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IS to Support Innovation: Weapons of Mass Discussion?

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ABSTRACT
Much has been written about the need for organizations to be more innovative if they are to have a source of sustainable competitive advantage. The literature describes approaches to innovation that range from doctrinaire, procedural methods to laissez-faire, complex methods. This paper takes the semiconductor industry as a case study of an industry where innovation is critical, and describes the systems that are actually in use in the industry today. It will be seen that a common theme running through systems to support innovation is the facilitation of discourse among and between people engaged in the design activity.

INTRODUCTION
Innovation can be seen as an outcome (product) or a process (activity) or a combination of both. Those with a product-oriented perspective see innovation as emphasizing commercial outcome as the defining characteristic of innovation: “invention is the solution to a problem. … An innovation is the commercially successful use of the solution” (Bacon and Butler 1998), “an innovation in the economic sense is accomplished only with the first commercial transaction” (Freeman 1982). Economists use patents or patent applications as a proxy for innovation thereby focusing solely on outcomes (Acs, Anselin et al. 2002).

Another research stream concentrates on the processes by which innovations are generated. Nightingale plays down the outcomes and focuses on the process through which innovations are developed seeking: “a theoretical model that explains how the innovation process moves from an initial, ill defined conception of a problem, through a series of sub-problems, to a finished technology” (Nightingale 1998). Van de Ven et al. see the innovation process as “a nonlinear cycle of divergent and convergent activities” allowing the process to take precedence over the actual outcomes: “innovation success or failure may be more usefully viewed as ‘by-products along the journey’ than as ‘bottom-line’ results” (van de Ven and Polley 1992). Shepard sees the process of innovation primarily as a learning process: “When an organization learns to do something it did not know how to do before, and then to do it in a sustained way, a process of innovation has occurred” (Shepard 1967).

Among those who see innovation as an activity view are those who emphasize the importance of the activity as either a rational planning process or as a complex social process. The next section will review both perspectives.

INNOVATION AS A RATIONAL PLANNING PROCESS
A process is a repeatable set of value-adding activities with a discrete beginning and a discrete ending that produces desired, predetermined, measurable outcomes. This view posits that all work is a process and all products or services are the outcomes of processes. To meet the customer’s requirements effectively and efficiently, each stage in the process should have an “owner” and be executed in a repeatable manner. In this way innovation is a strategic imperative of organizations and can be attained through a linear sequence of activities. The conduct of innovation is the result of a purposeful and conscious search. This view of innovation is rooted in systems thinking and holds that the origin of innovation is located in the reasoning capacity of autonomous individuals who choose the goals for a cybernetic system that unfolds the innovation.

Drucker focused on two aspects of innovation: the process of innovation i.e. how innovators search for opportunities and transform them into a new practice in the marketplace; and the practice of “entrepreneurship” i.e. institutional ways and processes embed the practice of innovation into an organization (Drucker 1993). He analyzed a large number of cases to propose five elements of the process of innovation:

(i) searching for opportunity:
(ii) developing a project or business plan
(iii) going out into the community, finding what they are receptive to; adapting the proposal to match
(iv) developing a simple articulation of the central idea
(v) positioning the technology to be the best of breed

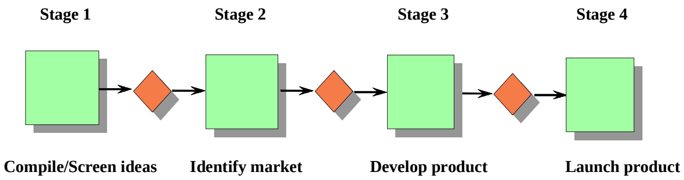
This routinization of the activity of innovation was adopted and taken even further by researchers in New Product Development (NPD) who devised and implemented a process called the Stage-Gate Process.

STAGE-GATE PROCESSES
Cooper introduced the idea of a Stage-Gate Process. A stage-gate process is a conceptual and operational road map for moving a new-product project from idea to launch (Cooper 1994). What differentiates stage-gate NPD processes from other NPD processes is that decision-making events follow each stage. Gates are meetings where the project undergoes a thorough examination and after which executive management decides whether to incur more R&D expense in the project or not. Product development teams complete a prescribed set of related cross-functional tasks in each stage before obtaining management approval to proceed to the next stage of product development. The gates represent control points where teams’ plans are repeatedly re-assessed in the light of the additional information that emerges during the life-cycle of the project. The diagram in Figure 1 describes a typical NPD stage-gate process and Table I indicates the purpose, activities and outcomes at the different stages.

Deppe sees the front-end of the stage-gate process as having four separate stages; preparation of the idea, idea generation, idea screening / evaluation, and the first concept. With the first concept the new product development process starts (Deppe, Kohn et al. 2002). The uncertainty decreases during the whole process while the available information increases. During the phase of the front end the uncertainty is very high and the available information is very low. Therefore the efficient handling of the front end is strategically more crucial than the handling of the new product development process (Koen, Ajamian et al. 2001).

INNOVATION AS A COMPLEX SOCIAL PROCESSES
Some academics see innovation as being heavily influenced by the social networks active in the organization. This school of thought has been influenced by the work of Fernando Flores who proposed the concept of “an atom of work” as the fundamental building block of all business processes (Flores 1997). In Flores’ model, most transactions between

Figure 1. NPD Stage-Gate Process



people in organizations are fundamentally requests and promises on one hand, and offers and acceptance on the other. Flores' assertion was that what was often missing from these transactions was a clear understanding of the condition of satisfaction, including the requested response time. He also pointed to a lack of an explicit declaration of the completion of a promise or a check to see if the performance was satisfactory to the customer.

THE IMPORTANCE OF CONTEXT

Nonaka sees knowledge as being embedded in *ba* (shared places), where it is then acquired through one's own experience or reflections on the experiences of others. If knowledge is separated from *ba*, it turns into information, which can then be communicated independently from *ba*. It is tangible. In contrast, knowledge resides in *ba*. It is intangible. Snowdon describes a somewhat similar concept that he calls *"cynefin"*. It is a Welsh word that represents the link between a community and its shared history "in a way that paradoxically both limits the perception of that community while enabling an instinctive and intuitive ability to adopt to conditions of profound uncertainty" (Snowdon 2000c) (p.10). Snowdon uses the concept to emphasize that people never start from a zero base when a knowledge management system is being designed because all the members of the system come with baggage, positive and negative, derived from multiple histories.

Fonseca described innovation "is the emergent continuity and transformation of patterns of human interaction, understood as ongoing ordinary complex responsive processes of human relating in local situations in the living present. It is in such patterns of interaction that innovative meanings emerge, often to be expressed in the reified symbols of books, procedural manuals and computer programs." (Fonseca 2002). This work built on contributions by Stacey who introduced the concepts of "adaptionist teleology" and "formative teleology" to describe innovations as being continuously disturbed equilibrium states requiring organizations and individuals to adapt in the present in order to survive in the future (Stacy 2000). He viewed innovation as the unfolding of what is already enfolded in it in order to realize a mature state of itself.

NARRATIVE

Denning emphasizes the importance of narratives in innovation processes (Denning 2004). In his view narratives capture context whereas abstractions decontextualize knowledge. Narratives also communicate tacit knowledge. Through narrative, people tell more than we know whereas abstractions only convey explicit knowledge. Through sharing narratives, it becomes possible to build collective trust and to build a community of people open to sharing their stories.

Bolin et al. show how common methods like BPR, and TQM, tend to fail in motivating and engaging people sufficiently to reach the goals and outlined an alternative method for driving change management (Bolin, Ljungberg et al. 2004). They view narrative as a vehicle for change and organizational development and propose the use of myths, tales, and stories as triggers in change projects in order to create a creative and dynamic atmosphere in which change can be achieved. Myths are interesting because they serve as a tool for formulating and recapturing a worldview; they integrate people into organizational culture and they can guide people in their individual psychological development.

Table 1. Stage-Gate Processes

Stage	Purpose	Activities	Outcomes
1	Compile and screen ideas	Identify market trends; determine consumer needs; conduct competitive assessment; conduct strategic assessment	"Rough" definition of concept; validation of consumer interest; validation of strategic fit; decision to continue
2	Identify market trends; determine consumer needs; competitive assessment; strategic assessment	Develop the business case; assess market potential; assess technical viability; create prototype	Validation of project viability; initial project and marketing plans; decision to continue
3	Develop the final product, process and package; test for ability to manufacture.	Finalize specifications, assure manufacturing capability; finalize financial analysis and marketing plans	Final product design; final business proposition; capital approval
4	Launch product into the marketplace	Purchase and install equipment; produce and distribute product; measure and monitor performance	Product in the marketplace; continuous improvement system in place

SMALL WORLD NETWORKS

This perspective holds that, in large organizations, the connection between external market opportunities and internal organizational resources may appear, on the surface, to be somewhat ad-hoc. Innovation processes depend on communication channels to facilitate the routing of information about new market opportunities. These communication networks have a critical impact on which ideas ultimately get commercialised. In practice, innovative capacity is dependant on informal social networks of professional acquaintances who make the linkages needed to form the appropriate project teams and realize the potential of new ideas.

Recent work by Duncan Watts and Steven Strogatz on "small world networks" (Watts and Strogatz 1998) and by Albert-Lásló Barabási and Réka Albert on "scale-free" networks (Barabási and Albert 1999) has enlarged our concept of what actually constitutes a network. For example, in social settings it is clear that the acquaintance network formed by a collection of individuals is strongly heterogeneous. Some people are essentially reclusive and have few links to the outside world, whereas others are linked to a wide circle of friends. It would be inappropriate to describe such friendship networks as a regular lattice; they are something more akin to an airline route map, with a large number of poorly linked nodes and a few well-linked major 'hubs'. A key contribution of this new "Small World Network" view is that it should be possible to re-wire links in a social network in a manner so as to get a small-world network effect, but also retain the benefits of high clustering. The key to the approach is the identification of social "connectors". "Sprinkled among every walk of life… are a handful of people with a truly extraordinary knack of making friends and acquaintances. They are connectors." (Gladwell 2000).

IS SUPPORT FOR INNOVATION IN THE SEMICONDUCTOR INDUSTRY

The role of IS in modeling and simulation is becoming more pervasive. From the financial modeling made possible by spreadsheet applications, to the use of yield management applications in the hotel, car-rental, and airline industries, the adoption of modeling and simulation applications in product development has transformed industries (Schrage 1999). In the semiconductor context, modeling and simulation is a core activity of the circuit design process, and supports agility in respect of customer interactions, communication and collaboration. Peer review is enabled by modeling and simulation in that it provides the vehicle for communication and collaboration between peers.

Learning is a key activity in knowledge transfer and creation. "Conventional explanations view learning as a process by which a learner internalizes the knowledge, whether "discovered," "transmitted" from others, or "experienced in interaction" with others." (p.47) (Lave and Wenger 1991). However, before one can initiate such a process, whether through discovery or interaction, there must be a mechanism by which people can easily find out what knowledge is being created in the organization and by whom. The knowledge being sought is, in fact, knowledge about knowledge or "meta-knowledge" (Swanstrom 1999), (Kehal 2002). The focus of much attention in IT initiatives relating in to agility in the semiconductor industry is on meta-knowledge.

Meta-knowledge attempts to provide answers to questions such as "Where can I get information about a particular technical topic? How can I find out more about this topic? Is there work in progress in this organization on this topic?" KMS applications address these challenges by making it easy for members of the technical staff to publish and locate technical reviews, notes, articles etc. - items which previously may have required several emails and phone calls to track down.

MODELING AND SIMULATION

In NPD in the semiconductor industry, the design process utilizes models at various levels, which differ in the level of abstraction utilized in the model. The highest level of abstraction, the system level, models the design as part of a larger system, allowing the exploration of interactions between the product under design and the wider world. By contrast, block level models deal with individual functional components of a whole product and are used in the context of a single engineer's design task.

The role of modeling and simulation has various forms:

1. One of the most obvious benefits is the ability to verify whether the design task is successful in comparison to the desired specification. This is the role of functional simulation and verification.
2. The ability to iterate quickly on the outcome of a simulation facilitates design changes in an agile market, as the specifications change during product development.
3. The role of rapid iteration is also an enabler of innovation, as the engineer reflects upon the outcome of a simulation, leading to insights regarding the operation of a design.
4. Communication of complex ideas is enabled via third party interaction with the model.
5. Collaboration between knowledge workers is enabled. In the design process, communication regarding the design may take place between engineers by referring to the model and the results of simulations. This facilitates the communication of complex concepts via the shared model.
6. Peer review is enabled by critique of the modeling method and simulation outcomes, facilitating a review of design specifics.

CATALOGS

A "Catalog", in this context, is an application that generates a list of previously designed products in the product development community. The catalog would enable product development staff to quickly find out if products were previously designed that were similar to those currently under development. The entries are created and owned by the product development staff. Each entry in the catalog represents is a potentially reusable circuit design. Catalog entries, depending on their utility, are potential candidates for inclusion in a repository. The problems that were identified in the NPD process that were to be addressed by catalogs are:

(a) a lack of awareness of what previously designed circuit blocks had been created and might be available for reuse in future projects

(b) a mechanism by which product development staff could <u>easily</u> make their products more easily "discovered" by members of the product development organization outside of their own organization unit

PEER REVIEWS

Peer reviews are an integral part of the stage-gate process, and has been referred to as a justification activity following the creation of an archetype (Nonaka and Takeuchi 1995). In this context, an archetype may be thought of as a prototype, which may be in the form of a model. The peer review activity facilitates the justification of design decisions and the design and verification activity. In this way the knowledge of a group of knowledge workers may be brought to bear on the design.

The medium for the peer review is the model and associated simulation results. During the peer review process the model and the simulations may be scrutinized for validity and applicability to the design context. The peer review encourages discourse by making the designer externalize and illustrate the design outcomes, allowing collective experience to be brought to bear in validating the design. A successful peer review process will reduce or eliminate unplanned design iterations following production prototyping, which cost several months in lost time-to-market and associated opportunities.

SUMMARY/CONCLUSIONS

This paper has described approaches to innovation that range from doctrinaire, procedural methods to laissez-faire, complex methods. It examined the semiconductor industry as a case study of an industry where innovation is critical, and described the systems that are actually in use in that industry today. This examination showed that a common theme running through systems to support innovation is the facilitation of discourse among and between people engaged in the design activity.

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