Product and Process Design and Delivery: Invention Through to Innovation

Gary E. Wnek[1] and Stanton G. Cort[2]
[1]Department of Chemical Engineering
[2]Department of Marketing and Policy Studies
The Institute for Management and Engineering (TiME)
Case Western Reserve University
Cleveland, Ohio 44106

Abstract

Many product/process design courses, including ours, focus heavily on ideas like the stage-gate and quality function deployment as their conceptual foundation. It is clear that effective realization of innovation depends heavily on creative and rigorous generation and capture into the innovation of many very early and sometimes ill-defined ideas, sometimes referred to as the fuzzy front end. Despite its importance, however, this critical first step receives scant treatment in most product/process design curricula. We suggest that this early, inventive stage merits considerable attention, and believe that tools exist (e.g., TRIZ) to demonstrate how early, ill-defined ideas can be injected quickly and rigorously into the innovation management process. Our presentation will outline approaches to consider invention through to innovation as an important perspective of product/process design and delivery strategies.

Introduction

The National Innovation Initiative defines innovation as 'the intersection of invention and insight, leading to the creation of social and economic value.'[1] Innovation is a national priority, central to economic growth in an increasingly fast-paced and global environment. The process of innovation begins with invention, and is only realized when a market develops. As noted in the 75th anniversary issue of Business Week, [2] innovation (1) can be taught, (2) can be managed, and (3) can be spurred. The same *BW* issue states that 'inspiration is fine, but above all, innovation is really a management process." Indeed, it is a topic not only critical to industry but also worthy of academic pursuit in both teaching and research, and sits squarely at the intersection of engineering and management.

We suggest that the early-stage process of invention be appreciated in similar terms. If commercially profitable inventions are low probability occurrences, the innovation process must capture into its initial analysis as many ideas as possible. Since effective invention can also benefit from and requires both support of senior manager and effective management of people and resources, when the invention idea enters the culling process it must be in a form that operations, marketing, financial and other managers can understand. However, this critical definition and structuring process is typically not emphasized, at least in coursework. This may be because creating initial, business-

oriented statements of early and untested ideas is seen as having little tangible focus and as being less amenable to being taught in a rigorous, logical and managerial framework.

We offer a brief outline the product design course we designed and co-teach as a useful vehicle to emphasize innovation and its many facets, make a case for why the inventive process should be integrated, and offer suggestions of how this might be accomplished.

Product and Process Design, Development and Delivery

A particularly opportune time to highlight the topic of innovation is through a course on product and process design. A specific example is the two-semester course entitled Product and Process Design, Development and Delivery (P2D3), an integral part of the Master of Engineering and Management (MEM) curriculum at Case Western Reserve University.[3] Briefly, the MEM degree involved a one-year, 42-credit curriculum for B.S.-degreed engineers and computer scientists. It was launched in 2001 in thoughtful response to much input from industry about the need for 'business-minded innovators.' We currently have students from a broad spectrum of technical disciplines, including biomedical, chemical, civil, computer, electrical, mechanical and systems engineering, as well as computer science. A unique aspect of our program is that most courses are team-taught by faculty from the Schools of Engineering and Management. This facilitates integration in real time for our students of the engineering and management perspectives. Also, our courses offer numerous opportunities for exposure to real-world problems through project work. Student teams maintain frequent contact with company representatives. Presentation skills are constantly refined through many opportunities during class.

Our P2D3 course is uses three popular texts[4-6] along with selected supplementary readings and notes. Topics covered include the theory of the business, the voice of the customer, value creation, intellectual property, concept development, Stage-Gate™ methodology, quality function deployment, pricing strategies, marketing, design implementation, and manufacturability. During the first semester, in order to introduce concepts, skills and techniques that will be applied during the second semester in live team projects with companies, students work on individual innovation projects. Each develops an idea capture sheet, product innovation charter, houses of quality, and preliminary specifications for their idea. As a facilitator of class discussions of the individual projects, all incorporate the common theme of a sensor as a key element of the final product.

The course capstone, organized by the end of the fall semester and a substantial focus of the spring semester, is team (4-6 students) projects sponsored by several companies and covering a broad range of technologies. Projects (companies) for the 2004-05 academic year include solid oxide fuel cells (SOFCo), lab-on-a-chip microfluidic devices (Infoscitex), polymer membranes for a novel HVAC energy recovery device (Dais Analytic), scheduling software for medical doctors and software to teach math to grade-school children (AcmeExpress), and, interestingly, a company being organized and

launched by six current MEM students with a focus on technical and innovation management consulting (Lake Effect Innovation; see http://lakeeffectinnovation.com).

Each individual and team project focuses on both technology and business issues, and students become part of the process of bringing products closer to market. Thus, they are first-hand participants in the innovation process. But are they comfortable working anywhere within the innovation spectrum? In particular, as engineers and managers, are they comfortable with structuring ideas so they can be communicated to the various functional decision makers throughout and organization, and with following a rigorous analytic and decision-making process in the early front-end of the innovation's life?

The Case for Attention to the 'Front End'

One of the recommendations of the National Innovation Initiative is to encourage risk-taking with the ability to tolerate failure. Interestingly, initial discussions with our P2D3 students regarding their preferences for corporate (team) projects revealed a decided bias toward projects that were relatively far into the development cycle versus more ill-defined, early-stage ideas, even though the latter (the so-called fuzzy front end or FFE) could be where the most significant opportunities lie. (Our list of potential projects did not cater toward either part of the innovation process.) Again, there was a desire to avoid 'risky' projects at the front end of the innovation cycle. Conversely, discussions with industry colleagues indicated that the front end is exactly where most attention is needed, especially regarding idea generation, categorization and screening, along with credible means to estimate the cost of and time to realization of a concept in order to prepare it for Stage-Gate™ deployment.

We sense a challenge and an opportunity in integrating the FFE into P2D3. The opportunity seems clear based upon feedback from industrial partners. The challenge is to bring meaningful tools to bear on the problem. We see a particular opportunity in focusing in some detail on idea generation, as there are now powerful tools to enhance the efficiency of the invention stage. For example, Koen et al.[7] note that the FFE is the weakest component of the innovation process, and offer useful ideas regarding tools and techniques to systematize thinking about the FFE.

In our P2D3 course we select from the tools developed by others and develop some of our own. A key example of a "home grown" tool is our Idea Capture Sheet (ICS). It grew out of extensive consulting work and classroom experience. The ICS is for our students to use at the very front end in both their individual and team projects. Its objective is to provide a vehicle for quickly capturing (literally, with practice, within about an hour) the essence of an innovative idea in a rigorous structure that contains enough of the product development decision criteria so that the idea can be introduced effectively to managers in the various functional specialties that will participate in the development screening process. Speed and ease of capture are essential to increasing the number of ideas that enter the innovation funnel, since successful commercialization of ideas is a very low probability event. Our classroom experiments with students and executives demonstrate that they generate an average of 5 ideas per person in a two minute exercise. So, the key question is, why do so few ideas see the light of day?

The four key reasons are lack of motivation to get started, over-commitment to routine duties that leaves no time for initial development of an idea, fear that supervisors and senior managers will not understand the idea, and fear that they will think the idea is foolish because it is not fully documented. The ICS addresses all four. First, it captures what the idea creator already knows and requires no data gathering. We also call it a "mind file dump." This addresses problems one and two. Second, the ICS is structured to address the essence of all the categories of decision criteria that the idea will face in the screen it must pass through on the way to commercial launch, including marketing, and product and process (technical, financial and strategic aspects). This addresses problem three. Third, clearly the ICS is neither fully researched nor exhaustive. Its essence is prior knowledge, creativity, assumptions and estimates. So, to address the fourth problem we coach students in how to respond to questions/challenges in the front end of the process. The principle is, "Remember, and estimate is a conversation started, not a position to defend to the death."

One specific tool developed by others is TRIZ (a Russian acronym for the theory of inventive problem-solving), initially developed by Altshuller[8] and based upon patterns of invention recurring over several decades. It is well-appreciated that the most prolific inventors rely on recognizing patterns and making analogies,[9] and it has recently been suggested that creativity involves making predictions based on patterns.[10] Moreover, TRIZ has the ability to circumvent 'psychological inertia' in approaching a technical problem from a familiar (and comfortable) perspective when the in fact the problem requires thinking beyond one's training and experience. Thus, we are looking to introduce and use TRIZ concepts early in P2D3, and have students apply these to their individual projects as well as subsequent team projects. TRIZ-based software has recently been augmented by Ideation International to include Anticipatory Failure Determination (AFD) and Directed Evolution (DE) modules, and these are being considered as course tools as well. The combination of mining the past for patterns of inventive solutions with new predictive ability may be particularly powerful for teaching (and doing) product design and development.

Cost estimation of the FFE is another key challenge and opportunity. Investment in the FFE ultimately needs to be grounded in estimates of the time and cost to reach a specific goal, although this has proved difficult because the FFE is, well, fuzzy. However, quantitative models to assess early-stage R&D risk are under development[11] and it is a propitious time to consider coupling invention/innovation efficiency enhancement tools with cost/time estimation. Not only will the FFE be significantly impacted. As the FFE is where product development ultimately begins, the entire product development process stands to benefit from a more efficient creative function and better fiscal discipline within the FFE. Perhaps this is an appropriate beginning for a course such as P2D3.

Summary and Conclusions

We believe that there is a compelling opportunity for more focus on the fuzzy front end in the teaching of product design and development. Our ASEE presentation will

summarize the current state of the P2D3 course, discuss one team project as a brief case study, and outline where and how attention can be given to discussion of the FFE along with tools to increase the probability of success of this important component of the innovation spectrum. Our ultimate goal is to give our students a timely and valuable experience to make them highly sought as the innovation leaders of the future.

Acknowledgments

We thank Zion Bar-El and David Bonner of Ideation International, Gideon Samid of D&G Sciences, and Paul Basar and James Schwind of Lubrizol Corp. for interesting and useful discussions, and Rodger McKain (SOFCo), Michael Cushman and Robert Kovar (Infoscitex), Scott Ehrenberg (Dais Analytic), and Donald Scipione (AcmeExpress) for offering projects for P2D3 and for their time given to our students. We also the Timken Foundation for its generous support of TiME.

Bibliography

1. National Innovation Initiative Final Report (2004): http://www.compete.org/pdf/NII_Final_Report.pdf
2. "The Innovation Economy," Business Week 75th Anniversary Issue, October 11, 2004.
3. The Institute for Management and Engineering (TiME): http://www.tiime.case.edu.
4. Cooper, R. G., Winning at New Producgts, 3rd ed., Basic Books, New York (2001)
5. Ulrich, K. T. and Eppinger, S. D., Product Design and Development, 3rd ed., McGraw-Hill Irwin, New York (2004)
6. Crawford, M. and Di Benedetto, A., New Products Management, 7th ed., McGraw-Hill Irwin, New York (2003)
7. Koen, P. A., Ajamian, G. M., Boyce, S., Claman, A., Fisher, E., Fountoulakis, S., Johnson, A., Puri, P., and Seibert, R., "Fuzzy Front End: Effective Methods, Tools and Techniques," The PDMA ToolBook for New product Development. http://media.wiley.com/product_data/excerpt/13/04712061/0471206113.pdf
8. Altshuller, G., The Innovation Algorithm: TRIZ, Systematic Innovation and Technical Creativity, Technical Innovation Center, Inc., Worcester, MA (2000)
9. Schwartz, E. I., Juice: The Creative Fuel that Drives World-Class Inventors, HBS Press, Boston (2004)
10. Hawkins, J., On Intelligence, Times Books, New York (2004)
11. Samid, G., "Can you predict R&D costs?", CHEMTECH, July 1996; Samid, G., "Validity Calculus: A Novel Methodology To Manage High-Uncertainty Projects" AACE-I Proceedings, July 2002