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LONGITUDINAL STUDY OF LEARNING OUTCOMES IN A NEW PRODUCT DEVELOPMENT CLASS

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ABSTRACT

This paper reports on a longitudinal study of lessons learned from a graduate-level New Product Development course taught at the University of California at Berkeley, comparing lessons learned by students during the course with alumni perceptions one to ten years after graduation. Previous research on student learning outcomes in New Product Development (NPD) found that on the last day of class students identify working in multifunctional teams and understanding user needs as their most important lessons learned. This study raises the question of whether or not students maintain the same emphasis on learning outcomes once they have moved on to careers in industry. To answer this question, we conducted 21 in-depth interviews with alumni who took the course between 1995-2005 and are now working in industry. A qualitative and quantitative analysis of the alumni interviews reveals that former students still highly value what they learned about team work and understanding user needs, but see more value in tools for concept generation, prototyping, and testing after gaining work experience. The results reaffirm the value of engaging students in multidisciplinary design projects as a vehicle for developing the professional skills needed in today's competitive new product development environment.

Keywords: New Product Development, Alumni Learning Outcomes, Alumni Reflection, Longitudinal Assessment

1. INTRODUCTION

Assessing student learning outcomes in project-based design courses is not easy [1,2], but it is even more difficult to assess long term learning outcomes once students have graduated and moved on to jobs in industry. Although there is much literature on course evaluation, self-assessment and self-reflection during a course and right after a course concludes, there is limited literature on whether or not students maintain the same "lessons learned" or priorities for learning outcomes once they have graduated and started working in industry. "Lessons learned," in this context, refers to data gathered through self-reflection during which students identify what they believe are important learning outcomes for themselves individually from a given course [2,3].

The New Product Development (NPD) course at UC Berkeley employs a project-based learning approach [4,5] that places students from the College of Engineering, School of Business, School of Information, and the California College of the Arts (CCA) on multi-disciplinary teams to develop the team and process skills necessary for successful product development in today's competitive marketplace.[1] The students work in teams of 4-5 on a semester-long product development project. The class emphasizes going beyond generating a single new product. Students are encouraged to learn from their design project by capturing lessons learned and understanding how to apply design process and team knowledge strategically to new product lines. Each student brings his or her own disciplinary perspective to the team effort, and must learn to synthesize that perspective with those of the other students in the group to develop a sound, marketable product or service. Students ideally finish the course with an understanding of the new product development process, as well as useful tools, techniques and methods that support new product development practice in industry. Industry highly values students who understand how to solve open-ended design problems and apply the tools of design [6],

[1] Although the class technically focuses on the new product development process, the process students learn is more broadly applicable to services, strategies and business models. Students learn a customer/user-focused innovation process, and study cases in which it is applied both inside and outside the product development realm.

but often regard this learning as lacking in current engineering curricula. (More details on the NPD course can be found in Appendix A.)

Hey et al. [3] conducted a study of lessons learned from students enrolled in the last six years of the UC Berkeley NPD course. The study of over 2,300 lessons learned revealed that at the end of the semester the students' most valued learning experiences focused around working in multidisciplinary design teams and gathering and analyzing customer and user needs (Tables 1a and 1b). One of the observations from the study was the disconnect between time allocated to subjects in the course and the frequency with which the subject was mentioned in the lessons learned exercise. On one hand, for example, the lecture time spent on customer and user needs (14.7%) corresponded to the percentage of lessons learned related to customer and user needs (13.5%). On the other hand, less than 8% of the class time was spent on lectures involving teamwork, but over 35% of the lessons reported were in this category. Team issues are hard to teach, as data from previous work suggests, yet are critical to NPD success.

While Hey's analysis focused on students' reflections on the course at the end of the semester, alumni perspectives are also an important part of assessing how well courses and programs prepare students for their future careers [7-9]. To better understand how well the UC Berkeley NPD graduate course prepares its students for jobs in innovation and design, this paper presents a qualitative and quantitative analysis of 21 in-depth interviews conducted with alumni from the NPD course. The interviews were semi-structured to allow alumni to reflect on the course and see if, in retrospect, they believed the course helped prepare them for their work in industry. We compare the alumni interview data with results generated by Hey et al. [3], to see whether or not students maintain the same emphasis on lessons learned once in industry.

Table 1a: Summary of Lessons Learned Data from Hey et al. [3]

Lesson Category	% of Total Lessons	% of lecture time
Multifunctional teams*	35.0	7.9
Customer and user needs	13.5	14.7
Meeting and scheduling	7.6	0.0
General NPD process learning	6.7	26.3
Other	6.5	15.8
Concept generation	6.3	5.3
Project management	5.7	4.2
Prototyping and testing	5.4	15.8
Concept selection	5.3	2.6
Mission statement	3.6	2.1
Design coaches	2.8	0.0
Financial, economic and business	1.6	5.3

**Lessons learned from multifunctional teams are further decomposed in Table 1b*

Table 1b: Summary of Multifunctional Team Lessons Learned Data from Hey et al. [3]

*Multifunctional Teams Lessons Learned Decomposition	% of Total Team-related Lessons
Roles, responsibilities and skills	21.6
Team diversity	19.8
Communication	18.9
General team learning	14.9
Team building	10.7
Conflict management	7.2
Leadership	6.9

2. LITERATURE REVIEW

Various methods for assessing learning outcomes are used in education research. Olds et al. [10] conducted an extensive review of assessment methods in engineering education and noted that the most widely used methods are: surveys, focus groups, interviews, and experimental design. Ethnographic methods and observation tend to be less widely used as assessment methods in education.

Prior work [7-11] surveyed alumni to obtain feedback on engineering curricula and educational experiences at a higher level, but focused primarily on entire degree programs rather than on individual courses. Students are typically surveyed or interviewed immediately upon exiting a course or program, but not after they have been in industry for some time. The ABET Engineering Criteria 2000 [7,12] called for continuous improvement of engineering programs across the U.S, with clear objectives and performance measures and prompted many to solicit feedback from primary stakeholders, including current students and alumni, to assess and evaluate program outcomes and program educational objectives [10]. Some programs employed surveys to capture information on the professional accomplishments of alumni and to measure learning outcomes and the success of engineering programs for enrolled students. At a macroscopic level, soliciting alumni feedback has proven useful in improving curricula.

Sheppard et al. [13,14] created a framework for curriculum assessment called ME-PEER. The goal of the project was to create a peer-review protocol to assess teaching in the Mechanical Engineering Department at Stanford University, in part by gathering student input through peer interviews. They found that student interviews are a source of rich constructive feedback, providing useful and concise information about learning and teaching methods that impact students' learning.

The 'lessons learned' exercises reported by Hey et al. [3] used students' semester-end self-reflection as an assessment method to provide insight into what students themselves viewed as the salient learning experiences in the course. This exercise, in which students share their individual lessons learned in small groups, helps students reflect on and learn from their individual and shared class experiences and personal stories. This promotes discussion and documentation

of each lesson as well as anecdotes of actual project experiences.

3. ALUMNI DATA COLLECTION

3.1 Compilation of Alumni Information

To initiate the process of contacting alumni for interviews, we compiled a list of nearly 400 students who took the course between 2000-2005 and also sampled students from 1995-1999. With the help of the Berkeley College of Engineering Alumni staff, the School of Information, and other alumni associations and faculty records, we obtained contact information for almost half of our NPD alumni list. As we wanted to focus our assessment efforts on alumni who had graduated and moved on to industry jobs, continuing students were removed from our list, leaving us with 85 potential alumni contacts for a first round of interviews. We initially contacted these alumni by e-mail and found 23 former students willing to participate in interviews, giving a response rate of 27.1% (23 out of 85 possible interviews).

3.2 Interview Design

Interviews allow one to capture data and information that cannot be captured through surveys or observation methods alone, providing one with a richer data set. Based on Hey's work on "lessons learned" [3], we developed interview questions structured to help us understand which aspects of the course alumni value and use in their current profession. We also generated a set of questions aimed at eliciting more general information about what the alumni are doing now, how innovation fits into their current work, and what they remember about or from the class. We created a semi-structured interview guide to maintain some consistency in the interviews as they were conducted by multiple New Product Development graduate students. The interview protocol contained both open-ended and numerical rating questions.

The categories covered in the interview included:

- Personal background (e.g., name of employer, type of business, position/title, experience with innovation or NPD)
- NPD course impact on career direction
- Importance of course topics in their day-to-day work
- Use of specific NPD methods and tools in their current job
- Importance of understanding customer and user needs in their current job
- Reflection on course project and team dynamics
- Advice and suggested course improvements

The interviews focused on learning outcomes, to see if the NPD course is truly serving its students. The instructors plan to use the results to identify course improvements and validate and retain successful course components. The interview analyses in the next section give a preliminary look at these alumni perspectives.

4. INTERVIEW ANALYSIS AND RESULTS

Overall, we conducted 23 in-depth interviews. Interview data consisted of either transcribed audio tapes or field notes. Two of the interviews were removed from the analysis because one was deemed incomplete and another came from a former student who was still attending the university, leaving 21 full in-depth interviews for the qualitative analysis in the following sections. Although our work deals with a relatively small, sample we attempted to get representation across course years and across disciplines. Breaking down alumni responses by year we have:

- 1995–2001: 5 alumni
- 2002: 3 alumni
- 2003: 5 alumni
- 2004: 4 alumni
- 2005: 4 alumni

There were responses from 5 College of Engineering, 3 School of Information, 10 School of Business, and 3 California College of the Arts (CCA) alumni. Although the NPD course has evolved over the years its core focus has remained the same, and many common themes arose from the interviews.

Our interview analysis looks beyond the numbers to gain an understanding of alumni feelings, impressions and viewpoints on the NPD course. We read each of the interviews over thoroughly and organized, on paper, the main categories and themes that initially emerged. We coded the interview statements to draw out the main lessons learned that arose during each interview and then categorized and coded the interview statements in an iterative process until a consensus was reached. Through this iterative process, we synthesized the main lesson categories and themes. Although the interviews were semi-structured, containing both quantitative and open-ended questions, we let the content of the responses drive the development of the categories in our analysis. The results are discussed in the following sections.

4.1 Background Information on Alumni Respondents

Nine of 21 alumni (43%) indicated that they had prior experience with NPD before taking the course. This experience was gained through prior undergraduate courses in NPD, internships and full-time employment. The CCA students were undergraduates, although a number of them worked before entering the program. Many of the alumni of the UC Berkeley School of Information and College of Engineering went directly to graduate school after completing their undergraduate degrees, so they had little if any full-time work experience. In contrast, the MBA students uniformly had at least 3-4 years of industry experience before attending business school. Twenty out of 21 alumni (95%) stated that their current jobs involve innovation and that they are either directly or indirectly working with some, if not all aspects, of the NPD process.

4.2 Motivation for Taking NPD and Impact on Career Plans

Reasons for initially taking the NPD course varied slightly, but most alumni decided to take the course because: (1) the class came highly recommended from classmates, (2) they wanted to work in a multi-disciplinary team, and (3) they had a general interest in learning more about new product development. All Berkeley alumni expressed at least one, if not all of these sentiments. The CCA students took the course because it was a requirement for their program, but expressed a strong desire to better understand engineering considerations in the design process.

Everyone genuinely appreciated the class, but only two alumni said it drastically affected their career decision, one referring to the course as a "career altering class." The 19 other respondents (90%) for the most part believed the NPD course did not drastically alter their career plans as many of them had prior job commitments, prior exposure to or interest in NPD, or already knew what career path they wanted. Those alumni who eventually took product development roles in industry, believed the course solidified their desire to do innovation and product development as illustrated by one response:

> *"In deciding to get my Masters, I knew that I wanted to work for an IDEO or frog[design] or similar product design company… I saw the NPD course as a way to gain the background and experience that would help me achieve this career goal."*

The interview responses suggest that students self select for the course. Most entered the course with an idea of the kind of career they wanted already in mind and some already had jobs in industry waiting for them once they completed the course. The graduate NPD course can be viewed as a vehicle that helps future product developers solidify their interest in NPD and, as mentioned in the course objectives, "develop the skills necessary for product development in today's competitive marketplace."

4.3 NPD Methods and Skills Valued in Industry

Alumni were explicitly asked to name or describe the NPD methods and tools they use in their current work as well as give examples of how they apply them. These responses are based on initial recollections of the course. We highlight the methods and skills that alumni use in industry, focusing on the methods, tools, and skills they employ. Table 2 illustrates which of the tools and skills taught in the NPD course alumni utilize or value the most in their current jobs.

'User needs' and 'working in diverse teams' were the two NPD lessons most mentioned across the interviews in response to the open-ended questions. This result parallels Hey's analysis of the frequency of lessons learned in the semester-end study [3]. The interview comments also make it clear that further industry experience has helped alumni refine their abilities in these areas. Most alumni believe the NPD course gave them their first real exposure to multidisciplinary team dynamics and skills to create effective communication among team members. Two alumni did not single out particular methods as they believed all are a vital part of NPD.

> *"All of the topics and methods that were covered in class have helped me in my current job."*

Table 2: New Product Development Methods and Skills Used in Industry

Method/Skill	Example Response	# of Alumni
Gathering and analyzing user needs	*Make sure to focus on capturing the customer's true needs and intents when work[ing] on projects.*	10
Working in diverse teams	*The most important…is dealing with the different personalities in a project team… it is important that each team member contributes to achieve the common goals of the team.*	9
Concept generation	*If you don't understand the cycle of product development, then it might get frustrating… So, concept generation and selection comes up in the back of your head as you're working through stuff…*	8
Concept selection	*I liked the concept prioritization matrix and felt that it was a useful tool and approach.*	6
General NPD process	*I think the essence of the class stuck with me and it's important to have that point of view.*	5
Concept testing and prototyping	*We also build prototypes all the time to kind of have a proof of concept and make sure it works.*	2
Design sketching	*It's…hard to remember specific topics, but all are relevant: User research, Drawing, Interdisciplinary [cooperation]…*	1

4.4 Rating the Importance of Lessons Learned

To supplement the open ended discussion on NPD methods and skills, alumni were presented with a list of the most frequently mentioned "lessons learned" from Hey's work which they were asked to rate based on how important the topics are to them in their day-to-day work. The lessons learned topics were rated by alumni on a scale of 1 to 5 (1=least important, 5=most important) to assess the importance of certain NPD tools, methods, and skills in their current job. The list included items they may or may not have explicitly mentioned or recalled in the open-ended part of the interview. The results are summarized in order of importance in Table 3.

Table 3: Alumni Ranking of Topics Relative to Semester-End Percentages of Lessons Learned

Lessons Learned	Average (1-5 scale)	Standard Deviation	% of Total Lessons [3]
Working in teams	4.75	0.55	35.0
Concept generation	4.35	0.93	6.3
Prototyping and testing	4.25	1.12	5.4
User needs identification	4.20	1.28	13.5
Setting goals and working with a mission statement	4.10	0.91	3.6
Effective meetings & scheduling	4.00	1.08	7.6
Concept selection	4.00	1.03	5.3
Project management	3.70	1.03	5.7
Financial, economic and business	3.40	1.31	1.6
Design for assembly/manufacture/ environment	3.00	1.62	≤ 1%

In looking over the results in Table 3, it is reassuring that on average all of the topics were rated "3" or higher, indicating that all were of value to the alumni. Working in multi-disciplinary teams ranked at the top. Although the team-related lessons were aggregated for the importance ratings, the result demonstrates that alumni use and value team-related skills in their current jobs. This shows that consistent with the semester-end lessons learned priorities reported by Hey et al. [3], having a skill set for working in multi-functional teams is important for both students and alumni. Also in line with the previous section of open-ended responses, each alumnus said that the ability to work on a diverse team and generate multiple design concepts for a problem are skills they utilize everyday in industry.

Developing the skills necessary to work in teams seems to be the big take away from the course based on the importance ratings and open-ended responses from alumni and Hey's previous lessons learned work. Many felt that the team situations they experienced in class prepared them for their current jobs. Some alumni also said they took the class because it was a chance to work with students from other disciplines.

'User needs' showed up in the top four, but unlike the semester-end lessons learned study, concept generation and concept prototyping/testing were also ranked with similar importance by the alumni. Some kind of reinforcement of the class learning must have happened in industry or in other classes to change the relative emphasis. This difference might be associated with how prototyping and testing was handled during the course project. User needs identification was viewed as a continuum of activities from "concept testing" the story or idea to the production and testing of the final prototype. Many of the teams were only able to develop rudimentary prototypes due to time limitations of the 15-week semester. Thus, although alumni now believe prototyping and testing are important NPD methods to use in industry, some felt their course project did not give them sufficient time or resources to prototype, iterate and test during the class. While some alumni did not recognize the importance of prototyping during the course, they wish they could have done more as they now recognize its value.

- *"Engineers … didn't get clearance for their shop so all the prototyping had to be done by the one designer!"*
- *"We had something tangible put together but we didn't have software engineers to actually write the code. But other people [in the class] had mockups or prototypes for real world products."*
- *"Could have gotten more out of prototyping if the timing were better."*
- *"There is importance in manufacturability and the environment – but I don't think you know about that unless you have prototyped it and done more work."*

Design for assembly/manufacture/environment and financial analysis were ranked "3" or higher, but had the lowest scores and largest standard deviations in the importance ratings. Alumni who valued these course topics most are the ones who now deal with these topics on a daily basis or are currently running their own companies and have to look at the product development process from start to finish.

4.5 Retrospective on Team Project

When alumni reflected on their projects and project-related experiences in the course, many first recalled team dynamics and then the project itself. Most stated that they did not have smooth team interactions at the beginning of the project, and that trying to understand and appreciate the different perspectives of their teammates is what prepared them most for their work in industry. Alumni expressed an appreciation for working with other disciplines as this now helps them deal with diverse teams at work. One alumnus stated that s/he tried to look at projects from everyone's view point. Overall, the team project is where alumni developed an appreciation for different skill sets and viewpoints on a product development project.

Alumni emphasized that most of their learning came from the course project, where they had a chance to practice the methods and tools discussed in class:

"The project was more important than lectures because it was more tangible…I remember very well the steps that we went through as part of the project in developing the product."

Table 4: Team Project Learning

Category	Example Response	# of Alumni
Working in diverse design teams	*I appreciated working in a cross-disciplinary team. I liked that people had different skill sets that they brought to the table…. This is how a team should be.*	15
Understanding the importance of customer needs	*Some of the key things that I learned from the project were: Who is your target audience?... Are you speaking to the right group to understand the user needs?*	8
Effective team communication and meetings	*Just the logistics of trying to get four people to a meeting is a learning opportunity.*	4
Understanding the design process	*I most remember how difficult it was to take the results of a brainstorming session and then steer the ship in a positive direction. We turned our wheels a lot before getting anywhere. But this is a very real world lesson.*	4
Prototyping and building	*Producing an object is very time-intensive, and you can't cut corners.*	3
Developing a shared vision	*A clear goal/vision is very key to the success of the project. The goal may change during the project but all the team members should be clear on what the team is doing at one point in time.*	2

4.5.1 Tools and Methods for Teams in Industry

On the topic of working in cross-disciplinary teams, alumni were asked to reflect on their team experiences in industry and were also asked whether or not formal tools for team building, such as Myer-Briggs personality tests and 360-degree peer reviews, were used to help form and evaluate teams. Three alumni (14%) explicitly stated that they use the formal team building tools mentioned, one of which indicated that tools slightly different than those taught in NPD are used. Nine out of 21 alumni (43%) said that they do not use any tools or methods to enhance teamwork in their current job, while the remaining nine out of 21 alumni (43%) characterized their company's approach to team formation and dynamics as a more "informal process."

- *"[My company] is not a "tool" based culture for managing people – getting people together is the main tool. Formal tools are not institutionalized."*
- *"The tools…like Myers-Briggs, they don't really happen, unless you're in leadership training…in every day it doesn't happen because people move in and out of teams very often…"*

For this informal process, team building activities and informal gatherings are often used to help team members form a bond and work well together.

360-degree feedback comes from peers, co-workers, managers, and others within an organization. The NPD course utilizes these methods for evaluating projects, but it is also used in industry. When implemented correctly, 360-degree reviews have been shown to have a positive impact within a company [15,16]. However, the majority of our alumni sample indicated that 360-degree reviews were not used in their company. Six alumni (29%) indicated that they do have formal performance or work reviews regularly. However, these are often done by managers and those in higher positions within the company. Two out of the six aforementioned alumni said their peers also took part in their performance reviews when working on large projects, but the general consensus is that 360 peer reviews do not take place often.

4.6 Understanding Customer Needs – Industry Perspective

In this section, we highlight the methods and tools that alumni use in industry to help better understand their customers and design products that meet customer needs (Table 5). For confidentiality reasons we do not reveal the details of specific projects alumni have worked on but discuss the methods they employ.

Fifteen alumni (71%) expressed a heavy and direct involvement with customer and user needs research at their current job, involving user observations, focus groups, interviews, and surveys. All of these alumni are currently working for design firms or are in product manager or design roles in their companies, so the direct involvement with customers is expected. The importance of understanding customers in order to have successful products was emphasized by each alumnus during the interview.

Three alumni (14%) have a limited or indirect involvement with customer and user needs for their work. Indirect involvement is described as using customer related data provided by marketing and human factors departments, and then stepping into the user needs process when concepts are being tested or have failed, requiring reassessment of the customer needs.

"Customer needs are given to us in the form of the product specifications."

The three remaining alumni could not identify strongly with the process of identifying customer needs during the interview because they minimal or no interaction with customers, but they recognized the importance of understanding customer needs in order to create successful products. There was one interesting comment from an alumnus regarding user needs. His/her current employer relies heavily on innovation, but does not believe in waiting for customer needs to emerge with the tools and methods taught in class:

"Henry Ford said 'if I would have asked customers want they wanted, I would have built a faster horse.' The idea is that we, the innovators/designers/marketers, should not

rely on customers to innovate for us…we should be doing that for them."

Table 5: Break-down of Customer Needs Approaches used by Alumni

Approach	Example Response	# of Alumni
Observing and listening to users	*Identifying customer needs is part of my work: The most important part is to go out and conduct primary research, what I am doing now and in any product development is important.*	9
Testing concepts with users	*Oftentimes for really visionary thinking for the future, companies have to build first and then have consumers react to get the best user feedback.*	6
Surveys and focus groups	*We usually use primary research such as focus groups and surveys to uncover and test customer needs.*	6
Uncovering latent needs	*Definitely use it in my past and current work and it's really all about the customer and with identifying needs… having to dig deep and ask the right questions, deciphering between what a customer says and means.*	3
Prioritizing needs	*What are the 5 things the person who buys it care[s] about most?*	2
Letting the market determine the success of the product	*Two needs were really important and the market was fragmented between the two, so [the company] introduced two products…it was not too much of a cost burden to do two designs and this increased [the company's] portfolio.*	2
Creating personas	*The persona process helped identify underserved customers and ways to talk to existing customers.*	1
Predicting customer trends	*Forecast trends... identify a problem statement and then do research.*	1

Alumni tended to connect user needs with concept testing. They stressed how important it was in their current jobs to take concepts to customers and clients in order to obtain feedback before releasing products to the market. Alumni who are indirectly involved with user needs research at their current jobs reported using the data provided to them by marketing. Once concepts were generated and prototyped, they were taken to customers for feedback and further adjustment. Two alumni currently work for corporations that can afford to let the market determine the success of their products using rapid and iterative product releases to determine market trends and user needs.

Many alumni also indicated that at larger corporations conducting surveys and focus groups was more common than ethnographic methods that follow users around in their daily lives to uncover implicit needs.

4.7 Alumni Recommendations

Alumni were also given the chance to reflect on what they would change about the course if given the opportunity. Their responses were more varied than the results discussed in previous sections. In reflecting on the course from the vantage point of their current jobs in industry, alumni tended to recommend specific changes such as more user needs analysis, more case studies, more failure examples, and more time with coaches. Others asked for fewer case studies, less lecture time, and less focus on user needs. One universal recommendation that arose was the concern that one semester is not enough time to truly cover all of the course topics in-depth. Alumni who felt certain aspects of the course should be reduced or increased often made those suggestions within the broader context that there was not enough time to cover and finish everything. Some explicitly stated that an extra semester would have given them a chance to really refine their product concept and prototype:

"I feel that the current format does not leave much room for prototyping and user testing iterations, two crucial phases of the process…one semester is a little short to really get into what design is."

Many alumni felt that they could have learned more about concept testing and prototyping, but due to the fast pace of the course had little time to fully carry out these tasks. Alumni felt they gained more experience with concept testing and prototyping through other courses in their degree programs or through their jobs in industry.

Alumni also gave related suggestions to improve the course and, in retrospect, their learning experiences. One former student proposed splitting the course into two semesters and better coordinating the topics with other NPD-related classes offered on campus, such as the High-Tech Manufacturing course offered by the Mechanical Engineering department or the Intellectual Property course offered by the School of Business. Suggestions were also made for an NPD program track or certificate offering within the School of Business or College of Engineering. Alumni emphasized that a NPD skill set is valued highly in industry.

"Create a New Product Development track or certificate… these [programs] are becoming very interesting for companies to hire from."

Many of the course alumni are in product manager and design-related roles, and now appreciate the skill set the course helps students build.

5. CONCLUSIONS AND FUTURE WORK

The interview analysis reported in this study provides a preliminary look at the tools and topics alumni value the most in a multidisciplinary project-based New Product Development (NPD) course taught at UC Berkeley. As the course is similar to project-based NPD courses taught at other universities [17,18] such as the Massachusetts Institute of Technology, University of Michigan, and University of Illinois, to name a few, we expect the results are of more general applicability. Alumni with one to ten years in industry valued working in multi-disciplinary teams as the most important aspect of the NPD course, similar to the emphasis students held at semester-end. However, in contrast to the semester-end lessons learned, where understanding user needs was ranked second highest in frequency, concept generation and prototyping/testing emerged as of more or equal importance to alumni. Alumni noted the value in being able to rapidly generate concepts, prototype and test ideas effectively and quickly in industry. Many of the alumni looked back on the course as the one which prepared them the most for industry work.

The alumni reflected on the class through the eyes of their current jobs. For example, those who valued costing analysis and design for manufacturability tools were those who now work with it on a daily basis in industry. Those who are currently in higher positions of management or running their own companies thought all aspects of the course were equally important. However, those with more focused roles in a company, such as test engineer, rated understanding user needs lower than other course methods and tools because they rarely interact with customers.

Although the results span a decade, 1995-2005, alumni universally valued the team-related lessons they learned. Regardless of their current employment, all alumni said that working in diverse teams was the main aspect of the course that prepared them the most for a job in industry. The multidisciplinary team projects gave all of the alumni a look at real world team dynamics. Whether or not the alumni appreciated the team project at the time, they all agreed that their team project experience is very close to what they now experience in industry.

As part of our future research, we also want to better understand entrepreneurship in NPD and why the majority of the students did not develop their class projects further the next semester or after graduation, while some did. We will identify what factors enabled some student teams to obtain further funding and turn their former NPD projects into successful commercial ventures.

Currently, we are moving forward in an effort to gather more alumni data through an online course survey to be sent to alumni who did not participate in the in-person or phone interviews in order to gather a richer data set and more insights into the findings from the interview analysis presented in this paper.

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REFERENCES

1. Wang, E.L., and Kleppe, J.A., "How to Assess the Effectiveness of Engineering Programs in Invention, Innovation and Entrepreneurship," In Proc. of *2000 ASEE Annual Conference & Exposition: Engineering Education Beyond the Millennium*, St. Louis, MO, June 18-22, 2000.
2. Malmqvist, J., Young, P.W., Hallström, S., Svensson, T., "Lessons Learned From Design-Build-Test-Based Project Courses," In Proc. of *the International Design Conference - Design 2004*, Dubrovnik, 2004.
3. Hey, J.H., Van Pelt, A.P., Agogino, A.M., and Beckman, S.L., "Self-Reflection: Lessons Learned in a New Product Development Class," *Journal of Mechanical Design*, Vol. 129, pp. 1-9, July 2007.
4. Dym, C. L., Agogino, A. M., Eris, O., Frey, D.D., and Leifer, L.J., "Engineering Design Thinking, Teaching and Learning," *Journal of Engineering Education*, 94(1), pp. 103-120, Jan. 2005.
5. Ulrich, K.T., and Eppinger S.D., *Product Design and Development*, 3rd Edition, McGraw-Hill Book Co., New York, 2004.
6. Nicolai, L.M., "Viewpoint: An Industry View of Engineering Design Education," *International Journal of Engineering Education*, Vol. 14, No. 1, p. 7-13, 1998.
7. McGourty, J., Besterfield-Scare, M., Shuman, L.J., and Wolfe, H., "Improving Academic Programs by Capitalizing on Alumni's Perceptions and Experiences," In *Proc. of 29th ASEE/IEEE Frontiers in Education Conference*, 1999.
8. Soldan, D.L., "Alumni Assessment in the ABET 2000 Environment," In Proc. of *1997 Frontiers in Education Conference*, pp. 1002-1005, vol. 2, 1997. ISBN: 0-7803-4086-8.
9. Regan, T.M. and Schmidt, J.A., "Student Learning Outcomes: Alumni, Graduating Seniors and Incoming Freshman," In Proc. of *29th ASEE/IEEE Frontiers in Education Conference*, San Juan Puerto Rico, 1999.
10. Olds, B.M., Moskal, B.M., and RL Miller, "Assessment in Engineering Education: Evolution, Approaches and Future Collaborations," *Journal of Engineering Education*, January 2005.

11. Rooney, D.M. and Puerzer, R.J., "Comparing Alumni Survey Data Over Time to Close the Assessment Loop," In Proc. of *34th ASEE/IEE Frontiers in Education Conference*, Savannah, Georgia, 2004.
12. ABET: www.abet.org
13. Sheppard, S., Johnson, M., and Leifer, L., "A Model for Peer and Student Involvement in Formative Course Assessment," *ASEE Journal of Engineering Education*, pp. 349-354, October, 1998.
14. Sheppard, S., Leifer, L., and Carryer, J.E., "Commentary on Student Interviews," *Innovative Higher Education*, Vol. 20, No. 4, Summer 1996.
15. Alimo-Metcalfe, B. "360 Degree Feedback and Leadership Development," *International Journal of Selection and Assessment*, 6(1), pp. 35–44, 1998.
16. Atwater, L.E. and Brett, J.F., "360-Degree Feedback to Leaders: Does it Related to Changes in Employee Attitudes?," *Group & Organization Management*, Vol. 31, No. 5, pp. 578-600 (2006)
17. Corporate Design Foundation: http://www.cdf.org/ed_multidisciplinary.php
18. Beckman, S.L. and Speer, L.E., "Learning about Design: Observations from Ten Years of New Product Development Class Projects," In Proc. of *2006 IDSA National Conference and Education Symposium*, September 17-20, 2006.

APPENDIX A. NEW PRODUCT DEVELOPMENT COURSE DETAILS[2]

Course Topics

The primary reading material for the course is the textbook *Product Design and Development* (Third Edition) written by Karl Ulrich and Steve Eppinger. Shown in Table I are the topics covered in the semester long NPD course.

Background on Multidisciplinary Design Project

The goal of the project is to learn principles and methodologies of product development in a realistic context. Students are asked to form project teams of 4 to 5 students, including a mix of Engineering, Business, School of Information, and California College of the Arts (CCA) students. The challenge in the project portion of the course is to design a new product, test it on a consumer group, and produce a prototype version of it. The goal of this exercise is to learn principles and methodologies of product development in a realistic context. Typical guidelines for successful projects are as follows:

- There should be a demonstrable market for the product.
- If students choose to work on a physical hardware product (rather than a software user interface design), the product should have a high likelihood of containing fewer than 10 parts.
- Students should be confident of being able to build a reasonable prototype of the product.
- The product should require no basic technological breakthroughs.
- Students should have access potential users of the product in order to talk with them and/or observe them as the product concept is being developed and refined.
- The most successful projects tend to have at least one team member with strong personal interest in the target market.

Table I: Outline of NPD Course Content

Course Module	Topics Covered
Introduction	Introduction to New Product Development (NPD)
NPD Environment	Overview of the NPD Process
NPD Environment	Strategic Alignment
NPD Environment	The Role of Design and Design Thinking
Team Project Lab	Project Proposals and Team Assignments
Team Project Lab	Project Organization and Launch
NPD Environment	Delta Design Exercise (A role playing design exercise)
NPD Environment	Project Management
Concept Development	Customer and User Needs Assessment
Team Project Lab	Mission Statement Review and Customer/User Needs Assessment Planning
Concept Development	Frameworks for Understanding Customer Needs
Concept Development	Translating the Voice of the Customer
Concept Development	Concept Generation Tools and Methods
Concept Development	Concept Selection Tools and Methods
Peer Review	Peer Review of Team Mission Statement, Competitive and User Needs Analysis
Testing & Refinement	Concept Testing Overview
Team Project Lab	Concept Generation Review
Testing & Refinement	Building Prototypes and Using Computer Aided Design Tools
Team Project Lab	Concept Selection and Concept Testing Plan
Testing & Refinement	Case Studies on Robust Design
Team Project Lab	Final Specifications and Prototype Planning
Design for X	Design for Manufacturability and Cost
Peer Review	Peer Review of Concept Prototype and Design Review
Design for X	Design for Environment
Design for X	Design for Flexibility using Product Architecture
Team Project Lab	Final Prototype Development, Testing and Refinement, and Financial Analysis
Supporting NPD	Intellectual Property Management
Class Summary	Other Things You Can Do With the NPD Process
Class Summary	Capturing Lessons Learned
Class End	Final Product Tradeshow

[2] More detail and lists of project topics over the last decade can be found at the course website at: http://best.me.berkeley.edu/%7Eaagogino/me290p/me290p.html