reader, the idea was to create electronic books as their own category:

“We’re really trying to create a new category here, and that is a really tough thing to do. I’ve been down this path a couple of times in my career before. It’s just very, very tough to create new categories.”—eBook Marketing Manager

In defining a new category, it meant that designers were asked to not fall upon models of making design decisions that might be the norm in existing categories, such as in PDA or computer design. The framing of a new category segment was well illustrated in the case of the PDAPhone as well, as they navigated a terrain between traditional PDAs and mobile telephones, by employing an overarching phrase such as “Facilitator” to cover a combined set of functions distinct from traditional cell phones. The phase of conceptual system definition ended when the description of the concept has been sufficient to enable a commitment to development.

The development of comparative relationships helps to define relationships that are critical to engineers’ understanding of how a new technology may fit within a system of known “operational principals” (Polanyi 1962), even if the new technical system is not yet defined. Rather than seek out existing categories that might be easier for customers and developers to make sense of (Goldenberg et al. 2001; Rosa et al. 1999), in each case new categories were proclaimed in relation to existing categories.

This demarcation of a new boundary may serve to provide a further hierarchical organizing mechanism (Vincenti 1993) that enables engineers to order the concept in a larger system of relationships.

Concept Elaboration

The second common element observed across the case studies drew upon practices associated with a phase of concept elaboration. Previous perspectives tend to examine a process of selection of design alternatives to meet a relatively fixed high-level concept (Clark and Fujimoto 1991; Fujimoto 1993). In contrast, with a focus on novel concept components themselves, additional concept components went through a modular and evolutionary process of variation, selection, and retention. As summarized in Table 4, there were three primary practices inducted across all cases: the identification of concept tensions, the introduction of new components, and a testing of new components for fitness to the concept.

--Insert Table 4 about here--

Identification of concept tensions In each case studied, informants spoke of at least one underlying concept tension that was present during product development. A concept tension existed when there was a definition of an identified range of options that one product attribute could take, where one aspect of the range was desired by project leaders, but the other aspect was equally feasible within the conceptual and technical system. In the case of RadCross, this new “cross-over vehicle” had an identified tension around the form of the vehicle, specifically as to whether the mix of attributes would be more sport-utility vehicle (SUV)-like or more van-like, as either could be a feasible interpretation of the concept of a cross-over vehicle. In the case of the eBook electronic book, one tension was in the domain of the platform for electronic book reading, specifically whether the eBook would also include the ability to read such material on the PC (or exclusively on the PC):

“But we were very much disciplined by the comment, ‘It’s a book!’ That’s helped us from making a pen-computer, or an organizer, or a PDA. And there were so many opportunities to turn it into something else.”—eBook Executive Leader

Introduction of limiting or comparative components A second practice observed in this phase was the introduction of limiting or comparative components. As the literature would suggest, at this stage of development some guidance of how to limit design decisions is common (Guilford 1967; Hales and Gooch 2004). While some of this limitation could come from developing specifications that embody concepts, there were also examples of new concept components introduced that did not have a strict limiting function but rather provided more general comparative mapping of the concept against known domains. As an example of one such component in the development of the FlexTruck. Through consideration of what functions might be most valued by customers, the concept leaders determined that there were two main criteria that any design solution would need to meet. This is limiting elaboration of the concept acted not only as a specification but also as a new concept component by limiting the form that a final product can take.

Testing for concept fitness As new components are elaborated, in each case a process of testing for “concept fitness” was observed. During the concept elaboration phase, new ideas were tried out, promoting *variation*. Leaders controlled which ideas were adopted as part of the product concept, a *selection* of new components. After this selection, components were promoted by leaders using various communication practices for use as guides for later design decisions, promoting *retention*. As can be seen from Table 4, the testing for concept fitness practice was among the consistently strongest findings across cases.

In the case of the eBook, engineers provided a great deal of variation regarding potential features to include in the new product. The project leader described how “... there is also a lot of anarchy...different engineers have had ideas and things that they wanted to try out and so they put it in there and test it out.” The engineers agreed that this sense of experimentation defined the process, one

stating that “[being told not to] didn't prevent us from going off and prototyping email...and doing medical forms, you know, wacky things.” Some potential features were reported to be easy to know whether to include or not, given the basic concept component and metaphor “It’s a book!” The phase of concept elaboration ends when design specifications are mapped to the technical system and work may begin on final design decisions that will lead to manufacturing specifications. However, before this could happen, in each case there was an interruption, a phase of concept shifting.

The concept tensions seen at this stage would not be expected in the realm of more incremental product development, where attributes accorded to product categories are more stable (Rosa et al. 1999). By indicating a field of such tension (such as form of cell-phone among known alternatives), one can link the range of possible decisions to a more limited conceptual domain. By emphasizing attributes associated with one end of the concept tension, decision-logics are provided for appropriate action (March 1994). Much activity in organizations takes the form of looking to ensure consistency among elements (Kogut and Zander 1996), and this process of testing for concept fitness is the means by which this is carried out at the conceptual level. The notion of fitness is not unlike notions of organizational systems and strategic fit (Siggelkow 2002). In the context studied here, fitness is part of a process of interpretation of individual elements and the eventual selection and retention of such element for the conceptual system.

Concept Shifting

The third common element in the case studies was a phase of concept shifting, a phase when a concept component was found to be no longer be supportable due to lack of fitness to the conceptual or technical system. Concept shifting came as an interruption of concept elaboration and can be seen to provide conceptual-level detail of change processes in novel product concepts. This process is described in more detail in Seidel (2007), which describes how at the conceptual level actors did not necessarily view such concept changes as classical iteration back to prior task development stages.

While all six of the cases exhibited this phase, it is conceivable that the process could unfold without a pronounced shift. But in the case of truly novel concepts, where there is much ambiguity at the outset and much change during the course of development, it is likely that a shift will take place. In fact, multiple shifts can take place (Seidel 2007) as the concept is realigned to a range of new information. For the current discussion, as summarized in Table 5, the four common practices within this phase will be highlighted.

-- Insert Table 5 about here --

Identification of lack of fitness A first practice within concept shifting is the identification of lack of fitness between a concept component and the technical system. The case of BodyCool provides one example. In the case of BodyCool, an original concept component was an expression related to the phrase “Cool for therapy.” During concept elaboration, the leadership team noted “We found that we can’t really do that. We’re not there yet. The understanding of the science and physiology is not there yet...” This identification of a lack of fitness between the conceptual system and the technical system meant that the original market for BodyCool, a medical market, appeared no longer attainable, requiring the leadership team to take some course of action.

Freezing of selected components and search Once a lack of fitness had been detected, leaders determined which components to freeze and which to allow to be redefined. In this process, a reevaluation of what constitutes the core concept was undertaken. As the project leader for PDAPhone related, even when dropping the concept component of ‘input device A’ technology, “the overall message is that it is still [the core concept of] a ‘Facilitator.’” In the case of BodyCool, the component that was frozen were the two key technical attributes, temperature control and an apparatus to deliver the temperature control to the user.

Substitution of components. After an inconsistency was identified and core concepts were frozen, a solution process was run to determine how to match the concept to the technical system. As a result, a new means to frame the concept and match it to a new feasible technical system was developed. There was a substitution of components at this stage, which marked the conclusion of this solution process. In the case of BodyCool, for example, a concept component that had been the story of how the technology would be used on medical patients were replaced with a sports-related story of how the technology enabled a grad student to have phenomenal recovery after doing push-ups during an informal laboratory experiment.

Management of dual conceptual systems. The final practice observed was particularly surprising. In each case examined, while the revised conceptual system was the one that led to the product that was produced, the original conceptual system was also kept alive and deferred to later development, rather than wholly dropped from plans. In both cases products that were originally developed for the medical device market, JointCool and BodyCool, the medical device focus was still kept alive even as the product was shifted for exclusive use as a sports therapy device. At the end of the interruption by concept shifting, the process continues with further elaboration of the revised set of concept components, until completion of elaboration and the commencement of the phase of concept execution.

The identification of lack of concept fitness serves to highlight coordination issues, by exploring the interaction between the technical elements as represented among concept components. As consistency is desired among actors in organizational processes (Kogut and Zander 1996), the identification of inconsistency serves to engage efforts to find means to replace elements that detract from fitness. Weick (1998) has that action is often a result of events that fail to fit together in the minds of participants. The freezing of certain components, followed by subsequent steps of change and re-freezing, follows a pattern most notably elaborated by Lewin (1951). Unlike wholesale change across a range of organizational components, this change was directed at one of several original concept

components. The function of fixing a few components helps to limit attention of the design and leadership team to a restricted set of elements, allowing a substitution process to commence. There are two primary functions that are served by keeping old ideas alive even as activity is shifted to the new concept. First, preserving participants' initial identity may be perceived to have advantages for the organization, such as decreased coordination costs among members (Kogut and Zander 1996). And second, the original conceptual system engendered a commitment to course of action (Staw and Ross 1987) which would be difficult to reverse if perceived as completely abandoned. As demonstrated above, concept components at this stage exhibit both decision-logic and identity. They help guide new decisions in the face of change, while allowing old conceptual systems to provide continued identity associated with the original direction.

Concept Execution

The final common phase was a period of concept execution. As summarized in Table 5, this phase is associated with practices that hold the concept as fixed, allowing design decisions to take place that lead to final manufacturing specifications, and working to defer other ideas to later products. This phase commenced when further elaboration was no longer needed in matching the concept to the technical system.

At this stage many design decisions are still to be made, and so a challenge is in limiting the decision to those that will embody the concept as it has been fixed and as it is able to map to a technical system. Preventing the proliferation of features—"feature creep" as it is generally known—was a focus across the cases. At JointCool, "[We would ask ourselves] 'What are the three things that we are going to leave on the 'back burner'? But don't forget about it, because if it becomes an opportunity we might want to do that.'" reported one engineer.

The end of this phase is marked by the concept being embodied in an actual product that is sold on the market. As a result, the new product is available as a reference concept for future novel product concept development. In each case studied there was comprehensive press mention of each product as it

became available on the market, as each represented a new idea in how to solve a user need. In this final phase the conceptual and physical become, in a sense, one.

DISCUSSION

Using a cognitive focus on the communication between and perceptions among actors in the process, the results describe practices by which leaders work in conjunction with a design team in crafting and managing novel product concepts, practices not apparent under more task- or control-focused perspectives. As the above results demonstrate, the process can be broken down into evolutionary components and one in which the concept takes on multiple roles.

An Evolutionary Context

A unifying common element to novel concept development was in finding the process takes place in an evolutionary interpretive context, enabled by the modular nature of components in use. As Aldrich (1999: 14) has noted, “evolutionary models do not specify the engines driving variation, selection, and retention, and thus they depend on ideas from other approaches for their power.” This study demonstrated an interpretive context (Daft and Weick 1984)—focusing on how leaders and those in the design team sought to create meaning and derive meaning from concept components—described the underlying dynamics of novel concept development.

The context of novel concept development is one in which the concept itself is formed through evolutionary mechanisms of variation, selection, and retention of components, all in the presence of a further evolutionary element, struggle (Aldrich 1999)—in this case the struggle of time constraints and the limited attention of participants. A majority of concept components were introduced by leaders of the organization, but not all were, and the process by which concept components were adopted was one of negotiation among participants as to which concept components fit with both the conceptual system and the technical system.

Although sketched in the prior examples, a succinct illustrative example of such evolutionary action comes from RadCross. The lead designer of RadCross saw a multipurpose jacket when he was out

shopping with his daughter, and it seemed to him to capture a concept he was hoping to incorporate in the vehicle, that of multipurpose outdoor functionality (variation). He took photos of this jacket into work, and these were plastered on the walls of the room where team meetings were held. Managerial leaders began to use this design icon in their discussions of objectives for the product (selection), and engineers and designers reported seeing this icon as part of their design meetings (retention). A range of interior and exterior accessories that were developed for the product were later added to the product line (outcome).

The context can be considered more generally. With respect to variation, within the social process of design in these cases, it has been shown how the ambiguity of the situation leads to varied proposals for understanding how the concept can be elaborated in terms of form, need, or technology. In the case of PDAPhone, for example, either the flip-phone or the simpler stick-shaped form could have been chosen, and each was suggested as a means to meet the existing concept components. Secondly, after an ongoing process of concept fitness testing, certain concept or specification components are eventually selected. This selection function is typically overseen by the leadership team in the design process, as was seen in the case of the form of the PDAPhone, or it can be negotiated to selection, as in the case of an address book for an eBook. Finally, such selected components are then retained as part of the concept that serves to guide and reflect decision-making and coordination through the development process. This retention may be facilitated in part through an emerging written record and detailed elaboration of the concept into specifications and eventual design drawings.

The Functions of Concept Components

As discussed above, the way in which concepts function is not just as a decision-logic or focal-point goal as might be expected from the focus of prior literature. Rather, multiple functions could be discerned from among the cases: functions of decision-logic, identity, and temporal marker, as summarized in Table 6.

--insert Table 6 about here--

As decision-logic, concept components provided a cognitive framing (Huff 1990) useful in making design decisions for coordinated outcomes. As was previously described, the eBook use of the “It’s a book!” metaphor was drawn upon by engineers in determining how certain software features were to be implemented. Some components did not appear to have a direct coordinating function, but they did appear to provide a level of organizational identity for participants and possible indirect coordinating functions (Albert et al. 2000) which may facilitate later organizational adaptation (Dutton and Dukerich 1991). For example, in the case of the PDAPhone, the program was internally referred to as the “atomic bomb” project to signify its importance to the firm. In such a case the effect can be two-fold: providing identification for what is framed as a critical program, but also providing some secondary level of decision-logic: for example, that much funding could be spent or that long hours are expected, as would be the case in developing an important weapon. In the case of JointCool, all participants were told how the base technology derived from lab research for the national space program, which may reinforce later decisions to emphasize high-technology features rather than cost-reducing methods. While this context may not assist in making immediate decisions, indirectly it linked participants to a shared identity.

Further, there may have been a temporal nature to the use of components. As temporal marker, the concept provides information in an under-specified process about just how far along the process one is. Components may provide a means for interpretation of not only what actions to take but also of the current state of the process itself, fitting into a model of interpretation as an important mode of organizational life (Daft and Weick 1984), especially in situations where a logic of consequence is a difficult or inadequate means to make decisions (March 1994).

In a directive sense, the concept provides framing for making mainly consistent decisions across the organization, serving as a representation of the object to be produced. The evolving concept also records decisions as they are made, through the elaboration of further components, serving to coordinate future action. By providing a sense of identity, the concept may coordinate broadly-shared and enduring

models of how decisions are to be made. Finally, by the level of (in-)completeness at a given point in time, concepts reflect the temporal nature of the process. Overall, as the elements of the concept are debated, the concept provides a platform for dialog about the goals and means employed among members, serving as a form of virtual boundary object (Carlile 2002), facilitating the learning or development of new coordination routines.

Contributions and Limitations

The Daft and Weick (1984) model of organizations as interpretation systems notes that scanning processes of data collection are followed by interpretive process of giving meaning to such data, in turn followed by subsequent learning processes. The construction of this study was to focus on those interpretive processes by which data is given meaning in order to allow decision-making activity. As such, this study provides a link to complementary studies that focus on earlier search activities (Gavetti and Levinthal 2000) and later learning activity (Cohen and Levinthal 1990) in innovation studies. This contribution helps to augment, rather than replace, our cumulative understandings of how radical innovation unfolds in organizations. While the indeterminate nature of evolutionary process theories (Aldrich 1999; Siggelkow 2002) stands in contrast to variance approaches, the resulting theory highlights the multiple modes in which leaders function in completing different phases of the process. This study hopes to help expand the means by which we look at the modular nature of systems, adding and linking a cognitive perspective to our knowledge about such systems of interdependence and substitution.

There are limitations to this study in addition to methodological considerations mentioned previously. The focus has been to focus on developing a process that is simply described and general across contexts, at the expense of some degree of accuracy in the details of all aspects expected at each phase. Details will by nature differ among industries and types of products—a novel product in the medical device industry will naturally undergo different scrutiny than one in the consumer market. Elements of this process may be evident in unsuccessful projects as well; the observation of some practices early in the process would not ensure that the process will be successful.

Future research on novel concept development can explore variance aspects of the process and the relationship to performance outcomes. Further, while this research has focused on the cognitive organizational system, future research could better explore how the practices outlined here interact with those of the task and political system.

CONCLUSION

The process theory presented demonstrates how novel product concepts are crafted and managed by leaders and their product development teams and what range of practices contribute to this process, focusing on the process of managing novel product concepts across this range of innovation contexts. This process is situated within an interpretive evolutionary context where the concept is crafted, elaborated, and shifted over time, transforming a new conceptual system into a concrete physical product. With a focus on the process of novel concept development across multiple settings, we gain an appreciation of the practices invoked in navigating this turbulent path from idea to product, in environments of considerable ambiguity.

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TABLES

Table 1: Evidence of novelty among cases

Case	Market evidence: Example press mentions and major innovation awards	Organizational evidence
eBook Handheld electronic book reader	<ul style="list-style-type: none"> – Example press: A <i>New York Times</i> article near time of launch asks “Is this the end for books?” – Awards: Two major design innovation awards 	“...we were making something that had never been made before, so it was hard to ask customers whether it suited their needs, because they had never seen one before” – eBook Executive Leader
PDAPhone PDA, e-mail, and mobile phone functions	<ul style="list-style-type: none"> – Example press: Positive reviews in <i>The New York Times</i> citing it as one of first in category – Awards: Major annual design innovation award. 	“[The emerging market] is defined as a combination of voice, data, and PDA. The platform together is just being defined...” – PDAPhone Engineering Manager
RadCross “Crossover” of car, van, and truck functions	<ul style="list-style-type: none"> – Example press: A <i>New York Times</i> review describes it as creating a niche – Awards: Major consumer award for appeal of combination of interior design, comfort and convenience features 	“It was a brand-new type of vehicle that we had never done before, being this crossover type of vehicle...”—RadCross (Premium Version) Product Designer
FlexTruck Pick-up truck and sport-utility functions	<ul style="list-style-type: none"> – Example press: A <i>New York Times</i> article notes the “clever idea” central to the concept – Awards: Two major (and many minor) automotive magazine awards including one for “design & engineering”. 	“When you are doing a very unique concept like what this truck is, you really would prefer not to have [supplier issues].”—FlexTruck Engineering Manager
BodyCool Novel body cooling function	<ul style="list-style-type: none"> – Example press: A <i>New York Times</i> article noted it as a new cooling system – Awards: Major award for “outstanding design innovation” bestowed by national medical charity 	“...when you are dealing with a revolutionary device, the customer itself doesn’t know what they want.”—BodyCool Quality Manager
JointCool Combination of two physiological processes	<ul style="list-style-type: none"> – Example press: <i>Wall Street Journal</i> covers novelty of approach and space science background – Awards: No national award, but testimonials from diverse national sports professionals. 	“People [who first try it] are like, ‘Wow, it’s different.’ This is what we were trying to connote [with the design] is: this is something new; this is not something that you’ve used before.”—JointCool Engineering Manager

Table 2: Case study interviews

	eBook	PDAPhone	RadCross	FlexTruck	BodyCool	JointCool
Leadership interviews	Executive Leader	Executive Leader	Executive Leader	Executive Leader	Executive Leader	Executive Leader
	Project Leader	Project Leader	Project Leader	Project Leader	Project Leader	Project Leader
Other member interviews	Engineering Manager	Engineering Manager	Engineering Manager	Engineering Manager	Engineering Manager	In-coming and outgoing Engineering Managers (2)
	Marketing Manager	Marketing Manager	Marketing Manager	Marketing Manager	Marketing Manager	Marketing Manager
	Software Manager	Engineer	Product Designers (2)	Engineers & Product Designers (5)	Quality Manager	Marketing Manager
	Engineers & Product Designers (3)		Engineers & other technical staff (9)		Engineer	Core (1) and peripheral (2) Engineers & Product Designers
Interviews (total=51)	8	5	15	9	6	8

Table 6: Overview of concept component functions

Component function	Description	Example
Decision-logic	Constraint type: limits design decision options	Flextruck: simple rules of solution to meet “flat and secure” criteria
	Comparative type: provides reference for decisions	eBook: “not a PDA” category
Identity	Provides broad characteristics relating project to individual	JointCool: “space technology” basis of project
Temporal	Helps define stage of process	eBook: Physical prototype indicated commencement possible

Table 3: Common practices: Conceptual system definition

Practice	RadCross*	FlexTruck	eBook	PDAPhone	BodyCool	JointCool	Examples from team leaders (Executive or Project Leaders)	Examples from team members (All others)	Interpretive function of practice
Generation of a concept genesis story	+	+	+	+	+	+	“...all of the electronic information I had printed out, [was] impractical to carry on an airplane and very heavy” – eBook Executive Leader relates story of need for electronic book on an airplane flight	“The original problem as I heard [it is that] on an airplane, you have a ton of paperwork, or a ton books that you would like to get through, why couldn't you...just download what you wanted in one place?”—eBook Product Designer	Provides “ends” focus allowing multiple means to meet story parameters
Generation of initial concept vocabulary	+	+	+	+	+	+	“we felt like we had used a metaphor [‘it’s a book!'] that people could easily understand.” – eBook Project Leader	“Even the [on-line catalogue] is presented as ‘a book’ in a sense” – eBook Software Designer	Provides initial grammar for invention
Generation of early physical prototypes	+	+	+	+	+	+	“To introduce the concept to people we didn't use descriptive words, we showed them a model and it was so obvious to people, the response was overwhelming” – eBook Executive Leader	“[Early on the executive] came with a...model of what an e-Book might look like.” –eBook Software Engineer	Visualization of possible solution; aids in commitment to an uncertain course of action
Comparison to known concepts and assignment of new category	+	+	+	+	+	+	“So the product development process started by being able to really invent the new category, so we had to define new things while it was at a really rough stage: what does it mean, what does an electronic magazine look like?”—eBook Project Leader	“We’re really trying to create a new category here, and that is a really tough thing to do. I’ve been down this path a couple of times in my career before. It’s just very, very tough to create new categories.”—eBook Marketing Manager	Comparison links new conceptual system to a feasible technical system; new category signals need for new organizational routines

*Legend: (++) Practice evident from both leaders and other members (+) Practice evident from leaders or other members

Table 4: Common practices: Concept elaboration

Practice	RadCross*	FlexTruck	eBook	PDAPhone	BodyCool	JointCool	Examples from team leaders (Executive or Project Leaders)	Examples from team members (All others)	Interpretive function of practice
Identification of concept tensions	+	+	+	+	+	+	“I could put my PDA functions on here, you know? I can look at spreadsheets...well you could, but...it's not a computer, it's a book.—eBook Project Leader speaking of decision to differentiate from PC devices	“As soon as you do email, you're going to want to read your attachments, and OK, you're going to need a spreadsheet to read your Excel attachments, and then you start being a computer...”—eBook Software Manager	Defines boundary conditions by which to generate new components
Introduction of new limiting or comparative components	+	+	+	+	+	+	“...the user interaction model, description of how somebody would use the product, was something that I had documented in detail.”—eBook Project Leader on the introduction of the interaction model after the project began	“We certainly have product specifications that are written down...” —eBook Software Manager referring to use of interaction guidelines that were developed to guide design decisions	Limits scope of future design decisions
Allowance for “concept fitness testing” of potential components	+	+	+	+	+	+	“there is also a lot of anarchy...different engineers had ideas and things they wanted to try out, and so they put [the new idea] in [the prototype] and test it out”—eBook Project Leader	“And [being told not to] didn't prevent us from going off and prototyping email...and doing medical forms, you know, whacky things”—eBook Software Manager	Makes visible the emerging selection process

*Legend: (++) Practice evident from both leaders and other members (+) Practice evident from leaders or other members

Table 5: Common practices: Concept shifting & concept execution

Practice	RadCross*	FlexTruck	eBook	PDAPhone	BodyCool	JointCool	Examples from team leaders (Executive or Project Leaders)	Examples from team members (All others)	Interpretive function of practice
Concept Shifting									
Identification of inconsistency	+	+	+	+	+	+	“We selected a [specific platform]. That was a little bit of why we chose the [width criteria].” –FlexTruck Executive Leader describing the constraint that led to inconsistency with automatic system.	“[With an automatic solution] we were in danger of losing the [width criteria], which was absolutely [something] you can’t do.”—FlexTruck Engineering Manager	Highlights areas of cognitive dissonance
Freezing of selected components	+	+	+	+	+	+	“...whenever you put the words on the paper there have to be proof points: simple, tangible proof points [of two main criteria] that are physical in nature...and that frankly was our challenge”—FlexTruck Executive Leader	[the constraints] allowed a [reconfigurable truck] that we ended up with to work.— FlexTruck Engineering Manager	Provides boundary conditions for new solution
Substitution of components to describe shift	+	+	+	+	+	+	“The inspiration came out of the [’68 sports car design].”—FlexTruck Executive Leader	“So, [the team] had to come up with some ideas, and actually they kind of drew from the past in this manually operated [’68 sports car idea].”—FlexTruck Product Designer	Provides new means for decision-making
Deferment of original concept	+	+	+	+	+	+	[Evidence collected from interviews with non-leaders and on-going project documentation]	“...that discussion [on electric window features] continues today on the [next series trucks], and what we are going to do in the future....” –FlexTruck Engineering Manager	Facilitates continued course of action
Concept Execution									
Freezing concepts and limiting features	+	+	+	+	+	+	Memo circulated by eBook Project Leader on controlling “Creeping elegance”	“[The Project Leader] was probably the throwing things away guy. He was the minimalist guy. And [the other software designer] and I were probably more driving towards features....”—eBook Software Manager	Focuses attention on revised conceptual system

*Legend: (++) Practice evident from both leaders and other members (+) Practice evident from leaders or other members