Perceived long term value of industry project-based design courses: Alumni reflections from two decades of the Product Development Project

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Abstract

As the landscape of higher education is changing with increased competition, being able to clearly articulate learning outcomes and their significance to students is becoming more and more important for universities. Project- and problem-based industry collaboration has been on the rise in order to cultivate more 'work life skills'. Typically, student feedback is collected at the end of such courses, perhaps augmented by feedback collected before and during the course as well. However, during their studies, students have yet limited understanding of professional activities in their discipline and work life, and thus may not be able to accurately evaluate the usefulness and applicability of the learning experience from a long-term perspective. Therefore, the aim of this paper is to gain better understanding of the real-world impact of these project- and problem-based courses in the long run, and what skills and attitudes alumni from project- and problem-based industry collaboration courses have found useful and utilized in development activities in their current careers. Moreover, we were interested to study if they differ from perceived skills learned directly from the course.

In order to address this aim, the current paper represents a case study of the perceived long-term impact of one of the longest running multidisciplinary project-based courses in Aalto University, Finland. During nine months, the interdisciplinary and international student teams translate an open design brief provided by a industry sponsor into a functional prototype. We reached out to the PDP course alumni to find out what they considered as significant learning outcomes from the course in hindsight, as well what skills, knowledge and attitudes have they utilized in the development efforts of their current careers. Based on 33 interviews and 239 survey responses from alumni that had completed the course between 1999 and 2016, we categorized the content of responses based on the thematic similarity of the reported learning outcomes from the course and reported needs in development efforts of their current careers.

Overall, the results highlight the perceived significance of socio-behavioral interpersonal skills, in which teamwork, multidisciplinarity and communication skills formed the largest categories. The second largest group was formed by attitudes, such as constant learning,

having a 'can do spirit' and optimism, out of which the majority were brought up as a part in the development activities of the alumnis' current careers rather than perceived learning outcomes from the course.

These skills and attitudes were then followed by a better understanding of the development process and project management, with the PDP course often representing a first complete development project experience for the alumni, rather than a piecemeal phase or task of it. The usefulness of being able to handle ambiguity and defining problems was also highlighted. Interestingly, domain-specific skills were the smallest group reported in both currently utilized skills and in learning outcomes from the course. The results thus emphasize the social nature of professional design and development efforts, as well as the additional insights long-term feedback collection and reflection from former course participants can yield.

Keywords: problem-based learning; applied learning; working life skills; learning outcomes; multidisciplinary education

1 Introduction

As the landscape of higher education is changing with increased competition, being able to clearly articulate learning outcomes (e.g. Davis et. al., 2003) and their significance to students is becoming more important for universities. Simultaneously, educators and employers increasingly recognize the need for not only domain-specific expertise, but various professional or work life skills (Passow & Passow, 2017; Savin-Baden, 2000; Shuman et. al., 2005) needed to effectively conduct such activities in organizations. Teamwork and communication skills are included in most lists of such needed professional skills. In addition, learning, analysis and information gathering, management and self-management skills are also frequently mentioned (Crawley et. al. 2007; Crebert et. al., 2004; Fry et. al., 2003; Grant & Dickson, 2006; Hesketh, 2000; Musa et. al., 2012; Rautavaara, 2015; Shuman et. al., 2005). The importance of these has been recognized in industry (Lang et. al., 1999; Passow, 2012), and have made their way to educational accreditation criteria as well. For example, the US Accreditation Board for Engineering and Technology (ABET, 2012) introduced professional skills to its required learning outcomes of engineering curricula. In problem-based and industry-partnered projects, these interpersonal skills such as team work and communications are emphasized even to a greater extent than domain specific or content skills (Savin-Baden, 2000).

One of the proposed answers to incorporating such learning outcomes to university education has come from integrating more project- and problem-based industry collaboration to coursework. This can be seen e.g. in Carleton and Leifer's (2009) study on Stanford's ME310 program, where they identified several problem-based and interdisciplinary academic programs that ME310 model had inspired. Particularly capstone courses can act as a bridge between the requirements in education and those in work life (Davis et. al., 2003). Problem-based learning, or more broadly experiential learning, is a student-centered rather than theory-driven methodology, conceptualizing learning as a social process where experiences are developed in interaction and through activities (see e.g. Dewey, 1938; Graaff & Kolmos, 2003; Kolb & Kolb, 2005; Savin-Baden, 2000). Experiential learning is holistic, with learning considered to happen everywhere, not only in a classroom (Dewey, 1938; Kolb & Kolb, 2005). It is said that problem-based learning "helps students develop competencies that will serve them throughout their professional lives" (Dunlap, 2005, p. 66) and it has also been referred as "apprenticeship for real-life problem solving" (Stepien & Gallagher, 1993, p. 26).

However, surprisingly little research has addressed the effectiveness of project-based learning in terms of professional skills. Typically, student feedback is collected at the end of such courses, perhaps augmented by feedback collected before and during the course as well. Studies have utilized for example student self-assessments of overall learning and enjoyability (Palmer & Hall, 2011), or self-assessment ratings of specific skills such as project management (de los Riós-Carmenado, Rodriquez López & Pérez García, 2015) at the end of a course or academic year. However, during their studies students have yet limited understanding of professional activities in their discipline, and thus may not be able to accurately evaluate the usefulness and applicability of the learning experience from a long-term perspective. Furthermore, Yadav and colleagues (2011) showed that while students learned more from problem-based learning sessions than traditional lectures as evidenced by exam performance, they self-assessed having learned more in the lectures. On the other hand, only time will tell what role the learned skills will come to play in the careers of students. Anecdotal evidence from 18 students in Wiek and colleagues' (2014) study for example showcases the positive perceived effect that learned professional skills can have on employment, with one student for example reporting:

> *"I developed many skills that helped me land a job right out of graduate school. Project management, leadership, stakeholder engagement, facilitation skills, and report writing are some of the invaluable tools I have added to my resume."* (p. 443)

To investigate useful and important experiences from a project-based course, and capabilities that are important in development efforts in later work life, this study looks into the experiences and career paths of alumni of one the longest-standing project-based courses, Product Development Project (PDP), in Aalto University Finland. PDP started in the Helsinki University of Technology in the 1980's at the department of Mechanical Engineering. Since then, PDP has grown into a multidisciplinary team-based learning experience, which attracts students mainly from Aalto University's disciplines of design, business and engineering, as well as remote student participants from 20 universities across the globe. PDP is aimed at master's level students and during the course, student teams work in real challenges provided by industry sponsors.

During nine months, the multidisciplinary and international student teams translate an open design brief into a functional proof-of-concept prototype. PDP has a strong emphasis on learning by doing, user-centered design and teamwork. In its twenty years of operation, PDP has been organized with 2490 students working in 254 projects and funded by 113 different sponsor organizations. Previous studies have looked at immediate PDP learning (e.g. Rautavaara et. al., 2014; Rautavaara, 2015) and this study represents the first time for systematically reaching out to course alumni throughout the 20 year history. As a result, we are able to shed light on the perceived long-term learning experiences of this project-based development course and better assess the learning needs for development activities in the professional realm.

2 Methods

In order to investigate the impact of project-based courses to alumni career paths and later development efforts, we reached out to the alumni of the Project Development Project course. The majority of the student teams are based in Finland, but as most teams have also remote student members in collaborating universities abroad, we reached out to them as well through their team members and the Design Factory Global Network.

The data collection was carried out in two ways: first, an online survey was posted on Aalto Design Factory's and other Design Factories' social media, as well as e-mailed to the course alumni email lists, in Fall 2017. The ongoing course and most recent class of 2017 that had only completed the course six months ago were excluded as we assumed the most recent graduates to have relatively little subsequent work experience for the purpose of this study. Second, the PDP alumni in the Design Factory Global Network were encouraged to share the survey with their former team members. The fifteen-item survey asked for background information (age, gender, PDP class, country of participation, and discipline), subsequent work experience and current employment information, what the participants considered as the most useful or important thing the experienced or learned from the course, whether they wished something would have been different, whether they would recommend the course for current students and what they felt had been the most important skills, knowledge or attitudes in their development efforts during their career so far. A total of 239 responses were received to this survey, representing roughly 10% of course alumni.

One part of the survey focused on reflecting the experiences of the PDP course in hindsight, and second part related to experiences after the PDP course, reflecting current career situation and skills needed in work life. The two most important questions from the survey for the focus of this study were:

1. Looking back to PdP: What was the most useful or important thing you experienced or learned?
2. Experiences after PdP: What skills, knowledge or attitudes have been most important for you to succeed in your development efforts during your career so far?

Both of these key questions were open questions with no response alternatives provided. (The full survey is included in the appendix.)

In addition to the online survey, we reached out during Fall 2017 to interview 33 alumni between the course classes of 2010 and 2015, aiming for a variety of backgrounds, as well as some years of professional experience after graduation. Some interviews were shorter phone interviews, whilst others were longer semi-structured face-to-face interviews. For the first, contacting was done directly through email and LinkedIn for a short 10 to 15 minute phone interview. 26 of these interviews followed roughly the questions as the survey, but elicited more comprehensive responses and reasoning behind them, compared to the the rather short (one or two lines) survey responses. These interviews lasted for an average of 11,5 minutes. For the latter, we reached out to 8 PDP alumni for more extensive interviews, eliciting more reflection on management experience and perceptions, in addition to development experiences. (These interviewees had been interviewed earlier for other research purposes during their PDP studies.) These interviews lasted for an average of 42 minutes. All interviews were recorded and transcribed for analysis.

Table 1 presents some background information and demographics of both the respondents of the online survey and alumni selected for interviews.

Table 1. Background information and statistics of the respondents

		SURVEY (n = 239)		INTERVIEWS (n = 33)	
Role in team	Team members		70%	Team members	55%
	Project managers		30%	Project managers	45%

Discipline	Engineering	69%	Engineering	64%
	Design & Art	16%	Design & Art	15%
	Business	9%	Business	18%
	Other	6%	Psychology	3%
Gender	Men	67%	Men	67%
	Women	30%	Women	33%
	Rather not say	3%		

The majority of the respondents reported being at the time of responding full time employees (67%). Some of them were still students (24%), some had started their own company as entrepreneurs (17%), some were part-time employees (14%) or PhD students (7%), and only 3% reported being unemployed. (The respondents could choose more than one of these options in the survey, for example, identifying themselves as entrepreneurs and PhD students.)

The transcribed interview and survey responses were combined into a larger data set of 272 alumni who had completed the course between 1999 and 2016. The data were segmented so that each segment represented a distinct idea or learning outcome, and these were categorized based on thematic similarity of the content in a data-driven analysis (Braun & Clarke, 2006). This resulted in four larger groups consisting of all together 31 categories (Table 2). The categories and their distributions were then compared between the perceived learning outcomes from the course and reported current needs in development.

3   Results

The responses to *perceived course learning outcomes* from the PDP course and *the most important skills, knowledge and attitudes that have been utilized in current development efforts* in alumni's current work life were grouped into four larger groups: interpersonal skills (n=388), attitudes (n=230), product development (n=172) and project management (n=127) (see Table 2, below).

Table 2. Perceived course learning outcomes from the PDP course and the most important skills, knowledge and attitudes that have been utilised in the alumni's current development efforts in work life

Group (total amount)	Learned from the course		Used in professional capacity	
	Category	No.	Category	No.
Interpersonal skills (388)	Teamwork overall	72	Importance of communication and how to do it effectively	44
	Multidisciplinarity	68	Teamwork overall	37

Category	Subcategory	Count	Subcategory	Count
	Importance of communication and how to do it effectively	43	Multidisciplinarity	37
	Multiculturality	33	Networking and collaboration	24
	Networking and collaboration (eg. Industry and university staff)	13	Multiculturality	17
	Total	**229**	**Total**	**159**
Attitudes (230)	Knowing one's own role and abilities	18	Curiosity, creativity and constant learning	43
	Confidence	17	Confidence	38
	Curiosity, creativity and constant learning	6	"Can do" spirit, optimism	30
			Persistence and getting work done	28
			Dealing with ambiguity and uncertainty	27
			Empathy	23
	Total	**41**	**Total**	**189**
Product development (173)	Product development process and practices	33	User-centered design and design thinking	25
	Prototyping and experimenting	19	Defining and solving problems	22
	User-centered design and design thinking	13	Domain specific skills (eg. technical, business)	19
	Defining and solving problems, working with uncertainty	11	Prototyping and experimenting	18
	Domain specific skills (eg. technical, business)	5	Product development process and practices	8
	Total	**81**	**Total**	**92**
Project management (127)	Managing and leading people	43	Managing a development project and its tasks	29
	Managing a development project and its tasks	40	Managing and leading people	15
	Total	**83**	**Total**	**44**

3.1 Interpersonal skills

Interpersonal skills, which included subcategories such as teamwork, communication and multidisciplinary collaboration, formed by far the largest group of perceived course learning

outcomes and utilization of important skills in the participants' current development efforts in a professional capacity. The two largest categories in this group were *teamwork overall* (n=109) and *multidisciplinary collaboration* (n=106). The examples of responses below show how multidisciplinarity had been an important experience during the PDP course:

> *"What I felt as an important experience during the course, was working in groups with people from different disciplines, because before that all the courses had been with designers with whom you don't have to explain to as much compared with engineers, for example. It was an eye opening experience to notice that they might speak with different words and ways about these design tasks."* (Design or art graduate, current student)

> *"For me, this was, at the time being, the most interdisciplinary team I had worked in so far. The experience highlighted the role of an industrial designer as a producer of material (e.g. visualizations) that helps the team communicate and collaborate."* (Design or art graduate, current researcher)

The third largest category was formed by *importance of communication and how to do it effectively* (n=87).

> *"Perhaps in some ways communication. How you convey your message to others, in a way that the common goal is clear and in what ways to do it effectively. I tried the whole year to think of ways how to improve our team's communication. In the PDP course, these challenges were more present than in any other courses where you don't collaborate with others as much."* (Engineering graduate, current quality engineer)

In addition, understanding the implications of multicultural collaboration and importance of networking were also reported as both learning outcomes and needed in current professional endeavors.

3.2 Attitudes

The largest difference between the learning outcomes and utilized skills in professional capacity emerged in the *attitudes* group. While 44 responses reported adopting an attitude as a learning outcome from the course, attitudes were the most frequently cited utilized skills in later development efforts within work life (n=189). This clear difference was not present in the other three categories. While the number of acquired attitudes varied between learned and utilized, there were some commonalities in the content. For example, *confidence* (n=55) and *creativity, curiosity and constant learning* (n=49) were brought up in the responses of both questions.

> *"The problem-based learning taught me how better to self-value myself and be aware of my own skills, weaknesses and strong suits. Also, what are the steps of product development and where do I fit in."* (Design or art graduate, current designer)

> *"Quickly picking up new contexts and business areas. As an agency designer, the industry I work with might change monthly. In other words, fast learning and fast feet."* (Engineering graduate, current UX designer)

The participants also reported utilizing *optimism*, *persistence*, *empathy* and feeling *comfortable with ambiguity* in development activities within their professions. The following example highlight some of these mentioned attitudes:

> *"Understanding and working with uncertainty - that's just part of the work when developing something new. Openness to different approaches and backgrounds of people. Hard work that includes failures and changes. Just do it -attitude."* (Design or art graduate, current service designer)

> *"It's the acquired mind-set 'Nothing is impossible' that I use all the time. If there is a problem, it has to be looked at from another angle and then it gets solved. There is no room for 'I don't know how to do this.'"* (Engineering graduate, current consultant for renewable energy)

3.3 Product development process

In the product development process group, most learned skills directly from the course were related to the *product development process*, while the important skills used in development efforts later on tended to be more *design process* oriented. The following highlights demonstrate the span of different skills associated with learnings related the product development process:

> *"First-hand experience with the full product development process. I feel confident being able to assess a project's feasibility and timeline, as well as identify specific hurdles that are likely to arise with design, prototyping, supply chain, manufacturing, distribution, business model, etc."* (Business graduate, current doctoral researcher)

> *"I suppose it was seeing a product development project from the very beginning to a working proto - that it really can be done, and even by students. Also, the little, sometimes quite sneaky tricks utilized in product dev i.e. how much stuff goes on behind the scenes, as well as real client experience, have been especially useful."* (Engineering graduate, current research trainee)

In terms of learnings in relation to the design side of the product development process, some of the responses mentioned specific tools that they have used in their professional development efforts, as highlighted in these responses:

> *"Especially ideation methods that we used a lot. They were useful. However, they require in a way same type of mentality from other people and that in the work environment there are people from your own generation with similar ways of working. Of course now you constantly try to introduce new ways to working, different views and ideas."* (Engineering graduate, current production manager)

> *"I enjoyed the PD6 event for brainstorming the most. It helped to kick start the design thinking process and helped to get the creative wheels spinning."* (Design or art graduate, current industrial designer)

Interestingly, only a handful (n=5) respondents highlighted domain specific skills as specific learning outcome from the course.

3.4 Project Management

Project management related skills were reported more frequently as important learning outcomes from the course (n=83) than as used in current development efforts (n=44). In the reported course learning outcomes, the division between *people management* (n=43) and *task management* skills (n=40) was quite even. Many the answers associated with the learning

outcomes of this group were specific skills such as setting milestones or how project planning is done. However, in some cases gaining a better understanding of what project management or leading a team is actually all about was highlighted.

> *"Managing/leading projects, coordinating and planning projects. Setting clear milestones, all work revolves around them."* (Engineering graduate, current researcher)

> *"When there are several stakeholders involved with one project, things tend to get difficult. Often the difficulties relate more to the people involved, rather than the actual tasks. Therefore, in reality, leading people is more important than the technical challenge, design challenge or other."* (Engineering graduate, current doctorate student)

Similarly, in a professional capacity, the participants mainly reflected back to their project management experiences through specific ways of doing things or through increased knowledge overall. For example, how different types of people work or what it takes to be a team leader.

> *"It was great that in some ways a kind of empathy and project management knowledge grew significantly during the nine months as we worked together with different types of people, who think in different ways - the different mental models, ways of working and social skills, and all these things. It was really cool to lead this type of a team, and not only lead, but facilitate a multidisciplinary team."* (Business graduate, current entrepreneur)

> *"How to break a big project into smaller and independent tasks. I think at the moment this is one of the most important things related to my own work every day, which I similarly have to deal with."* (Engineering graduate, currently works in customer service)

4 Discussion and conclusions

Based on the responses and interviews of 272 alumni of the Product Development Project (PDP) course, the results highlight the perceived significance of socio-behavioral interpersonal skills and attitudes in successful development and design activities. Teamwork overall and communication skills formed the largest category reported by the alumni in both significant learning outcomes of the course and skills needed in current development efforts. From a professional perspective, most participants however cited various attitudes such as curiosity, optimism, confidence and persistence as the most important "skills" in their current development efforts. The usefulness of being able to handle ambiguity and multifaceted projects was also highlighted. These collaboration skills and attitudes were followed by grasping a better understanding of the development process and project management, with the PDP course often representing a first complete development project experience for the alumni rather than a piecemeal phase or task of it.

These findings align with previous studies around PDP learning outcomes and experience conducted by Rautavaara (2015) and Rautavaara et. al. (2014) where they found that communication skills, teamwork, and proactive attitude where some of the key learnings. However, in their study global collaboration and domain specific skills such as product development process and prototyping skills (Rautavaara et. al., 2014) were more highlighted, which might be a result of interviewing students right after the finish of their PDP project when the experience was still fresh in interviewees minds. On the other hand, much of the PDP course is based on the framework of product development presented by Ulrich and Eppinger (2008). In the present study, however, the alumni talked more about utilising design

processes rather than product development processes in their current work. This suggest how traditional product development and engineering education is faced with new requirements to educate graduates with user-centric design processes and creative problem-solving skills (e.g. Passow & Passow, 2017; Clavert & Laakso, 2013; Laakso & Clavert, 2014).

The results also emphasize the social nature of professional design and development efforts. These findings are in line with research highlighting the role of interpersonal skills, mainly communication and teamwork (e.g. Passow & Passow, 2017; Shuman et. al., 2005), in professional life and justify how learning experiences such as PDP can bridge the gap between academic education and professional skills needed in work life. However, it is interesting to look at these results from the viewpoint of new curriculum and course development. As mentioned, for students during their studies it might be difficult to evaluate the usefulness and applicability of certain study projects from a future work life perspective. This study shows how most participants name attitudes such as curiosity, optimism, confidence and persistence as the most important factors or skills needed for succeeding in work related development efforts.

Project-based learning can be an effective way to teach and enhance such attitudes through its approach of student-led learning and working with real world challenges (e.g. Hmelo-Silver, 2004), however, educators struggle with explaining and managing students' learning outcomes as these courses differ from traditional engineering courses (e.g. Davids et. al., 2003). The learning outcomes of these PBL and hands-on learning experiences should be more clearly communicated to the students, as the number of these courses grows in all academic institutions (e.g. Davis et. al., 2003). Instead of students learning generic team working or communication skills, the learning outcomes could identify for example how a particular course will enhance students' confidence in multicultural collaboration, curiosity for combining multiple approaches, and provide a holistic understanding of the development process.

It is important to note that the data used in the current study had some limitations. First, it is safe to assume that the majority of the alumni responding to the survey had had positive experiences with the course and by responding wanted to give back to the community. Second, all respondents had still some connection to Aalto Design Factory or the PDP alumni network or they followed activities related to PDP, since the survey that was shared in social media and via old email lists reached them. As the responses represented a little over ten per cent of the course alumni, many other learning experiences and career paths were still left undocumented. Third, a large number of the respondents were project managers in their teams, which may indicate already a higher level of commitment and activeness towards the community and the course. The current study did not analyse the responses of student project managers separately from the other student team members, nor the difference in responses reported by students from different disciplines or from different career paths, and both of these viewpoints should be taken into account in future research.

Subsequent research could also look into matching formal immediate student feedback results with the results gained from this long-term survey to gain an even bigger database and pool of answers and to analyse similarities and differences in responses right after the learning experience and in hindsight. Nevertheless, the current study already illuminates the large emphasis alumni put on social and attitudinal factors post-graduation and how project-based courses are perceived as useful for preparing for the demands of working life. Although the majority of planning may frequently be targeted at the discipline-specific content, the current study suggests that more care in designing the collaboration elements may be important for cultivating the students' professional capabilities.

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PDP alumni insights

Product Development Project, PDP, is organized by Design Factories around the world. We would like to understand better how students - our number one stakeholders - have or have not found the experiences gained during the course useful in their subsequent endeavors. We hope you'll help us in developing our universities by sharing your thoughts! However, responding to the questions is totally voluntary.

Background

In which academic year did you take PDP? (e.g. 2016-2017) _____

In which country?
[dropdown menu of participating countries and a final option of "other]

Were you a PDP manager?
__ yes   __ no

What discipline were you studying?
__ engineering   __ business   __ design or art   __ other, _____

Looking back to PDP…

What was the most useful or important thing you experienced or learned?
_____
__
_____
__
_____
__

Is there something that you wish had been different?
_____
__
_____
__
_____
__

How likely is it that you would recommend taking PDP for current students?
[scale from 1 - not likely to 10 - very likely]

How was your experience of the Design Factory?
_____
__
_____
__
_____
__

Experiences after PDP

After completing PDP, have you worked
(check all that apply)
__ in product or service design projects or tasks?

__ in cross-functional or multi-stakeholder projects or tasks?
__ in projects or tasks with international collaboration?
__ in managing projects or tasks?

Have you worked for the sponsor company of your PDP project at any point after the course?
(check any that apply)
__ Yes, as a summer worker, intern or part-time employee
__ Yes, as a full-time employee
__ Yes, doing your thesis at or for the company
__ Yes, as a consultant or independent contractor
__ No, but we did launch our own venture based on the project
__ No
__ Other, _____

What   is   you   current   job   /   position?
_____

What skills, knowledge or attitudes have been most important for you to succeed in your development
efforts during your career so far?
_____
__
_____
__
_____
__

Last few questions about you

Gender
__ female __ male __ other __ prefer not to say

Age _____

Current status
(choose all that apply)
__ part-time employee
__ full-time employee
__ entrepreneur
__ unemployed
__ bachelor or master-level student
__ doctoral student

Thank you so much!

Is there anything else you would like to add?
_____
__
_____
__
_____
__