Marketing Enhances Engineering Product Innovation

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Abstract

Product innovation is increasingly a multi-disciplinary undertaking. In an effort to prepare leaders for this interdisciplinary effort, the authors are developing a methodology and a guiding model to teach the product innovation process to graduate engineering and marketing students. In this innovative program, two parallel courses are offered in one semester. The classes follow the same schedule, and participate in the same experiential learning component but have different curriculum, texts, and faculty. The classes meet together or separately in order to facilitate a learning community surrounding the product innovation process. Faculty members evaluate students in their own disciplines. The objective of the project is to design a new to the world product and create a market entry plan. The engineering and marketing students work together to research and develop a product that the customers want and that can be produced for a price the customers are willing to pay.

The complex collaboration between marketing and engineering students is facilitated using a modified product innovation process. The model provides a framework to integrate marketing's focus on the customer, research, information technology, and the core benefit into the innovation process with the engineer's focus on function and technology. The contributions marketing and engineering make to each phase of the product innovation process are emphasized. The second theme is iteration and adaptation. As marketing and engineering develop information about the product and its potential market, the design and marketing plan must change. Suggestions are made for improving the courses based on what has been learned and where the program is going.

I. Introduction

Before the winter2003 semester Engineering 610, Engineering Design, was taught not taught with any links to a marketing course. The course was a requirement in the practice oriented engineering masters degree program in the Padnos school of Engineering at Grand Valley State University. The class had evolved to include team, semester-long, design projects. Student usually proposed design projects related to their jobs or project topics were solicited from the Small Business Technology Development Center on campus. With only engineers in the class, creativity was stifled and much of the new product development process was not

covered. In the summer of 2002 the authors received a grant from the Pew Teaching and Learning Center to develop a curriculum that would allow Marketing and Engineering students to learn the product development process together. The result of the grant came to be known as parallel coursing and was implemented in the winter semester of 2003. [1]

I.I Structure of the program

Parallel Courses are two courses taught in part in the same space and time by two different faculty teaching two separate and distinct classes. In this case, the Engineering Design course was taught in parallel with a New Product Marketing course. Each semester project, now sponsored by local industry, was assigned to an interdisciplinary team of marketing and engineering students. The goal of the parallel courses was to take the teams from the client's introduction of ideas to a product design and a market entry plan in fifteen weeks.

I.II Product Innovation Model

The class was organized around the Product Innovation Model illustrated in Exhibit 1. The different stages of the process are shown as they lead up to the traditional product life cycle curve. The circles with arrows at the top of the exhibit represent iterations that are a critical part of the product innovation process. The authors, colleagues and practitioners from industry developed this model.[2]

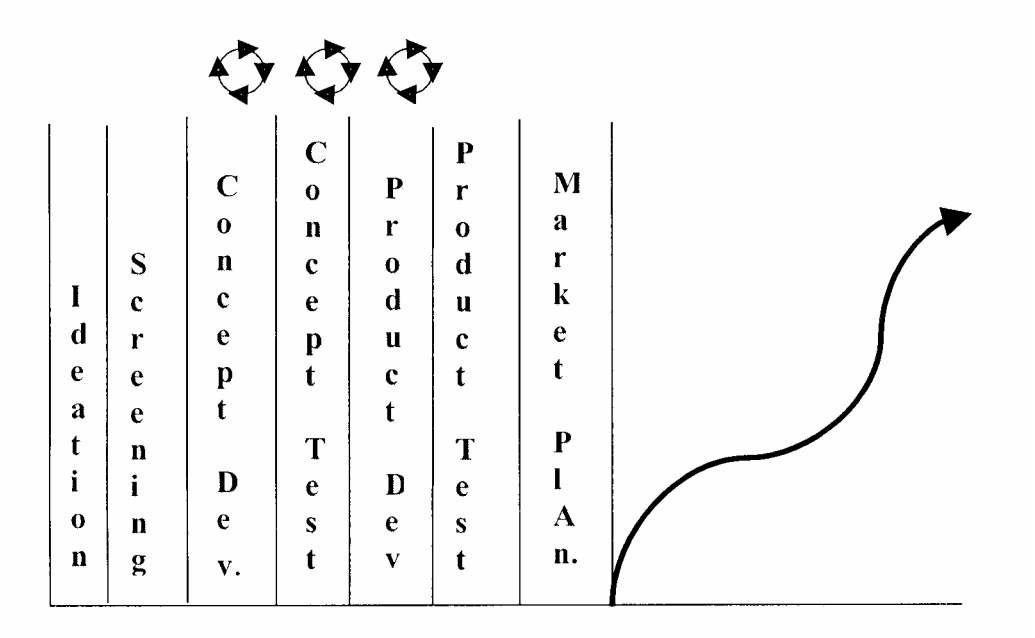

Exhibit 1. The Product Innovation Model.

Exhibit 2 presents the new product process as outlined in Exhibit 1 in a vertical format from ideation down to Market Entry Planning. The relative effort required from each discipline to complete each phase is shown. The figures are derived from the author's subjective observations of students enrolled in the parallel courses in Engineering Design and Marketing New Product.

In industrial practice other disciplines do contribute to the process, this exhibit will be used as a basis for discussion. The concept of iteration has been put in twice but new information can cause the team to iterate at any point in the process. However, in the author's experience most teams iterate after the concept test and the product development phases in the process. The remainder of the paper will detail the marketers' contributions to the different phases of the process.

Engineers %	Product Innovation Task	Marketers %
30	Ideation	70
60	Screening	40
40	Concept Development	60
15	Concept Test	85
20	Iteration	80
90	Physical Prototype	10
90	Product Development	10
70	Iteration	30
50	Product Test	50
10	Market Entry	90

Exhibit 2. The relative contributions of Marketing and Engineering students to the different phases of the Product Innovation Process.[3]

II. Ideation

The goal of the ideation phase is to generate a large number of diverse ideas through brainstorming and other creative techniques. As the figures in exhibit two indicate, the marketing students led the activities in the ideation phase. After reviewing different ideation methods in class, the teams picked the methods most appropriate their project. During the class each project team had a chance to lead and then participate in a session. A marketing student from a local small appliance manufacturer who was familiar with the ideation led the first session. The rest of class was a series of high-spirited ideation sessions as groups of students attacked problems. Each team was required to carry out at least three different methods of ideation outside of class. Two groups chose to carry out on-line ideations sessions.[2] The following week the teams presented the ideation methods they used and the five ideas they considered "best" and the five ideas they considered to be the craziest.

The addition of marketing students to the teams markedly improved the diversity and number of ideas generated. The marketing students who had undergraduate degrees in business disciplines had different experiences and thinking styles than the students educated as engineers. Engineers tend to approach problems in a similar way. This uniformity of thinking styles was not conducive to creativity. The marketing students stimulated the production of more diverse ideas by providing a counterpoint to the engineer's thinking style.

The marketing students tended to focus on the needs of the customer and the form of an imagined product while the engineers focused on the technology that might be employed. In addition the marketing students were more comfortable spending time generating and considering many different ideas. Engineers, eager to start designing, had a tendency to want to take the first seemingly feasible idea and begin work. The engineers had to be convinced of the benefits of spending time generating many ideas that would be rejected later. The contribution to the design process the marketing students made in the ideation phase had a significant impact on the quality of the final design.

One of the things that the faculty members have learned is that the inclusion of non-engineering students can significantly change the focus of the ideation process. This can be accomplished by linking up with a class such as the marketing class used here. Alternatively students could be encouraged to bring their non-engineer friends to ideation sessions. In addition faculty can invite non-engineering faculty, practitioners or interested community members to participate in ideation sessions. The goal is to break out of the engineering mind set that tends to start worrying about how to make it in detail, before expanding the pool of ideas.

III. Screening

The term screening refers to a systematic and unbiased process of selecting a small number of ideas to investigate further from the many ideas generated in the ideation phase. This is an important concept in the marketing New Product Development process and is enumerated in the Crawford and Benedetto text that is used in that class. Student teams began this phase by designing a screening method that reflected the priorities of the project sponsors. Despite the fact that the most teams adapted a screening model presented in the marketing textbook, the engineers drove the screening process.[3] The engineers quickly saw that the screening process would allow them to focus on the best ideas. Moreover they were comfortable deigning and implementing a screening system. Criteria were selected and weighting systems were defined. The marketers had the most effect on the criteria. They challenged the engineers to consider more than just technical criteria. They pushed for the inclusion of target markets, customer needs, pricing, distribution, packaging and other customer orientated criteria. These additional criteria improved the ability of teams to select ideas that were both technically sound and feasible from a marketing and engineering point of view.

Screening was a learning experience in both classes. There were three major lessons that were learned: First, the screening process from marketing allows ideation to roam all over with the security that it will be brought back to the mission and scope of the project. Second, the screens need to be designed before the ideation takes place to prevent students from tailoring the screening process to favor certain ideas. Third, the ability of a screening process to take an overwhelming number of disparate ideas and reduce the list to a manageable number of ideas for further consideration makes screening valuables to both engineers and marketing people. Since complete objectivity is not possible, screening results should not be exclusively relied upon to determine which ideas are moved forward in the process. In 2004 the screening part of the course has been changed radically in recognition of these three points. Screening will now be taught before ideation and the screen will be designed before any ideation occurs. .

IV. Concept Development

In the concept development phase a small number, usually three to five, product concepts are developed from the screened ideas. The concepts are then refined and documented for presentation to prospective customers in the concept test phase. Generally each concept was represented by a written description and some graphics. Graphics ranged from hand sketches to rough solid models. The marketing students challenged the engineers to keep the process focused on the customer. Marketing worked hard to convince the engineering students that the customer cared about the benefit of the product and not the technology employed. They forced the engineers to produce graphics that emphasized how the customer interacted with the product and how the product would benefit the customer group.

The marketing students worked hard to answer questions as: Who was in the target market for the product?, What was the core benefit of the product? And what were the sub benefits of the product? With the answers to these questions, the teams could further refine their product concepts. As a result of the marketers influence, the product concepts were more customer focused and elicited better quality information when presented to potential customers. Hopefully the engineers learned that customers do care, and that designers do not know what customers want until they ask them. One project was turned around completely by the results of some customer focus groups.

In the 2004 class it is hoped that both marketing and engineering students will understand that it is the job of the marketing students to advocate the position of the customer. Having an active and vigorous representation of the voice of the customer is essential to the product development process at each stage.

V. Concept Test

During the concept test phase, the concepts are presented to customers in the target market. Feedback is solicited and documented. The marketing students planned and executed most of the activities in this phase. They identified potential customers, arranged for meetings, created protocols and lists of questions and documented the results. The engineers began the concept test phase skeptical of the value of soliciting customer input. The engineers believed that they knew the problem and therefore could accurately predict the needs and desires of intelligent customers. Similarly, the engineers were at first baffled by the effort the marketing students expended to ensure that the customers consulted were in the target market.

Impatient to get to the next phase, the engineers pushed the marketers to consult any available respondent. The attitudes of the engineers changed markedly when confronted with real target customers and their concerns. They were surprised and intrigued by the number of customer concerns that they had not anticipated. As a result of the customer interaction arranged by the marketing students the entire team understood the customer requirements on a much deeper level. The engineers became convinced of the value of consulting customers when they translated the customer input into product specifications. Quality Function Deployment (QFD) was used to help the engineers and the marketing students to formulate a complete and coherent set of product specifications.[4] The customer input that was provided by the marketing students

enabled the team to create a set of product specifications that more closely described the product that the customers desired.

In 2004 it is hoped that the marketing students can focus on managing the concept test in the most objective way possible. It is hoped that the engineering students will support the marketing students with more detail sketches, CAD models and physical representations where possible. One of the learning experiences that occurred is that marketing has often used words only to introduce a product concept. When the disciplines are combined they each have a lot to offer.

VI. Iteration

Iterative thinking may well be a contribution of marketing. They are used to working with changing customer ideas. Iterations can occur at any time in the new product development process. New information developed during any phase can trigger the team to go back and repeat a phase in the process. New Product Development can sometimes seem like a game of Monopoly, at any time a tea, can be sent back to jail or be catapulted forward to Go. In this process you can move ahead or go back one or two stages. Both marketing and engineering students were frustrated by the delays in the process and increased work caused by iterations, but each group viewed the results of iteration differently. The marketers were more likely to view iteration as moving them closer to the ultimate goal of satisfying the customer. The engineers on the other hand saw iteration as a break in the flow of the design process caused by a failure or oversight made during a previous phase of the process. Moreover, the engineers were more aware of the costs of iteration. Schedules slipped, high quality work had to be revised or discarded, and the goal of a completed project receded.

The engineer's attitudes arose from their belief that the ultimate goal was to meet rigid product performance, cost and schedule targets. However, if the product's performance was less than expected, or the chance arose to add a feature that the engineers deemed worthy, then the engineers did not hesitate to initiate an iterative cycle. On the other hand, the engineers were reluctant to invest time and money in performing iterations when the customer requirements were perceived as contradictory. The customer may desire many features for an unattainable low price. Since no design could satisfy the customer why bother to iterate?

Reconciling the conflicting views of iteration was the key to maintaining team unity, capturing the value of iteration, and designing a product that satisfied the customer. Marketers must not only be cognizant of the consequences of iteration, but also convince the engineers that the benefit of performing some iterations is greater than the cost. Engineers must recognize the value of satisfying the customer can outweigh the consequences of iteration and that satisfying the customer is a responsibility they must share with marketing. A product that meets performance, cost and schedule goals will fail in the market place if the customer is not satisfied. This is not only a marketing failure but also an engineering failure.

Teaching the benefits of iteration is not easy. Students are used to straight line course plans that flow exactly like a text moving from chapter to chapter. Teaching iterations implies teaching that the world is imperfect. It implies that faculty and students do not have perfect information. For younger students, accepting the idea that they could have it wrong is not easy. In 2004 the

class builds much more expectations of the iterative process as essential to product development and a major learning process.

VII. Product Development

During the product development phase, how the product will function, the product architecture and the form of the product is defined in enough detail design to allow a quick prototype to be built. The prototype will be used in two ways. First the engineers may do some feasibility testing with the prototype. Second, the marketing students will use the prototype to gather feedback from potential customers. These two activities do not require that the prototype be an exact replica of final product.

Engineers were most comfortable in the product development phase and readily took responsibility for leading the teams and ensuring the quality of the work produced in this phase. In some groups the engineer's lack of customer focus prevented their designs from achieving their greatest potential. Engineers made design decisions that affected the customer without consulting the marketing students. Most often this occurred when the engineers could not find a feasible or cost-effective way to satisfy the customer requirements. Compromises and trade offs are an inevitable part of the design process. Unfortunately, the engineers often did not consult the marketing students and simply made the decisions based on their own judgment. The marketers, feeling out of their depth in this highly technical phase, were sometimes unwilling to vigorously represent the interests of the customer.

In the most successful teams marketing students monitored the engineer's progress and challenged their decisions. Ideally, the interplay between marketing and engineering leads to innovation that improves the customer's satisfaction with the product. In other cases both marketing and engineering recognized and supported the cost and feature compromises that had to be made.

It is hard for engineering students to accept the important of the voice of the customer as represented by the marketing team members. This becomes particularly true as the teams move closer to completion of the project. Students often complain to faculty that there is not enough time to complete the project. "Wouldn't a real product development team simple take more time?" they ask. Conversely our clients talk about developing innovative products in far less time because the demand is there. In a world of shortening life cycles, increasing global competition, and significant market segmentation, marketing and engineering functional areas must work together as a very responsive team to quickly develop new products. In this sense the limited time frame of the course closely resembles the challenges faced by practitioners in the field.

VII. Product Test

The product test phase involves presenting the prototype to potential customers and soliciting their feedback. Since this phase involves interaction with the customer it was expected that the marketing students would organize the events and the engineers would provide the product prototype. Many of the groups did not adequately plan or prepare for the product test phase.

Sometimes delays in creating computer models caused delays in acquiring the physical prototype. Other times the marketers did not have a group of potential customers ready for a product test when the model was ready. More profoundly neither the engineers nor the marketers were motivated to perform a product test. The marketers were not interested because of the amount of work required and the engineers were reluctant to subject their design to another round of criticism. The authors were disturbed by the attitudes of some of the teams. The opportunity to gather valuable customer feedback was lost. The feedback may have been of great value to the teams and the project sponsors.

In the 2004 cycle the authors, recognizing their own weakness in setting student expectations, are challenging themselves to build expectations about this phase. Students start having to think about it weeks ahead of time. It was discussed on the first meeting of the class. In addition the engineers will be coached to view negative feedback from customers as an opportunity to improve the design and not as a failure of the design. All of this it is believed will motivate students to perform a product test.

VIII. Market Entry Planning

Market entry planning is the culmination of the whole new product development process. Decisions about product pricing, positioning, lead times and packaging are made. Many engineers thought that market entry planning was the sole responsibility of the marketers. They quickly learned that they have much to contribute to the market entry planning. For instance, only the engineers can estimate the cost of the product and the lead-time required. Engineers can also design and specify the packaging. Packaging is important in the marketing mix as it can impact product placement, communication, display, perceived value pricing, and how the product is distributed. Engineers had to learn the difference between costs and perceived value pricing. The perceived value by the target customers must be at least three times the manufacturing cost of the product for the product to be a retails success.

If the engineers have not responded to the customer needs as brought to them by the marketing members of the team, then this phase quickly exposes any problems. If a product truly meets the expectations and perceived needs of the target customers, then Market Entry Planning flows easily. Thus the engineers will have had to think about how the product benefits meet the expressed needs of customers. They will have had to think about the cost in order that the product can be delivered to the market at the expected price and deliver the perceived value. They will have to think about packaging for transport storage and placement. They will have had to think about features that may aid in market positioning, and distribution. What was experienced was far too little realization of how much engineers could and should be involved in this process on the part of students and faculty. Now the faculty is awake to the challenge and will be able to help the students see the connections in the future.

The marketing portion of the team needs to start compiling the market entry plan from the start of the project. They should be working on a draft outline from the beginning of the project, filling in the pieces as they proceed through the new product development process. For example, once management, or in this case the clients have identified a target market the specifics of that group, demographics, geographic, lifestyles, benefits, access, loyalty etc. could be fleshed out as

research is completed. Once the product class is known, the situation analysis pieces including macro environmental and competitive analysis can be developed. Each piece of research should be adding to the draft outline of the market entry plan across the marketing mix.

In 2004 the faculty have tried to restructure the class assignments so that the students are consciously building the bricks of the market entry plan house throughout the semester. In the past, students were expected to make connections and an organize structures on their own.

IX. Successes

Students with a marketing background added much to the class. These students brought different experience and point of view to the project teams. Students with engineering undergraduate degrees, including the ones enrolled in the marketing class, think and approach problems in similar ways. Engineering students focused obsessively on how the product might work. They thought that the customers should adapt to the design. The engineers pushed hard to limit the number of ideas under consideration. Marketing students represented the customer throughout the project. They struggled to define the features of the product that would deliver benefits to the customer. They believed that the design should be adapted to better suit the customer. The marketers were more comfortable considering many different ideas in pursuit of the concept that would bet satisfy the customer. The tension between the groups produced the many important lessons and the most creative designs.

X. What does Marketing contribute?

In summary marketing students contributed many things through out the process, in the beginning they contribute creativity and diversity to Ideation. They brought the screening concept itself. They bring the project back to a customer focus as representatives of the segment. The structure and plan to provide customer input. Most of all they should be contributing a process leading to market entry. This focus on market entry should include target markets or segments. Further it should have thoughts on how the product might reach the final customer. It is the marketing group that must lead in developing a marketing mix that will help to position the product for the chosen segment.

X.I How does this impact teaching new Product Development?

Having taught this way it is clear to the authors it is a much richer, deeper and broader way to approach this subject matter for students. It would be hard to imagine how a faculty member could do all this and provide sufficient interaction. There is something about peers challenging peers! The cross fertilization of the disciplines as marketing students sit in the classroom truly enriches the engineering program.

XI. Challenges

Students need help with the idea of a continuous calendar that changes all the time in a class setting. They are used to receiving a calendar or syllabus that is organized by week or by day. They know what is due and they can make decisions alone as to whether to do it or not. Students

expect that when they complete one element of the course they are done with that element. In most courses when you complete a chapter or learning module you are done. New product development is different. Teams have to be prepared for continuous change, as things take longer than students expect and iterations are required. This is true in both engineering and marketing.

The nature of innovation and new product development is that you are never done. Knowledge gained in one step leads to more innovation and change. Knowledge based change is what is sought. It is being able to make the necessary changes in a timely fashion and adjust calendar as a team that brings success. A calendar negotiated and agreed to by Marketers, Engineers and the client is essential. The new plan is to have the faculty provide an initial calendar and the students will have to adjust the calendar for delays and iterations. Iterations can occur at any time and students need to be flexible. A group ahead one week can be behind the next week. The faculty will need to impress upon students that this is to be expected and will ultimately lead to better products. Failed products are developed without iterations.

Student satisfaction is the result of the student's expectations being met. One of the problems in the first cycle of the program is that in many cases the faculty ignored these expectations. Faculty did not think about the impact of taking students out of a traditional class mode without changing their expectations. The faculty simply assumed that the students would embrace the challenge of an unorthodox class with real world projects. Some students resented the extra time, energy and creativity required to deal with team members from different disciplines, clients and customers. Student expectations also need to be alerted to the fact that they will be graded on process as much as results. The engineers stubbornly held on to the idea that if the final design was innovative and the client was pleased, then they should receive a high grade. The faculty on the other hand expected to see evidence that the processes taught in class were followed correctively and productively. The authors believe that it is the process, which if learned will allow the students to lead others in new product development teams.

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[3] (???John we should reference the Spain Paper here where we first published this)