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What Alumni Value from New Product Development Education: A Longitudinal Study

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ABSTRACT

We present a longitudinal study of what graduates take away from a cross-disciplinary graduate-level New Product Development (NPD) course at UC Berkeley over a 15-year period from 1996-2010. We designed and deployed a longitudinal survey and interviewed a segment of our NPD alumni population to better understand how well our course prepared these alumni for careers in design, innovation, entrepreneurship and product management. We questioned alumni regarding the value of specific NPD skills, methods, and tools taught in the course. This paper presents a quantitative and qualitative analysis of survey and interview data. The results reaffirm the value of engaging students in multidisciplinary design projects as a means for developing the skills needed in today's competitive NPD environment and highlight the similarities and differences that exist between academic and industry NPD practices. We believe the findings will inform educators about what is valued in NPD courses by graduates now working in industry.

Key Words: New Product Development, Longitudinal Assessment, Engineering Education

INTRODUCTION

New Product Development (NPD), the process of bringing a new product from conception to market, involves an increasingly large range of disciplines including, but not limited to, marketing, engineering, manufacturing, industrial design, finance, software engineering, and biotechnology. Henderson *et al.* (1999) speak about the increasing complexity of NPD as it relates to different disciplines and the impact on institutional forces. Many variations of similar NPD courses are offered in the United Stated (U.S.) and world-wide. Beckman and Speer (2006) describe eight courses first offered in the U.S. in the period 1988–2003 that involve engineering, business and design: Carnegie Mellon University, MIT/RISD, University of Michigan, North Carolina State University, Arizona State University, University of Illinois at Chicago, and Columbia University/Parsons School of Design. Other U.S. programs with multidisciplinary design courses include the Wharton/University of Pennsylvania, Lehigh University's Integrated Business and Engineering program, Segal Institute at Northwestern University, the IIT's Institute of Design and the Institute of Design (d.School) at Stanford University. In collaboration with M.I.T., Singapore created an entire university with a multidisciplinary design theme – Singapore University of Technology and Design (SUTD) – with several multidisciplinary design course offerings. All of these courses, although different in their implementation, strive to provide an authentic learning experience and impart NPD knowledge and skills to students who will be future designers, entrepreneurs and innovation practitioners. As NPD course offerings at universities continue to grow and cross multiple disciplines, how do we know if the training students receive in these various courses adequately prepares them for NPD roles in industry? Are the skills taught sufficient to prepare students to contribute effectively? Is a project-based learning approach the most effective teaching methodology? How, as educators and practitioners, can we improve? We set out to tackle these questions by performing a longitudinal study of alumni from a graduate-level, multidisciplinary NPD class taught over a 15-year period at UC Berkeley. We obtained contact records for 494 alumni from the course and developed and deployed an online survey. We then conducted 19 follow-up interviews with alumni who had completed the survey to gain more in-depth data. The survey and interviews provided alumni insights and reflections on the effectiveness and appropriateness of the skills and experiences provided in the classroom, and also on the extent of their use and relevance in industry. This paper discusses a series of NPD topics valued by alumni: the value of multidisciplinary teams, specific NPD tools and methods used in industry, a comparison of industry and classroom-based NPD practices, and finally, suggestions for further improving NPD education. Learning from our NPD alumni, as opposed to non-alumni new product developers, has the advantage that the alumni are in a position to compare what they know now with what they all commonly learned in the course at UC Berkeley. We believe the findings from this study are of interest to design educators seeking to appropriately focus and improve their NPD classes. We

begin this paper by examining related research in this area, explaining the context of the NPD class studied and detailing our research methods and analysis. We then present the key research findings followed by a summary of results and recommendations for NPD education.

BACKGROUND

Longitudinal Assessment of Design Courses

Evaluations of the utility of NPD classes to their graduates are surprisingly rare. However, there has been more general research conducted on using alumni feedback to improve program outcomes. ABET issued a national appeal (the ABET Engineering Criteria 2000) for the integration of alumni feedback into educational assessment. The ABET criteria called for continuous improvement of engineering programs across the U.S., with clear objectives and performance measures, prompting many to solicit feedback from primary stakeholders, including both current students and alumni, to assess and evaluate program outcomes and program educational objectives by the year 2000 (McGourty *et al.* 1999). Some programs subsequently deployed surveys to capture information on the professional accomplishments of alumni to measure learning outcomes and the success of engineering programs for enrolled students. Soliciting feedback from alumni proved useful, but difficult to obtain with large response rates. Other research studies (McGourty *et al.,* 1999; Soldan, 1997; Regan and Schmidt, 1999; Rooney and Puerzer, 2004) surveyed alumni to obtain feedback on engineering curricula and educational experiences, focusing on complete degree programs rather than individual course experiences. Olds *et al.* (2005) conducted a review of the assessment methods utilized to evaluate engineering education outcomes and noted the most widely used descriptive methods are surveys, focus groups, and interviews, while the most widely used experimental methods are randomized controlled trials (RCT) and matching. Additionally, they found that longitudinal studies were very effective in measuring long-term learning impacts but are less utilized due to difficulties in tracking students once they graduate (Olds *et al.,* 2005). More recently, Borrego *et al.* (2009) applied concept maps to assess student development in interdisciplinary education and demonstrated how concept maps can help represent connections across different content areas in student learning.

In many educational assessments, students are surveyed or interviewed immediately upon exiting a course or program – not after they have worked in industry and are better able to reflect on the benefits of a course to their careers. Dori and Silva (2010) used pre- and post-questionnaires to assess their Product Design and Development (PDD) course within the EDAM (Engineering Design and Advanced Manufacturing) focus area of the MIT-Portugal Program both for studying the course objectives and comparing three different groups of students participating in the course. Similar to

many research studies, these studies are conducted during and immediately after course completion. Postmortems are valuable assessment tools and it is important to incorporate the lessons learned from postmortems into future projects in order for the beneficial effects to be fully realized (Koners and Goffin, 2007; Von Zedtwitz, 2002). Our study conducts a longitudinal postmortem of the NPD class after students have gained industry experience and are able to reflect on what they believe are the most valuable aspects of the course as it relates to their current jobs. We continuously integrate this feedback into the NPD course curricula in order to enhance the students' learning experience.

As we tried to better understand the effectiveness of various approaches to teaching NPD students, with a view towards the practices that will most likely benefit current NPD and innovation practices in both academia and industry, we reviewed the literature. Page and Schirr (2008) conducted an analysis of 815 NPD articles written between 1989–2004 and found extensive research on cross-functional teams (teams composed of individuals representing different functional units in an organization with different disciplinary expertise working together towards a common goal) and NPD processes, but identified a need for more NPD research on service innovation. Rosenau (2002), from his own NPD teaching experience with industry professionals, advises educators to use product demonstrations, real-world NPD examples, promotional video clips, and examples of product literature to fully engage the students. Kahn *et al.* (2006) benchmarked NPD practices to identify gaps and opportunities and to show industry leaders how to potentially change their NPD practices. Six NPD best practices emerged: (1) have a strategic, long-term orientation toward NPD, (2) have a formal portfolio management process, (3) implement a formal discipline-supported NPD process, (4) conduct market research proactively, (5) utilize multifunctional teams, and (6) employ standardized criteria and metrics. Golish *et al.* (2008) completed a series of interviews with academic and corporate inventors to learn how they differ in their approaches to technology development. Participants were asked to develop concept maps based on the processes they followed, and the resultant maps were examined. Academics had less complete and organized maps while their industry counterparts had more financial, societal-impact, and human design issues embedded in their process maps.

Although many studies address the value of NPD and propose best practices for teaching NPD, fewer studies seek to continuously learn from current and former students about the value of their NPD educational experience. A step towards this has been part of a research effort at UC Berkeley and is discussed further in the next section.

NPD Programs

As described in Section 1, a growing number of academic institutions offer classes that engage students in multidisciplinary project-based learning with students from business, design, and

engineering (Beckman and Speer, 2006). Each program takes a slightly different approach. The NPD course at the University of Michigan, for example, creates competing teams of students from business, engineering, and industrial design, who work with faculty advisors and professional designers to solve the same customer issue. At the University of Illinois, Chicago, on the other hand, multidisciplinary teams work on different projects suggested and funded by a corporate sponsor. The corporate sponsor in turn benefits from the projects by receiving ownership of all the concepts developed throughout the course. Yale University offers a graduate-level product design course to its students that utilizes a project-based learning approach and places students together on multifunctional teams, drawing from the engineering and business disciplines (Apfel and Jeremijenko, 2001). The NPD course at UC Berkeley shares a number of features with these other multidisciplinary courses offered elsewhere, and thus we believe the results of our research will be broadly applicable to current and future NPD educators.

UC Berkeley New Product Development Course

Course Background and History

The New Product Development course at UC Berkeley is a graduate-level design course that brings students together to form multidisciplinary teams to collaboratively apply the NPD process to a project of their choosing. UC Berkeley students from graduate programs in engineering, information sciences, and business join undergraduate industrial design students from the California College of the Arts (CCA) in teams of 4–6 to learn the skills, tools, and methods necessary to execute the new product development process. The NPD class uses a project-based learning approach combining project work with traditional classroom education (Dym *et al.*, 2005; Ulrich and Eppinger, 1995). The students apply the NPD tools and methods they learn in the classroom to execute their projects culminating with a prototype to be presented to a panel of professional designers at a tradeshow at the end of the semester. Although the course uses an authentic learning approach and tries to replicate best practices from industry, the academic setting provides the opportunity to introduce activities that can be difficult in a fast-paced industrial setting, such as the ability to self-reflect and document one's process work. The class covers the following topics:

- NPD Process and Overview
- Portfolio Planning
- Multidisciplinary Teams
- Project Management
- User/Customer Needs
- Concept Generation

- Concept Selection
- Prototyping and Testing
- Design for X (e.g., Manufacturability, Environment, Assembly)
- Costing and Financial Analysis
- Information Technology (IT) Tools for NPD (e.g., Computer-aided Design (CAD), modeling)

The graduate multidisciplinary NPD course at UC Berkeley was first taught in 1995. As the competitive environment has changed, the course has also evolved over the years. We conducted a syllabi analysis, focusing on the course from 1995–2010. Examining the syllabus content, each day of class was categorized based on the aforementioned topics covered in the NPD course. On average, 29 of the 60 class days per semester contained lectures; the other days consisted of design studios. Each of the course topics demonstrated a small amount of fluctuation in coverage in the first few years of the course (1995-1998), and this can be explained by the course instructors iterating to find out the best class structure and plan for a brand new course on product development. Overall, the coverage of course topics was consistent from 1999–2010 with *Prototyping and Testing* and *Design for X* demonstrating a small variance (between 1–3 days of total lecture time). This fluctuation is attributed to the availability of guest speakers, and the instructors modifying content near the end of the course to serve student project needs. Appendix A contains a summary course syllabus from 2006 and additional archival information on past NPD course syllabi.

Prior Research Studies

The UC Berkeley NPD class has been the subject of prior studies upon which we build in this paper. An initial study examined more than 2,300 lessons learned as reported by students from 2000 to 2005 (Hey *et al.*, 2007). These lessons were short statements collected at the end of the semester through a class exercise that allowed students to reflect on what they believed was most valuable, useful or challenging during the course. The study compared the students' lessons learned with feedback from professional designers who coached the student design projects. The most frequently mentioned lessons from the students – also echoed by the coaches – related to the challenges and benefits of working in multidisciplinary teams. Lessons relating to the design process and dealing with customer/user needs was the next largest category.

Following up on Hey *et al.'s* (2007) work, an initial study of alumni of the NPD course, reported by Cobb *et al.* (2007), performed in-depth interviews with 21 alumni to determine whether what former students said were their most salient lessons learned at the end of the course still held true after they had been working in industry. The interview analysis indicated that working in multidisciplinary teams remained of the highest importance for alumni, and customer and user needs became less important, while concept generation, and prototyping and testing increased in importance.

Alumni said they valued prototyping and testing more after realizing its importance in industry. With respect to academic training, there were responses from business, engineering, information, and industrial design students, while in Hey *et al.*'s (2007) study the data were largely without input from industrial design students.

In a related study, Cobb *et al.* (2008) examined ten years of data from the same UC Berkeley NPD class to understand how the skills and methods taught foster social entrepreneurship and continuing projects beyond the class to pursue additional funding towards a social or business venture. This study discovered that (1) a higher proportion of women in engineering and information sciences enrolled in the class than in the general population for those two departments and (2) a project that moves beyond the NPD course requires passion and motivation, as well as a premeditated project plan before the NPD class starts, as evidenced by descriptive case studies. Although many former students did not turn their course projects into business ventures, they still found the course content and lessons learned helpful in their careers.

Based on this prior work, our goal in this paper was to better understand what former students, who have moved on to careers in industry, value in New Product Development education by surveying a larger portion of our alumni, characterizing their current role in industry and conducting a deeper analysis of the open-ended questions.

RESEARCH DESIGN

For the current research, we designed a survey (see Appendix B) to send out to a larger pool of alumni. A survey method was chosen to: (1) reach a larger number of alumni by allowing them to complete the survey at their own convenience, (2) ask structured questions and capture a consistent data set, and (3) apply a data analysis with a larger number of responses. The survey included questions about what alumni recalled about the NPD course and the relevance of particular NPD methods, tools, and skills to their work in industry. At the end of the survey, we gave alumni the opportunity to indicate whether or not they would be willing to participate in a follow-up phone interview in the event we had further questions about their responses. Appendix C contains the questions we asked alumni in the follow-up interviews.

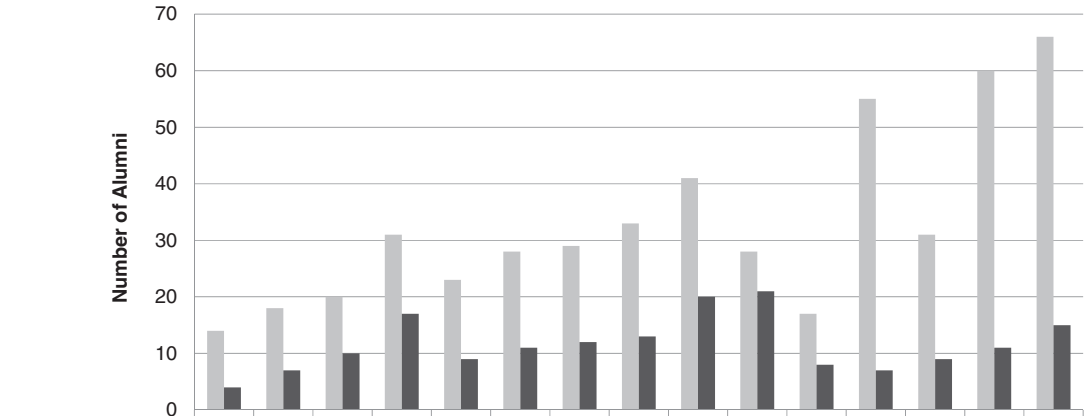
We obtained updated contact information for NPD alumni by contacting the Haas School of Business, College of Engineering, and School of Information alumni departments at UC Berkeley and the Industrial Design Department at CCA. As shown in Table 1, we had a pool of 888 alumni to draw from. We were able to obtain current records for 494 out of 888 (56%) of our alumni who took the course from 1996–2010. We were unable to obtain a course roster for alumni who took the class in

1995 (when it was first taught), and as a result this alumni group is not considered in the analysis. 54% of the 494 records were for former Master of Business Administration (MBA) students, and38%were for former engineering students. Only 35 (7%) Information students had contact records, reflecting their smaller numbers in the class. Unfortunately, we were only able to track two of the 98 CCA students as UC Berkeley does not keep records of visiting students from other schools. We contacted these 494 alumni via email to complete the survey; 174 alumni replied, yielding a 35% response rate. Figure 1 shows the number of respondents based on the year they took the NPD course. Because our research focused on what alumni remembered from the course, and the extent to which they were able to use the knowledge in their work, we needed responses from only those alumni who had left school and were currently employed in industry. Of the 174 survey respondents, 160 responses met those criteria. Respondents were allowed to complete all or only a portion of the survey. As a result, all of the survey questions did not have 160 responses, but 160 alumni did complete all or some portion of the survey. Alumni were given a window of three months to complete the survey. After the survey closed, the evaluation team (non-instructor co-authors) closely and iteratively analyzed the survey responses. The responses included short answer and open-ended questions. The open-ended questions required coding the responses according to the various themes that emerged. These themes are discussed in more detail in the following Section.

The quantitative and qualitative survey data showed some interesting trends which prompted us to design an interview guide as a follow-up to the survey targeted at gathering more detailed responses to clarify the trends we observed. Thirty-three alumni said they were willing to participate in a follow-up phone interview, while 40 indicated that they might be willing to participate. We first contacted all alumni who indicated they were willing to participate in an interview with the assumption that these alumni would be the most responsive to an interview request. Eighteen alumni responded in our given time frame. Because our interviews had a strong MBA representation, we contacted three additional

	Number in NPD class	Number with contact records	Number of survey respondents	Number of survey respondents in industry	Number participating in follow-up phone interviews
MBA	363	268	90	V89	14
Engineering	365	189	67	54	5
Information	62	35	16	16	0
Industrial Design	98	2	1	1	0
TOTAL	888	494	174	160	19

Table 1. Breakdown of the number of NPD alumni from 1996-2010. 494 contact records were obtained in total and 174 alumni responded to our survey.



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number contacted	14	18	20	31	23	28	29	33	41	28	17	55	31	60	66
Number replied	4	7	10	17	9	11	12	13	20	21	8	7	9	11	15

Figure 1. Survey response by the year alumni took the NPD course. 'Replied' indicates an alumus responded to at least one section of the survey.

engineers randomly selected from the 'maybe' list. Of those, one was willing to participate in an interview during our given time frame. The interviewers used the interview guide as a general guideline but allowed the interviews to remain open-ended. After transcription, the three non-faculty co-authors first independently analyzed the interviews to extract unique cases, common themes or particularly interesting comments and recorded them on Post-Its. We then met as a group to share the extracts. Using a variant of affinity diagramming, also known as the K-J method (Brassard and Ritter, 1994), we iteratively sorted the extracts as a group and combined them into an emerging set of themes that evolved from the data. Differences in categorization were discussed with the result that some extracts were attached to multiple themes. These emergent themes are discussed in the following sections.

While we present some insights from the alumni interviews with the survey results, the interviews highlighted several important issues that did not show up in the survey. The nineteen interviewed alumni were in project management, product management, or executive-level positions in their respective companies at the time of the interviews. Additionally, it should be noted that the nineteen alumni who agreed to be interviewed generally held a positive view of the course (all but one agreed or strongly agreed that the course had been useful in his/her work since leaving school), so we recognize that the interview sample is positively biased.

Background of Survey Respondents

Alumni from the NPD classwork in a wide range of industries as shown in Table 2. One-hundred and twenty (out of 160) alumni specified their current industry in the survey, and by far the largest

Industry	MBA	Engineering	Information & Industrial Design	Total
Computer Software & Information Technology (IT) Services	22	7	6	35
Biotech/Pharmaceuticals	5	5	0	10
Financial Services	6	3	0	9
Health Products and Services	5	1	0	6
Consumer Products	4	1	1	6
Electronics/Computer Hardware	2	5	1	8
Media	5	0	0	5
Automotive/Transportation/Manufacturing	2	3	0	5
Diversified Services/Consulting	3	1	2	6
Real Estate	4	0	0	4
Energy	1	5	0	6
Materials and Construction	0	4	0	4
Non-Profit and Social Services	2	0	0	2
Retail and Wholesale Trade	1	0	1	2
Other (includes one alumnus each in aerospace, telecommunications, healthcare, chemical, government, education, and marketing)	7	4	1	12
Total	69	39	12	120

Table 2. Alumni by industry sectors. 120 out of 160 eligible alumni responded to this question.

number of alumni, 35 of 120 (29%) surveyed, worked in the software industry. The others are spread across a range of industries including biotech/pharmaceuticals, financial services, and health products and services. Twenty-nine of 120 (30%) surveyed alumni held marketing roles in industry, while 19 out of 120 (16%) had a strategy/business development role. The heavy marketing, strategy, and business development role presence in the overall sample is likely due to the fact that 89 of the 160 NPD alumni surveyed were former MBA students. The engineering graduates were more concentrated in engineering, manufacturing, research and development (R&D), strategy or consulting roles. Eleven of the MBAs and three of the engineers identified themselves in executive management roles (CEO, CTO, company co-founder).

RESEARCH FINDINGS

This section discusses our research findings based on survey and interview data from alumni. We begin with an overall evaluation of the course, and compare that evaluation to results from

prior studies of the same course (Hey *et al.*, 2007; Cobb *et al.*, 2007). We then discuss a series of topics in the following order: (1) the value of multidisciplinary teams, (2) specific NPD tools and methods valued in industry, (3) the practice of NPD in industry, (4) a comparison of real-world and classroom-based NPD, and (5) suggestions for improving NPD education. It is worth noting that we did not explicitly test alumni for their recollection of the NPD course content, and as a result, we realize alumni may have different recollections based on how long ago they took the course. As a means to mitigate this, we asked alumni to only respond to the questions they felt comfortable answering.

Overall Course Evaluation

Our initial survey questions were aimed at gaining the overall impressions alumni had of the NPD course after gaining industry experience. Alumni were asked to rate how useful the NPD course was to them while in school in addition to the course's usefulness to them now as they work in industry. As shown in Figure 2, alumni views changed somewhat over time as 91% of surveyed alumni agreed that the course was useful while they were in school (49% strongly agreed), but a lower 84% agreed that the course has been useful to them since leaving school (only 29% strongly agreed). Twenty-seven surveyed alumni who had marked 'strongly agree' shifted and marked that they only 'agreed' the course had been useful to them after graduation. No one felt the course was not useful for their academic study, but 5% of surveyed alumni felt the NPD course had not been useful for them after graduating. Although there is an expected drop of value of school work years after graduation, it is reassuring that such a large percentage still value the course content so many years after graduating.

Since the NPD course employs a project-based learning approach, we asked alumni if, in retrospect, their class project was an effective learning experience (Figure 3). Eighty-nine percent of surveyed alumni respondents thought their class project was an effective learning experience (53% rated it as 'highly effective'). However, when asked if any of the lessons learned or knowledge gained from the project experience had been 'effective' in their current work, 80% responded affirmatively (22% said the project lessons had been 'highly effective' in their work, while 58% said they were effective). This represents a clear shift in the strength of ratings for course and project experience utility once an alumnus left school; 36 alumni who had marked the course project as 'highly effective' while in school, marked the class project lessons as only 'effective' in industry. Again not surprising, as it would be expected that they would gain more effective authentic project experiences to add to their learning portfolio after graduating. Additionally, some of these alumni chose to pursue careers after graduating where NPD skills and lessons are not necessarily needed for their daily work.

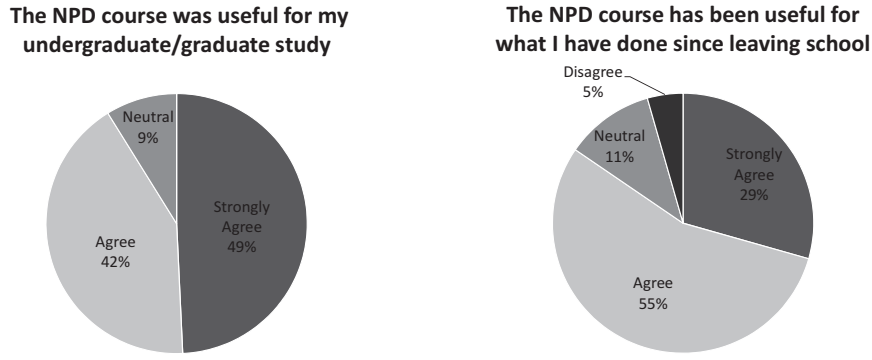


Figure 2. Usefulness of the NPD course.

This shift was a common trend we saw in the survey results. During the interviews, we were able to clarify the shift from 'highly effective'/ 'strongly agree' to a response of 'effective'/ 'agree' upon having spent some time in industry. Some interviewed alumni stated that they did not feel that the work they were doing now was directly relevant to NPD, and thus they rated the effectiveness of the course and project lessons lower after industry experience. However these alumni were still able to draw parallels between NPD and their current work during the interviews. One alumnus felt that the lessons he/she learned from the course and project were not the most important part, but rather having a general NPD background and mindset is what has been vital to him/her in industry.

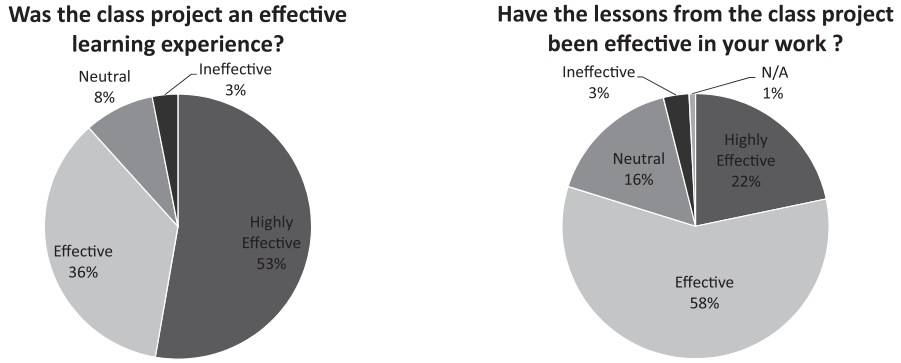


Figure 3. Effectiveness of the class project.

Importance of NPD Tools and Methods in Industry

Cobb *et al.* (2007) asked alumni to rate a set of course topics and their relevance to the respondent's current work in industry on a scale of 1 to 5 (5 = very important and 1 = not important). To further explore the importance of these topics to alumni in industry, we asked those who took our survey the same question. The results from the survey are shown in Figure 4 disaggregated by discipline.

Assuming our MBA and engineering population samples are independent and normally distributed, a multivariate Hotelling's t-square test was performed to test whether or not the differences between the MBA and engineering populations for the rating of NPD topics shown in Figure 4 are statistically significant at a 5% significance level ($\alpha = 0.05$). The results yielded a Hotelling's T^2 value of 32.99 with a corresponding F-value of 3.05 and p-value of 0.002. As a result, there is a statistically significant difference between the MBA and engineering alumni populations in their ratings of NPD topics. This difference is largely due to the variation in ratings both groups had for the following NPD topics: *Prototyping and Testing*, *Design for X* and *Costing and Financial Analysis*. The engineering graduates rated *Prototyping and Testing* and *Design for X* higher than the MBA students, while the MBA students rated *Costing and Financial Analysis* higher than the engineering students.

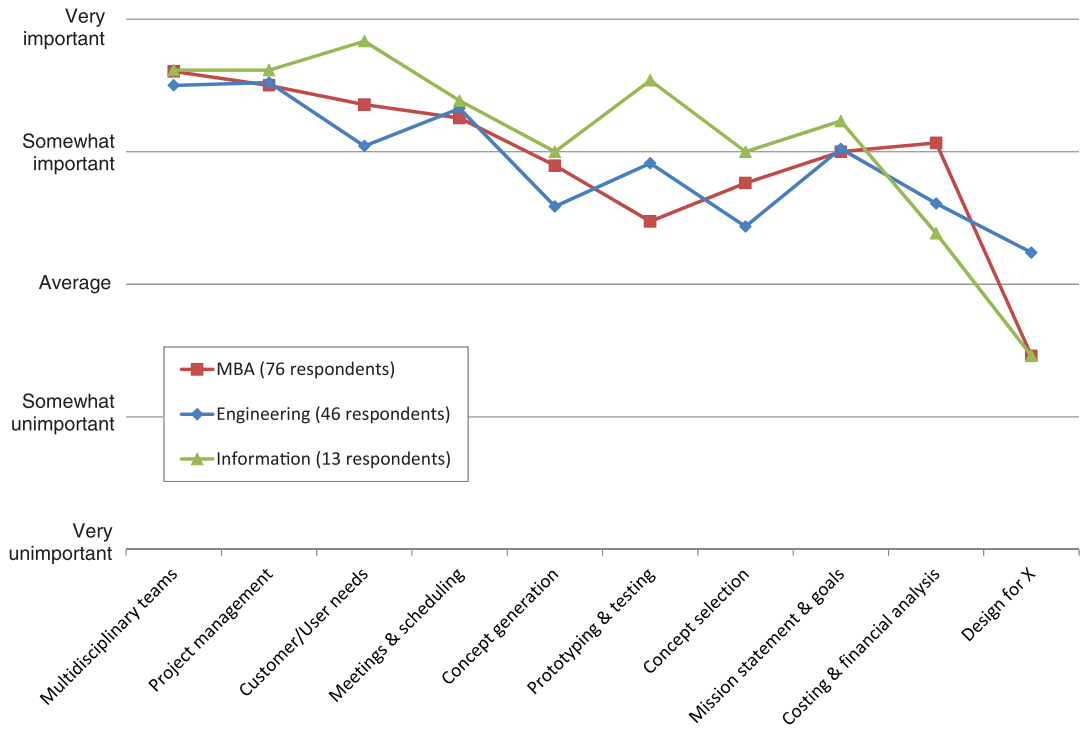


Figure 4. Survey data for the average rating of NPD topics disaggregated by discipline. 135 alumni responded to this survey question.

The number of Information alumni respondents to the survey was not sufficient to test for differences between them and the MBA and engineering populations. It is interesting to note, that the Information students, on average, gave the highest marks to *Customer and User Needs* and *Prototyping and Testing.* This difference in ratings relative to the MBAs and engineers may be attributed to the fact that most of these alumni are in a consulting role or information technology field where *Project Management* and *User Needs* are especially critical for project success, and that both are emphasized in the Information School curriculum.

If we compare the alumni interviews conducted by Cobb *et al.* (2007) and survey results with Hey *et al.'s* (2007) lessons learned work, one of the most interesting results is that surveyed alumni on average most value what they learned about working in multidisciplinary teams, just as the students did on the last day of the course. On the other end of the spectrum, we found that Design for Manufacture/Environment/Assembly (better known as *Design for X*) consistently emerged as one of the least important NPD tools for alumni, just as they did for the students. *Design for X* tools are often applied during later supply-side manufacturing stages of product development, and because at the end of the course student teams are expected to only deliver a concept prototype, the importance of manufacturing issues may not yet be appreciated. Additionally, 29% of our surveyed alumni currently work in the software industry and *Design for X* could be less relevant to their work. During one of our follow-up interviews with an engineering alumnus, they saw more value in *Design for X* after industry experience:

> *Design for environment…is probably most germane to what I do…we definitely, keep environmental aspects in mind at all times, because that's part of our brand…that's definitely something we use in my business. I think people are getting more and more interested in it because the 'green aspect in business' becomes more strategic…I think more time should be spent on design for environment.*

The Value of Multidisciplinary Teams

Previous studies (Hey *et al.*, 2007; Cobb *et al.*, 2007) demonstrated that multidisciplinary teamwork was the most valued aspect of the NPD course. Collaborating with peers from diverse disciplines requires working with different skills and mindsets. Responses from alumni indicate that the value and need for multidisciplinary teamwork still continues in industry. In this section we discuss several aspects of multidisciplinary teamwork reflected in the survey and interviews, including the overall value of the multidisciplinary project experience, team formation, and effective communication within multidisciplinary teams.

The Value of Multidisciplinary Project-Based Learning

While reflecting upon their NPD project experience, alumni were asked to recall which aspects have been most useful in their careers. In our survey, 44 alumni identified the multidisciplinary teamwork aspect of the course project as the most helpful to their current work in industry. Working with students from different academic backgrounds helped prepare alumni for team project experiences in industry. Even many years after graduation, one alumnus said, "*I appreciated the team approach to concepts, the ability to air different views, delegation and success for a common goal - all of which I still use today*" (1996). Another alumnus emphasized that multidisciplinary and diverse teams are a vital course lesson and went on to state that: "*This is the most helpful right now because in my everyday job I am working with at least 6 different nationalities and at least 4 different bodies of expertise*" (2004). An engineering alumnus from 2009 emphasized that "*working with MBA and design students was an eye opener*," as the course project showed them that they cannot do everything on their own and need to leverage the skills and expertise of their team members. The multidisciplinary teamwork the NPD course fosters provides useful lessons that many of our alumni apply in industry. One respondent said, "*[I try] to think as if I was my teammates to understand what they are expecting… The purpose is to make the team work more smoothly. I try to apply this to my co-workers now to better see how I should interact with them*" (2005). We also found that multiple times throughout our survey, former business students mentioned they appreciated having the chance to work with engineering and industrial design students, and engineering students valued having the chance to work with business and industrial design students.

The importance of the multidisciplinary project experience was further reinforced by our follow-up interviews with alumni. One alumnus said, *"It's got to be in multidisciplinary teams"* (1998), while another stressed that, *"if it wasn't multidisciplinary, it wouldn't be nearly as valuable - I think that's a requirement for it being a good class"* (1999). Primarily from the multidisciplinary team project experience, the value of mixing disciplines was highly appreciated. For example, one alumnus said, *"the way the class is split up between engineers and business school people, I thought was fantastic…I think both sides learn from each other and I think it helps in my career"* (2002). By sharing more explicit knowledge about how multidisciplinary teamwork is applied in industry, alumni further emphasized the value and reality of mixing different functional roles and backgrounds to form teams. As one alumnus shared, *"the skills definitely come up…we have soil engineers, electrical engineers, as well as biologists and other environmental experts – we have to coordinate all of their work"* (1998).

Although many alumni found what they learned about multidisciplinary teamwork in the class to be invaluable and applicable to much of their work today, a few alumni in smaller companies encountered fewer multidisciplinary team experiences. One alumnus highlighted that although he/

she works in teams often, because his/her company is a small start-up, the team typically consists of only engineers and the company does not have the luxury of forming multidisciplinary teams in its current composition. Discussing less collaborative multidisciplinary experiences, one alumnus particularly appreciated the value of multidisciplinary work but had several experiences of NPD being driven by one person: *"Our chief designer proposed a [product] based on his/her assessment of the feature set that would sell well and what competitors were doing… he/she was also very resistant to any changes. In some senses, that's almost, but not quite, the polar opposite of multidisciplinary NPD"* (1999). These less than positive experiences with multidisciplinary teamwork were few in number compared with the vast majority of survey responses, but are worth highlighting to demonstrate that although multidisciplinary teamwork is important, it is not universally well utilized in industry.

Working in diverse multidisciplinary teams in our NPD course enabled many alumni to gain experience and better understand how others communicate and think. Understanding how other disciplines work and think was a recurring theme in our study as well and is discussed in greater depth in below.

Communication: Ways of Thinking and Speaking

Over 50% of the alumni interviewed commented on the value of understanding how different disciplines think and speak, and what motivates them, both in terms of the benefits of the class and what is required in industry. For the business graduates, engineers were seen as their *"partners in crime."* There was an emphasis in industry on different ways of thinking and speaking across disciplines to help communication, *"Understanding how the two sides (business and engineering) communicate with each other is really the key"* (Alumnus, 2002). Team members need to have experience*, "working with people of different views,"* who have, *"their own way of thinking – a different language."* A manager at a biotech firm who took the course in 2004 commented, "*In the real world, someone's going to have an MBA, a Masters in design and another will be an engineer and you have to figure out how to speak each other's [language]."*

Many interviewed alumni referenced the class as a good vehicle for understanding how other disciplines think in a risk-free environment:

"It was more about the exposure to others and how people think" (1999).
"A good insight as to how their minds work and what makes them tick" (2004).
"The higher-level impact is understanding the product development process from an engineer's side. It helps me communicate with them better" (2002).

As another example, one alumnus said, "*Working with engineers, or maybe more generically with someone who is not an MBA, requires a different framework. And, communication is so critical to any*

endeavor, especially a process as involved as new product development" (1998). In particular, the challenges of working with different disciplines surprised graduates but underscored the positive learning experience: "*I did find that the engineers communicated very differently and there was a personality difference between the business students and the engineers, even though some of the business students were engineers themselves. It definitely was a different way of communicating; a different way of handling things... The communication was hard at first so it was a great learning experience*" (Alumnus, 1998).

Project Team Formation in Industry

Teams are strongly influenced by how they are formed and thus it is interesting to contrast class team formation with the alumni experience in industry. In the NPD class, strong efforts are made to form student project teams with a balance of disciplines and skills sets while incorporating student preferences for projects and team members. As part of the survey we asked alumni to explain how project teams are formed where they currently work. Responses from alumni indicate various approaches to project team formation including, but not limited to the following: skill sets, interests, availability, or simply convenience.

The most common approach (with 32 responses from surveyed alumni) concerns forming teams based on matching the skills required for the project from different disciplines. Alumni emphasize that in industry one must *"determine skill sets needed and find the people that best fit those criteria"* (Alumnus, 1997). Skill sets or expertise areas commonly mentioned included marketing, engineering, sales, research and development, manufacturing, operations, finance, and project management. In smaller companies, team formation is essentially forced by the skills available —*"We have a very small company, so nearly everyone has a unique skill set, such that teams form based on necessity of skills"* (1998). In larger corporations, in contrast, the process can be far more complex, *"We have multiple teams with different performance metrics and different team missions. We are in a matrix environment, so buy-off is very complicated"* (2005). Alumni often commented simply that bringing together different disciplines is important, but forming great teams is difficult.

Nine alumni explained that teams are simply predetermined, meaning there is no frequent rotation or selection process for teams. Once teams are fixed the challenge is simply making it work. One alumnus said, *"As we have limited resources, there is no "selection" process – who we have is who we have. That being said, we are careful to hire good people and quickly remove those who do not fit"* (2004). Two alumni from 2004 and 2008 who are now in manager roles commented on how they 'inherit' their teams, but both emphasized they try to employ lessons learned from NPD to work through team conflict and adversity. Once the decisions are made on team formation, everyone

must learn to work together effectively and efficiently. An alumnus from 2005 added that once teaming has been decided by upper-level management at their company, *"We do our best to utilize everyone's skills and work as one unit. This can be challenging, but is a part of real life – you have to learn to work with everyone and understand the different roles each team member can play."* During a phone interview, another alumnus commented on the difference between team formation in the course and in industry, explaining that in the NPD course, *"you also get to self-select the teams a little and you don't have to work with these people beyond graduation. I think that changes the dynamic… If a group doesn't work well you may not be in another group with them. You may see them after the project, but you won't have to work with them…In the real world you don't necessarily have that much choice"* (1999).

Only three surveyed alumni wrote that team formation was based on interest in the project with one alumnus commenting that individuals' commitment to their project is the most important feature. Another three surveyed alumni suggested the process was "*ad hoc,"* "*informal"* and "*organic."* Eight surveyed alumni simply explained that team formation was performed by upper management or team leaders, suggesting that the team members themselves have little say in their assignment. Availability was often mentioned as a key criterion as stated by another alumnus in a follow-up interview: *"Everyone's pretty tied up, so whichever engineer is free…is who you're going to work with"* (2004).

NPD Tools and Methods

We asked alumni to describe, if applicable, how understanding user/customer needs, concept generation, and concept selection are approached in their current work. These were open-ended survey responses that we sorted and categorized based on the tools and methods described, sometimes assigning one response to multiple categories if it identified multiple approaches. Table 3 summarizes our findings, highlighting the top three approaches used in each category. In the following sections, we explain some of the tools and methods alumni employ in industry.

NPD Topic	Approaches Used
Understanding customer/user needs	Surveys, focus groups, interviews
Concept generation	Brainstorming, collaboration, customer input
Concept selection	Management-influenced, financial analysis, multi-criteria ranking/prioritization tools

Table 3. Summary of most utilized approaches to user needs, concept generation and selection.

Understanding User/Customer Needs

Survey respondents stressed the overall importance of doing some form of user/customer needs assessment in industry. Eleven surveyed alumni mentioned the general importance of understanding user/customer needs in their current work. One alumnus believes user needs research is "*hugely important"* and "*continuous customer check-ins are necessary since the industry moves at such a fast pace"* (2002). Another respondent stressed that understanding user/customer needs is "*seen as critical to creating differentiated, competitive products*" (1999). Moreover, 35 surveyed alumni said that understanding user/customer needs was one of their top takeaways from the NPD course. Alumni stressed that from the course, they learned "*the importance of designing a product that meets customer needs,"* and *"traditional market studies and focus groups are not that insightful–observation and ethnographic studies are much more powerful tools to get to the information you want*" (2006).

When surveyed alumni were asked how they currently approach user/customer needs at their companies, 82 out of 96 (85%) indicated that understanding user/customer needs is relevant to their current work and many gave representative examples to demonstrate this point. Twenty out of 96 (21%) alumni emphasized that they employ traditional market research techniques such as surveys, focus groups, and competitive analysis to understand their customers or target market. These techniques provide the opportunity to interact with customers and learn what a customer wants and needs through data and market trends. More direct one-on-one methods such as interviews were used by 18 out of 96 (19%) alumni and observational methods were employed by five out of 96 (5%) of the alumni surveyed. Although observational methods were used less often among the alumni, one respondent stated that customer observation was helpful for researchers to see, "*how users currently use the product*" (1997).

Within the context of the 19 follow-up interviews, four alumni emphasized the value of understanding user needs in their current work and provided additional insights with regards to their companies' approaches. The NPD course teaches students that understanding the key stakeholders is essential to creating successful new products and services, and alumni stressed their attempts to apply these human-centered design techniques in industry. One interviewed alumnus working on software design explained:

> *We actually have user-interface mock-ups and designs that we want to get feedback on. Sometimes we'll build actual prototypes or simulations and look at more detailed interactions with the user interface. We have labs where we can make some observations and record what [the users] do…I remember even for some projects in the class, when we would have different prototypes, and we would actually get some [user] feedback…There's actually a lot of relevance between what you learn in class and what actually happens in the real world* (1998).

Concept Generation and Concept Selection in Industry

Alumni approach concept generation in several ways at their companies. Concept generation is part of the early phases of the design process and can include tasks such as benchmarking and brainstorming sessions that may be done within multidisciplinary teams. It is interesting to note that although there is a wide array of concept generation methods available, brainstorming is the most widely used method with 25 of 96 (26%) of surveyed alumni explicitly noting that brainstorming is used in their current work. We theorize this may be due to the simple principles involved in a brainstorming task, allowing almost anyone to participate.

Twelve alumni out of 96 surveyed alumni (13%) highlighted that concept generation is conducted in a collaborative manner with cross-functional or multidisciplinary teams. However, five alumni (5%) described a dual approach that starts with conceiving ideas individually and then sharing with the group. One respondent said that concept generation is, *"usually developed by a single individual with some input from others. In practice, this seems to be more typical than the process oriented approach from [the class]"* (1998). Another alumnus stated with regards to collaborative concept generation, "*this is the fun part - my team tries to spend as much time as we can strategizing about possible solutions*" (2005). In addition, eight alumni (8%) use user/customer input to help them ideate during the concept generation process, taking "*customer requests that show promise for becoming standard products."*

Twenty-one alumni out of 96 (22%) surveyed alumni stated that they do not use explicit concept generation techniques at their companies because they are focused on product refinement as opposed to the development of new product concepts.

Focusing on concept selection, thirteen surveyed alumni (14%) said that concept selection is heavily influenced by the upper-level management within their respective companies. One survey respondent said concept selection is by consensus and "*strongly influenced by top management"* (1998). Six alumni mentioned a criteria-based approach or formalized tools such as prioritization matrices for concept selection including the criteria: *"Price, quality, competition, market, achievability."* To realistically work on concept selection, six respondents highlighted that concept selection is driven by the company budget or financial analysis and is a *"rational trade-off selection between impact and cost and resource availability."* One respondent who took the course in 2000 also said that while financial feasibility affects the beginning phases of concept selection, later phases are *"mostly driven by customer applicability and resources."*

Context of NPD in Industry

A Widely Applicable Process

One theme which ran throughout our interviews was that the team and process skills learned from the NPD course are valuable across a range of industries much wider than was

perceived by students when they took the class. For example, one alumnus working in real estate explained:

> *I would never have thought that what I'm doing now would have been part of what the course prepared me to do…I realized actually in a tangential way, but in a very tangible way, I am doing [the NPD process] now* (1998).

Other interviewed alumni working in venture capital, healthcare, scientific commercialization and biotechnology, also noted that the NPD process is applicable in their current industry. One alumnus working for a social media company saw the process applicable, more or less unchanged, to the development of online applications and offerings:

> *The feedback loops are different, but the process is still the same. How would you test it and tell other people about it. You've got to understand there are problems people don't know they have, and find whitespace in the market and create a simple, elegant solution. Is that any different from creating a physical product? I don't think so. The general process is more or less the same* (1998).

This emphasis confirms that the process taught in the class, though originally for NPD, can be seen more generally as an innovation process – one that is applicable across a wide range of industries and contexts.

A Matter of Scale

Attitudes towards the implementation of the process in industry varied substantially depending on the size of the alumni's company. Employees at larger firms often noted that: *"you have additional resources, you have market research department, you have a user-interface design department… it's a matter of scale"* (Alumnus, 1998). Though not always the case, some employees at larger firms also experienced more difficulties with buy-in, bureaucracy, and resistance to implementing new processes. Smaller companies however, consistently spoke to the challenges of implementing what was often seen as a highly structured NPD process. Rather than being limited by large existing structures, they were challenged by the chaos of a startup. *"In smaller companies you want it done faster and lower cost. If you had unlimited resources and time, it would make it much easier to implement a more thorough process. In a counterintuitive sense it's almost easier to build and release a product, figure out what fails about it and then build a second one, than it is to follow the complete NPD process to be sure the first time around"* (Alumnus, 1999). A product manager at a

startup firm who took the course in 2006 agreed, *"[the NPD class] prepared me very well within a structured environment because it's...very distinct, very defined. Within the chaos of a startup...a lot of that structure loses some of its meaning and value*."

Given the difficulties following the process in small firms, one alumnus suggested adding a class discussion on how to adapt the process to specific contexts: *"Here's the way we would do it if everything were perfect. By the way, in the real world, here's how it typically happens. Here are the shortcuts that are likely to work and here are the shortcuts that are likely to lead to disaster"* (1999). However, despite the difficulties of implementing the process in small firms, alumni found knowledge of the process, and even knowing that a process exists, to be valuable even if it was not always followed:

> *Having an understanding of what the process looks like and what the components are... is helpful in framing your perspective on moving into a product development activity. But as far as making the leap and applying the component process you learn and the tools to the real world environment, the class starts to feel a little bit theoretical. And it's incredibly difficult particularly in this context to do that sort of process rigor* (Alumnus, 2006).

> *Understanding that there is a methodology is beneficial. In the real world if you can't do every stage, maybe you can do some of them and not others, and know which ones you're missing. But knowing about that process helps* (Alumnus, 1999).

Comparing NPD Education and NPD Industry Practices

One trade-off in designing a course with authentic learning in an academic setting is deciding which industry practices should be replicated and which ones should be modified to increase student learning. Students' comments on the similarities and differences in the course experience can be used to better understand how well we have done in striking the correct balance.

Similarities in Industry

The alumni phone interviews provided us with insight into similarities between the course and industry. Many alumni said that the project element of the course was similar to what they experience in industry. For example, one alumnus said, *"Keep the project. Sometimes for graduate school projects, finding time to work on them is inconvenient. In reality no one has the same schedules and same interests, so why should it happen in class?"* (2004). Another alumnus from 2004 said, *"unpredictability combined with the amount of work I think is quite representative of what you experience in the real world"*.

Alumni also reported similarities between the course and industry with regards to teamwork, and the difficulty of working in teams. Several alumni commented that although teamwork in the class was difficult, dysfunctional teams also exist in industry. For example, one alumnus said, *"If nothing else, [the class] was a lot closer to the real world [than other classes] because in the real world teams are dysfunctional"* (1999). In spite of these team challenges, alumni thought overall the project was a great learning experience. This alumnus further highlighted: "*I remember the project well because we had the most dysfunctional group of my entire time in [graduate school]. It was challenging… for certain projects it's hard to pull through*." The authors note that the instructors devoted time to developing multidisciplinary teamwork skills and provided interventions as needed, particularly to seemingly dysfunctional teams.

Differences in Industry

The interview data also exposed several important differences between practicing NPD in an ideal class setting versus practicing NPD in industry. In our nineteen follow-up interviews, alumni expressed the following general themes with respect to industry and classroom NPD practices:

- It is challenging to get others on board with your project in industry and convince management of the validity of your project.
- In industry, it is difficult to convince others of the value of NPD.
- There are often company politics or other internal factors not present in the class that affect a product's direction.

Twelve of our 19 interviewed alumni described the challenges they face in industry when it comes to proposing new projects and garnering support from their colleagues, as well as obtaining support for practicing, more formally, the NPD process. A few alumni in particular felt that in the class everyone is vested in the process and project and everyone shares a common goal, whereas in industry, processes and projects require more approval and justification.

> *With the project experience in the class, you really only had to convince the other 3 or 4 other people on your team that you were on the right course… In industry, I found that there really is the need to be able to present and explain in detail why you're making the recommendations and choices that you're making. The stakes are a lot higher before you get to the point of the company devoting personnel resources and a great deal of money towards developing a project - that's a lot different than what we were doing in the class* (Alumnus, 1998).

> *Because we were all in the class we all kind of learned about different pieces of the process and we were all really invested in learning and applying the methodology. I've found that in*

industry it's a very 'new' process that companies and some people may not be used to using. To that effect they may latch on less to the notion of how you're going to go about the work (Alumnus, 2005).

In a class setting, many students are invested in getting a good grade whereas in industry coworkers may have different goals for projects. In industry, more justification and approval is also required to sell your concept and the process to upper level management and the company as a whole. This might be best explained by the more strongly differentiated roles alumni hold in industry relative to the NPD class project experience.

In industry, roles are more clearly defined than they are in our NPD class, according to three of our interviewed alumni – *"Roles are clear cut from the beginning in the real world"* (Alumnus, 2004). In the class project, roles are not specifically enforced and can be more organic in nature. Also, in industry there is often less interplay between the roles of management, design, and engineering, than there is in the class. Because roles are more strictly defined in industry, each person has his or her own desires and goals for a project to succeed.

Alumni highlighted that in industry, projects are often chosen, altered, or cut based on decisions that are not necessarily influenced by the NPD process. One of our interviewed alumni expressed the challenges she/he faces when it comes to company politics.

The class also doesn't take into account the politics of the company because you have an individual who wants responsibility because that's how they justify their existence within the company. I can see there are a multitude of reasons why it's hard to implement [the process]. The reasons are not as simple just as time and cost, I think they're much deeper (1999).

Use of Specific Lessons Learned

In our survey, we asked alumni about the use of specific lessons from the NPD course in their daily work. For this particular section of the survey we had 136 alumni responses. The results from the alumni survey revealed that 50% agreed that they are using specific NPD lessons in their daily work (13% "strongly agreed") and 50 out of 136 (37%) remained neutral on the topic. 50% is relatively high rating for course topics to be useful in one's daily work, motivating us to better understand which specific lessons from the course were more useful than others. We used the phone interviews as an opportunity to further clarify these findings.

Overall, most alumni identified the importance of leaving the course with an NPD mindset rather than specific tools to use. One interviewed alumnus said, *"I think the best classes aren't classes that give you a specific tool that can be applied in specific situations, but rather classes that tell you...*

the world is heterogeneous so we're going to teach you how to think so you can apply the knowledge over multiple scenarios" (2004). Others emphasized that although they do not recall specific lessons, they still recognize elements from the NPD course in their work. An interviewed alumnus thought that the mindset was helpful, *"so you can hit the ground running"* (1998). Also, the course gave students an introduction to what they might see in the real world. Another alumnus from 1998 compared the course to red wine, *"You're going to expose people in a course, but it's only a taste. It's like red wine – you get a taste but you're not yet an aficionado."*

Suggestions for NPD Education Improvement

We asked alumni in both the survey and interviews for their recommended improvements to the current NPD course for students interested in careers in design, innovation, and entrepreneurship. Most of the survey responses and interview comments were quite positive overall, with many alumni emphasizing how much they enjoyed both the course and the lessons learned. We used the open-ended survey questions and interviews as a chance to solicit additional qualitative feedback and recommendations from alumni to help further improve the NPD course. As an example, one alumnus stated: *"I think the class is great, and one of the best I took at Berkeley. However, working at my current company and talking to people from other universities, I have realized that they come out of classes like this with a real tangible product or prototype that they can show off"* (2009). As instructors we made a concerted effort to put more emphasis on the NPD process, rather than the quality of the final prototype. However, feedback like this made us realize that students do have a need to sell their work during job interviews and when looking for seedling funding to carry their product idea beyond the class. Thus, we started workshops in portfolio development to show students how they can highlight quality process work in addition to prototypes as part of their portfolio. Additionally, as the campus' prototyping capabilities increased, we also articulated a wider range of access to medium to high fidelity prototyping facilities.

Overall, the recommendations from the surveys and interviews were diverse, but common themes and suggestions emerged. We believe these suggestions regarding improving NPD at UC Berkeley are also widely applicable to similar design courses at other universities and the suggestions also give insight into design and innovation practices in industry today. Three of the most frequently mentioned suggestions from the open-ended survey questions and interviews included the following:

- Relevance of NPD in the software industry
- Additional entrepreneurship opportunities to help accelerate projects beyond the course
- Additional course modules and guides for NPD best practices

The themes which emerged from alumni touch on the tools and resources students felt they needed to succeed in an innovation environment and also touched on resources needed to turn

semester long class projects into entrepreneurial ventures. The following sections further detail the course improvement recommendations from our alumni based on their responses to our open-ended survey and interview questions.

Software-based NPD

Currently, 29% of the alumni surveyed work in the software industry. This was by far the most represented industry sector in our survey. In both the open-ended survey questions and follow-up interviews alumni highlighted the importance of showing students how NPD is directly applicable to software products. These alumni gave explicit recommendations for software-NPD course modules. More specifically, seven surveyed alumni expressed that they would like the course to examine NPD in other industries, focusing on the software industry rather than industries that deal with more traditional tangible products as exemplified by the quotes below from two alumni below:

> *When I took the course in 2003, it was pretty focused on tangible product development. I generally support this approach because it is easier to teach the general concepts in this format. However, some material on bridging to software and services would be interesting as well* (2003).

> *Given the focus in Silicon Valley on software, it would be useful to have more projects that entail software development. Software development is a different animal than other types of product development with its own nuances. Although the NPD course is focused on tangible products, it might be useful for students to learn about NPD in other industries, which could be addressed in lecture* (2004).

In our follow-up interviews with alumni, two alumni again made recommendations for including more software-based NPD projects, expressing that the process is not that different from traditional NPD. One alumnus even highlighted a reality of teaching at UC Berkeley: "*A lot of students at Berkeley are going to stay in the Silicon Valley area, so it would be useful to do something that's software specific*" (2004).

To further understand the software-based content recommendations from alumni, we compiled a list of all of the NPD course projects from 1995-2010 and categorized them to see the frequency of software-based projects. A student project was categorized as software-related if the project addressed an unmet customer need with software-based solutions. Based on that categorization, we plotted the percentage of NPD projects that were software-based over the time span of 1995-2010 (see Figure 5). In 1995 and 1996, almost all (78%) of the NPD projects were software-based, whereas in 1997, software projects were only 20%. It is interesting to note that in 2000, there were

no software-based projects. The span of 1995-2000 coincides with the «dotcom» boom in Silicon Valley (Goldfarb *et al.*, 2007); the start or 'boom' of the dotcom era (1995) coincides with the highest representation of software-based course projects while the lowest representation of software projects coincides with the end of the dotcom era in 2000. Note that the class on average has between 8-17 student projects each year with an average of 12 projects a year. While 2000 and 2003 have the lowest representation of software NPD projects, the percentage has been steadily climbing since 2004, and in more recent years we have encouraged and given students the opportunity to pursue more software and services-based NPD projects. Although software NPD is covered briefly in the course, students now have the opportunity to take an in-depth information technology (IT) NPD course in the Haas School of Business titled: *Design and Development of Web-based Products and Services*.

Complementary Entrepreneurship Opportunities

We found that only a small number of NPD student projects in our course took the next steps to form an entrepreneurial venture once the course had ended. Most of the teams who considered turning their NPD project into a more entrepreneurial venture "*...did talk about bringing the product to the market but...stopped at the talking phase"* (Alumnus, 1998). Reasons varied for why projects

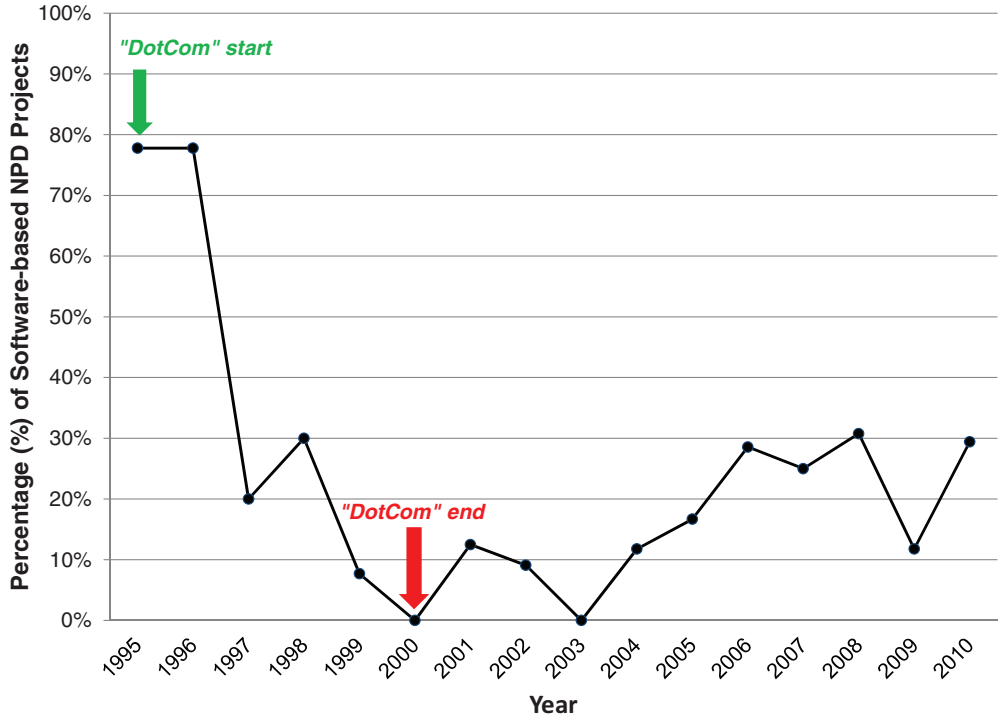


Figure 5. Percentage of software-based projects in NPD Course from 1995–2010.

did not continue. Cobb *et al.* (2008) interviewed a different sample of NPD alumni and found that the two main reasons why alumni felt they did not pursue their project further were (1) different commitment levels amongst team members and (2) not fully understanding who the customers were and what their salient needs were, similar to our survey results. More broadly, students often had a short timeframe for seeing their project through. Within the last six years we have made a conscious effort to encourage more entrepreneurial ventures by helping students enter business plan competitions and apply for funding through organizations such as Venture Well. These venues give student teams the opportunity to obtain additional funding and advice in order to take their projects further. At least two successful and innovative companies have been formed from NPD class projects and some high impact nonprofits as a result.[1]

Four surveyed alumni expressed interest in a follow-up course to guide students in how to take their products to market. One respondent suggested covering the next steps in taking a project forward, focusing on "*research distribution channel[s] and funding or partnering.*" The follow-up course would provide the tools and motivation for students to continue on with their project once the NPD course was over. Another alumnus from 1999 emphasized the importance of having a complementary course, rather than adding more content to the current course. The alumnus said, "*It's hard to pack in more than you have. Really it's about having complementary opportunities for the students. I do not recommend cutting curriculum for the new product development class. I think you [need] a new course that's a complement*."

Similar to adding complementary courses to the current NPD course, two interviewed alumni suggested teaming up with other disciplines to introduce more components of the NPD experience. For example, one alumnus said, "*You could simulate the legal experience and do something with the Boalt [School of Law]…That would be great training for the [students] to have*" (Alumnus, 1999).

In response to these comments, we have worked hard to make connections to funding opportunities and entrepreneurship mentoring opportunities through business plan competitions, collegiate innovation grants, Lester Center for Entrepreneurship (Haas School of Business) and the Fung Institute for Engineering Leadership.

Additional Course Modules

In the open-ended portion of the survey, alumni listed additional tools and methods they would like to see expanded upon in the NPD course which includes: quantitative methods for measuring product success, project budgeting, the role of marketing in NPD, existing software tools to assist with NPD

[1]More detail on successful NPD entrepreneurship projects can be found at *Design Innovation at UC Berkeley* (2015): http://best.berkeley.edu/design-thinking-and-doing-at-uc-berkeley/ (Accessed 12-20-2015)

processes, and financial evaluation methods. Six surveyed alumni made specific recommendations for lessons to teach around the areas of business forecasting. For example, one alumnus from 2002 thought more "*exposure to a lot of different ways to forecast*" would be valuable to students. During follow-up interviews, an alumnus from 1999 further clarified this by adding: "*If you can encourage the students to really think about the ecosystem and what is the business system it fits in, the complementary products, and understanding the roadmap…How do you take advantage of the ecosystem?… That's where the real fun is in the real world…How do you start to think three steps ahead*?"

Focusing on course materials on the NPD process, three surveyed alumni thought a quick reference NPD guide would better serve them in industry: "*Using something like [a little handbook] for the different modules might be a good takeaway…a quick reference guide could be useful.*" Similarly, some alumni thought the course should introduce or define what are known as the 'best practice' methodologies utilized in different industries. One alumnus noted, "*The challenge is that in different industries different processes are considered best practices. And in some industries there are no best practices. Some primer on the different methodologies out there may be useful."*

CONCLUSIONS AND RECOMMENDATIONS

In this paper, we have presented a qualitative and quantitative analysis of alumni perspectives from a graduate-level NPD course taught at UC Berkeley. To better understand if the course is truly serving students who will pursue industry jobs in design, innovation, and entrepreneurship we surveyed and received responses from 160 alumni of the course over 15 years (from 1996-2010). We designed a survey with which we gathered a rich data set of alumni reflections on the course itself as well as NPD practices currently used in industry. As a follow-up to the survey, we conducted nineteen interviews with alumni to clarify data trends from the survey and obtain a more in-depth reflection on the course offerings.

Some of the key results from this study demonstrated that alumni highly value the lessons they learn from the course regarding multidisciplinary team-work. Supporting previous work by Hey *et al.* (2007) and Cobb *et al.* (2007), this study demonstrated with a richer data set, the similarities and differences between what students learn about NPD in a classroom setting and how NPD is practiced in industry. Alumni drew parallels between the UC Berkeley NPD course and the way NPD is carried out at their companies, focusing on the teamwork aspect of the course project and emphasizing that it is true to what is experienced in an industry setting. Conversely, alumni also highlighted many differences that exist between a 'real-world' NPD setting compared to the more ideal NPD classroom setting, focusing on (1) corporate politics and (2) needing to sell the value of the NPD process to

their colleagues. Alumni also gave several course recommendations, such as the addition of more entrepreneurship opportunities and course modules on NPD best practices, aimed at making some aspects of the course closer to how NPD is practiced in industry and to generally better prepare future students for careers in innovation and entrepreneurship.

As evidenced by the survey and interview data, NPD is applicable to a wide range of industries, including software, healthcare, real estate, and social media. Because of the heavy software industry representation in our survey respondents, the most direct implication for improving NPD education is to add more material and projects relevant to the software industry in addition to modules that demonstrate how NPD is applicable in more services-based industries. In addition, we have recently encouraged the development of a complementary course at UC Berkeley titled: *Design and Development of Web-based Products and Services*.

The study conducted here, has the potential to impact not only the NPD course at UC Berkeley, but similar courses at other universities and colleges. More real-world industry scenarios and modules should be integrated into NPD courses to give students exposure to NPD in authentic learning environments. The breadth of responses presented not only gives us a means to improve NPD education, but it gives us a window into how NPD is currently carried out in a wide array of industries.

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APPENDIX A: COURSE SYLLABUS

Below is a course syllabus summary from the NPD course taught in 2006. All book chapter references (eg. Ch. 1) refer to specific chapters in the textbook written by Karl Ulrich and Steven Eppinger (1995). The full course syllabus with more detailed descriptions as well as historical course syllabi can be found at the location below:

http://best.berkeley.edu/~aagogino/me290p/

Lecture	TOPIC
1	Introduction to New Product Development (NPD) Ch. 1: Introduction Reading: "The Discipline of Innovation"
2	Product Development Environment: The NPD Process Ch. 2: Development Processes and Organizations Case Study: IDEO Product Development
3	Product Development Environment: Strategic Alignment Ch. 3: Product Planning Case Study: Linking Strategy and Innovation – Materials Technology Corp.
4	Product Development Environment: The Role of Design and Design Thinking Ch. 10: Industrial Design Reading: "How Increasing Value to Customers Improves Business Results" Individual Assignment Due: List of 20 "bugs" Individual Assignment Due: Bring a good or bad design to class
5	Project Proposals and Team Assignments Individual Assignment Due: Project proposal Project Preferences due today by 5 p.m.
6	Project Organization and Launch StudyNet Reading: "The Discipline of Teams" Guest speaker: Jane Creech, Strategic Business Systems Individual Assignment Due: MBTI Personality Test Results and Cognitive Style Survey
7	Product Development Environment: Delta - A Design Exercise Prepare role to play Delta Design Exercise Reading: "Delta Design Exercise – The Design Task"
8	Product Development Environment: Project Management Ch. 16: Managing Projects Reading: "Innovation at the Speed of Information"
9	Concept Development: Customer and User Needs Assessment Ch. 4: Identifying Customer Needs Reading: "Consumers in the Mist" Guest Speaker: Michael Barry, Principal, PointForward Individual Assignment Due: Customer and user needs interview
10	LAB: Mission Statement Review and Customer/User Needs Assessment Planning Project Deliverable Due: Mission Statement and Customer/User Needs Assessment Plan
11	Concept Development: Frameworks for Understanding Customer Needs Reading: "Get Inside the Lives of Your Customers" Reading: "Spark Innovation through Empathic Design"
12	Concept Development: Translating the Voice of the Customer Ch. 5: Product Specifications Reading: "Turn Customer Input into Innovation"

13	Concept Development: Concept Generation Ch. 6: Concept Generation Reading: "Creative Thinking Techniques"
14	Concept Development: Concept Selection Ch. 7: Concept Selection Individual Assignment: Assessment of competitive products using concept selection matrices
15	Peer Review: Mission Statement, Competitive and Customer and User Needs Analysis Project Deliverables Due: Presentation, mission statement, customer and user needs analysis
16	Testing and Refinement: Concept Testing Overview Ch. 8: Concept Testing Case Study: Bank of America (A)
17	LAB: Concept Generation Review Project Deliverable Due: Concept sketches,
18	Testing and Refinement: Building Prototypes and UsingComputer Aided Design (CAD) Tools Ch. 12: Prototyping Reading: "Boost your Marketing ROI with Experimental Design" *Tour of Prototyping Labs at UC Berkeley*
19	LAB: Concept Selection and Concept Testing Plan Project Deliverables Due: Final concept selection and concept testing plan
20	Testing and Refinement: A Case Study Ch. 13: Robust Design Case Study: Team New Zealand (A) (9-697-041)
21	LAB: Final Specifications and Prototype Planning Project Deliverables Due: Final product specifications and drawings
22	DfX: Design for Manufacturability and Cost Ch. 11: Design for Manufacturing Ch. 15: Product Development Economics
23	Peer Review: Concept Prototype and Design Review Tradeshow Project Deliverables Due: Updated customer needs, concept generation sketches, concept selection matrices, product specs and drawings, concept prototoypes
24	DfX: Design for Environment Reading: "Mainstream Appliance Meets Eco-Design" Reading: "Cradle to Grave – How Products Impact Natural Systems" Reading: "Less is More at Interface"
25	DfX: Design for Flexibility using Product Architecture Ch. 9: Product Architecture Reading: "Principles from Toyota's Set-Based Concurrent Engineering Process"
26	LAB: Final Prototype Development, Testing and Refinement, Financial Analysis Project Deliverables Due: Financial analysis, results of product concept testing
27	Supporting NPD: Intellectual Property Management Ch. 14: Patents and Intellectual Property Reading: "The New Instant Companies" Guest speaker: Robert Krebs, Thelen Reid & Priest LLP
28	Class Summary: Other Things You Can Do with the NPD Process Reading: "If Managers Thought Like Designers" Guest speaker: Arnold Wasserman, The Idea Factory
29	Class Summary: Capturing Lessons Learned Reading: Learning from Projects – Note on Conducting a Postmortem Analysis Individual Deliverable: Lessons learned
30	Final Product Presentations and Judging Final Project Deliverables: Summary Project CD Individual Deliverables: Journal/sketchbook and team evaluations

APPENDIX B. SURVEY QUESTIONSON COURSE CONTENT AND RELEVANCE TO ALUMNI

Question Type	Questions
Course Relevance Since Leaving School	1. Please rate the importance of each of the following NPD topics in your current job (1=not important, 5=very important): Costing and Financial Analysis, Setting Project Goals, Working in Multidisciplinary Teams, Concept Selection, Concept Generation, Prototyping and Testing, Design for Assembly/Manufacture/ Environment, Meetings and Scheduling, project Management, User Needs Identification. (1=strongly disagree, 5=strongly agree) 2a. On a scale of 1-5, indicate the extent to which you agree with the statement: Overall the NPD course was useful for my undergraduate/graduate study. 2b. On a scale of 1-5, indicate the extent to which you agree with the statement: Overall the NPD course has been useful for what I have done since leaving school. 2c. On a scale of 1-5, indicate the extent to which you agree with the statement: I would recommend this class to anyone who has an interest in product development 2d. On a scale of 1-5, indicate the extent to which you agree with the statement: I am presently using specific lessons from the class in my daily work. 3. How did this course change your interest in new product development? 4. We are interested to know a little about how some of the elements of the NPD process are carried out at your company. Please briefly explain how you approach: Understanding customer/user needs, concept generation, concept selection, and project team formation. You may answer generically for your company or for a specific project on which you have worked. 5. Please let us know if you have any other comments about the topics covered in the class and their relevance to you.
Team Project	1. Was the class project an effective learning experience while you were in school? (1=highly ineffective, 5=highly effective) 2. Have the lessons you learned from the class project been effective in your work since leaving school? (1=highly ineffective, 5=highly effective) 3. Did your team ever consider taking the product or service you developed any further after the class ended? 3a. If you DID pursue your product or service beyond the class, how far did you get in the process? Did you or are you pursuing additional funding or entering business plan competitions? 3b. If you ARE still pursuing the project, how has your team changed since the class? If you DID NOT pursue taking your product or service to market, please tell us why. 4. Overall, did you feel more engaged in this class compared to others you took? (1=less engaged than most, 3=more engaged than most) 5. What do you remember most from your project experience that has been helpful in your work since the class? Can you give any examples?
Course Reflection	1. Describe at least two tangible takeaways about new product development or innovation that you received from the course. 2. From your experience to date with new product or service development what would you add to the course that can help the current students in their careers?

APPENDIX C. OPEN-ENDED PHONE INTERVIEW QUESTIONS

Question Type	Questions
Utility Since Leaving School	1. Do you believe the NPD course either gave you or enhanced your project management skills? If so, how and can you give an example?
	2. In retrospect, did you find the course to be useful to you during your studies at UC Berkeley and/or in industry since you graduated? If the course was useful to you in industry, are there any specific lessons you learned or NPD principles from the course that you use in your day to day work?
Class vs. Real-world Setting	1. Do you think the multidisciplinary team project in the NPD course has affected how you work in teams in industry? Why or why not? Can you give examples?
	2. What do you think are some of the biggest differences between your current industry role and your NPD team project experience?