# Self-efficacy in new product development teams

Entrepreneurship

Master's thesis

Martti Jerkku

2016

**Aalto University**
**School of Business**

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**Abstract of master's thesis**

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**Abstract**

In the constantly globalizing world of complex problems, there is a growing demand for educational methods for preparing students to face real life challenges. This thesis focuses on discovering perceived self-efficacy in new product development teams. The study was conducted among students who were taking part in a Master's-level course that involves intensive teamwork in interdisciplinary and international product development teams. The research presents self-efficacy as key factor for self-development through practical learning. In addition, self-efficacy beliefs are considered having an influence on development of entrepreneurial behavior and intentions since the process of product development and new venture creation can be seen very similar. Classic and current research trends in related fields of study are used to provide understanding about the role of perceived self-efficacy and entrepreneurial mindset in product development process.

The studied course is open-ended, lasts for whole academic year and is part of the product development major at Aalto University. The educational methods used in the course base on project oriented problem-based learning and the course exploits a design-thinking innovation process. The data used in this study was gathered during academic year of 2014-2015, from nine students in three teams based on interest. Semi-structured interviews were used as a method in data gathering. Three interviewees were project managers and six were team members. First, the data was analyzed by thematic analysis approach.

This thesis first introduces the product development models used during the course work. Then, Albert Bandura's theory of self-efficacy is presented as well as its relation to entrepreneurial behavior and intention theories. This theoretical background is used to reflect findings of this particular study. More precisely this study aims to discover: (1.) What kinds of situations affect the self-efficacy of team members during a product development process? and (2.) How interaction and emotions affect team member's perceived self-efficacy during a product development process? The findings suggest that the students face various interaction points and go through emotional processes influencing perceived self-efficacy. In addition, this work-in-progress analysis presents that soft and interactions skills are in fact in the core of confidence in product development project work whereas product development is traditionally seen as a mix of professional as well as practical skills.

**Keywords**  Entrepreneurship, New product development, Self-efficacy, Teamwork

ACKNOWLEDGEMENTS

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**ACROYMS**

| | | |
|---|---|---|
| ADF | - | Aalto University Design Factory |
| ACE | - | Aalto Center of Entrepreneurship |
| AVP | - | Aalto Ventures Program |
| d.school | - | Design School at Stanford University |
| DBL | - | Design Based Learning |
| DB | - | Design Brief |
| DFGN | - | Design Factory Global Network |
| DL | - | Deadline |
| DT | - | Design-Thinking |
| EE | - | Efficacy Expectation |
| OE | - | Outcome Expectation |
| PBL | - | Problem Based Learning |
| PjBL | - | Project Based Learning |
| PDP | - | Product Development Project |
| PM | - | Project Manager |
| SE | - | Self-efficacy |
| TKK | - | Helsinki University of Technology |

## 1. INTRODUCTION

A vast set of practical skills and experience is required from today's University graduates before entering the working life (Aalto University – Strategic development of Aalto University, 2012, p.15). Recent discussions among employers concern student's ability to gain professional experiences during their studies and how could the universities provide the practical skills for the students before the graduation (Crebert et al, 2004; Murtonen et al, 2008). Consequently, universities are pressured to actively involve industry collaboration as a part of the curriculum. If looking a bit deeper into this topic one cannot avoid stumbling upon the word *entrepreneurship*, which has been gaining a lot of attention in both industry as well as academia side over the past years. Entrepreneurial behavior is one of the key characteristics that the companies are looking for in the prospective new employees (Kyrö, 2006). Entrepreneurial behavior is also often related to "entrepreneurial mindset". If a person possesses an entrepreneurial mindset, he or she tends to act entrepreneurially, which often means identifying and exploiting new opportunities (Bird & Schjoedt 2009). Additionally, acting entrepreneurially is usually seen as a capability to tolerate uncertainty and to take calculated risks to achieve set goals and create new innovations (McGrath & MacMillan, 2000). Self-efficacy beliefs play a central role in better understanding the entrepreneurial mind. Individuals with high level of self-efficacy are more likely to take actions towards opportunities and realize intentions (Lee et al., 2011). Since university students are encouraged to learn entrepreneurial behavior during their studies it is interesting to investigate how self-efficacy beliefs of students are affected during a capstone course of product development.

Universities are increasingly keen to research and teach entrepreneurship. In Finland, the newly formed Aalto University is the flagship institute that aims to promote multidisciplinary education and research to provide its students a better basis for working life. Aalto University is also exceptionally promoting entrepreneurship education as a part of its strategy (Aalto University – Strategic

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Development of Aalto University, 2012). In fact, MIT research by Ruth Graham (2014) showed Aalto as one of the top five most potential University-based innovation ecosystems in the whole world. Especially, Startup Sauna, Aalto Centre of Entrepreneurship, Aalto Ventures Program and Aalto Design Factory were seen highly beneficial for this entrepreneurial environment (Graham, 2014). Aalto Design Factory is one of the three factory projects. ADF was created to act as a physical co-creation platform where students from different disciplines are working together with company partners to tackle real industry problems (aaltodesignfactory.fi, 2015). Product Development Project -course (PDP), which is studied in this research, is currently part of Aalto Ventures Program and takes place in the premises of Aalto Design Factory. Therefore, PDP -course also promotes different aspects of entrepreneurial skills such as project management, creativity, prototyping and innovation (avp.aalto.fi, 2015). Self-efficacy beliefs are in a central role so these skills can be obtained and mastered.

This thesis explores team members' perceived self-efficacy during new product development (NPD) project covering the phases from project team formation to building a functional prototype. Self-efficacy can be defined as one's belief on his or hers capability to succeed in different situations (Bandura, 1977). Furthermore, the role of emotions and human interactions in terms of perceived self-efficacy are discovered to better understand the self-development opportunities of individuals in educational framework. The thesis uses the qualitative research approach and it is carried out in the PDP -course context in Aalto University. The objective of the thesis is to provide better understanding about the changes in self-efficacy beliefs of an individual team member in a context of new product development and in a multidisciplinary capstone course environment.

In PDP, multidisciplinary student teams develop products as solutions for a problems presented by sponsoring companies (Aalto University Design Factory - Annual Report, 2015). The course follows problem based learning (PBL) philosophy so the main aim of the course is to learn by going trough the different

phases of product development process from team formation to building functional prototype (PDP.fi, 2015). After the course, the student should be more aware about his or her own capabilities as a part of multidisciplinary team as well as the potential and the challenges of the team itself. After the completion of the course students are also more capable of carrying out different kinds of product development tasks by using traditional and modern methods of creative working. Communication skills are practiced within the team and also with the project stakeholders such as potential users and customers, company contacts and the university personnel (Appendix 3). All together these aspects of project working challenge the students to find creative solutions to given problems by exploiting identified opportunities within the field that they are working in. As a part of Aalto Ventures Program the learning outcomes of the PDP course support the students not just to learn product development process but also develop entrepreneurial mindset, which is exactly what the companies are expecting from University graduates (avp.aalto.fi, 2015; Appendix III).

Self-efficacy beliefs have an essential role from the perspective of the individual student if thinking about the learning goals of the PDP course. Self-efficacy refers to one's belief of succeeding in given tasks and is affected mainly by different emotions, experiences and interactions with others (Bandura, 1977). These beliefs also play a major role in formation of motivation and intention to tackle challenges (Bandura, 1977; Boyd & Vozikis, 1994; Carsrud & Brännback, 2009).  In this thesis, self-efficacy is studied in individual level in context of three product development teams of PDP class 2014-2015. The research was done by conducting and analyzing individual student interviews in which the project progress was discussed by reflecting on emotions and levels of motivation during different phases of the project.

The study explores how students experienced learning and self-development during PDP course from a psychological perspective. Bandura's (1977) theory of self-efficacy is used to analyze students internalized learning experiences by

reflecting project work in new product development (NPD) teams. Following research questions were formed to explore this theme:

1. In what kind of situations the team member's self-efficacy is affected during new product development process?

2. How interaction and emotions affect team member's self-efficacy beliefs during new product development process?

The study identifies most significant situations where the self-efficacy beliefs are affected during the PDP projects. At first, the situations described by students are detected by using Bandura's original theory of self-efficacy. Later the, results are discussed from entrepreneurship research perspective to open up the discussion about the relationship between product development education and entrepreneurship. Therefore, the study participates in the discussion of self-efficacy in engineering education by exploiting research of self-efficacy in new venture creation (NVC) and in the entrepreneurship framework. In the context of this study NVC and NPD are seen as identical processes since they both include same phases from opportunity identification to first functional concepts or prototypes. Both processes also require an innovative and resilient mindset in order to be successful. Additionally, the results of the study can be used in development of PDP as well as in any PBL based product development course in order to provide meaningful learning experiences and practical utilization of existing skills for the students.

The thesis consists of five main chapters in the following order: the literature review, research methodology, results, discussion and conclusions. The literature review (2nd chapter) first presents different models of the NPD process and the theory of self-efficacy by Albert Bandura. Building on Banduras original theory, self-efficacy literature in educational as well as in entrepreneurship context is introduced. After the literature part, the methods of single case study research and

data gathering are presented in research methodology chapter (3rd chapter). In the results chapter (4th chapter) the research findings are presented in themes and evidence is provided with quotes from interviews. Finally, the discussion chapter (5th chapter) reflects and interprets the research findings and suggests implications for further research. In the end, conclusions chapter (6th chapter) evaluates how well the research questions were answered and summarizes the findings of the study.

## 2. SELF-EFFICACY AS A FOUNDATION OF SUCCESS AND CONFIDENCE

This chapter introduces the theoretical framework used in this research. First, the different approaches to new product development are reviewed since this study concentrates on exploring new product development teams in university environment. Since the studied teams are not following one particular process model of NPD, three most relevant models are briefly introduced. These models are later referred to in the discussion chapter in order to pinpoint different project phases where influential experiences occurred.

Second, Albert Bandura's self-efficacy theory is introduced to comprehend how self-efficacy beliefs are constructed in theory. Bandura's theory is grounded in analysis sections since the research aims to discover experiences affecting perceived self-efficacy during product development projects. Additionally, self-efficacy theory was used in the generation of interview guide used in this research. Finally, the chapter expresses how Bandura's theory of self-efficacy is used as a part of different theoretical approaches to entrepreneurship. More precisely Self-efficacy theory is reviewed as a part of entrepreneurial intentions and behavior as well as entrepreneurial self-efficacy. This outline of entrepreneurship research is used in discussion chapter to understand if the experiences during product development project process can have an impact on one's entrepreneurial capabilities.

### Different approaches to new product development

New product development refers to set of activities that aim to develop and implement a new product for a certain market (Krishnan & Ulrich, 2001). Conventionally, industrial companies have their own designated department for product development activities. The aim of these departments is also to constantly

enhance already existing products by using knowledge gained from research and user feedback (Ulrich & Eppinger, 1995). In a nutshell, product development ultimately exploits market demand by turning the demand into products that can be sold. Traditionally product development processes have been used in development of tangible products but currently same processes are also widely used in generation of software products and services (Kahn et al., 2013).

Where new product development used to be seen as field of engineering it nowadays engages professionals from various fields of expertise such as business, design, psychology and anthropology. In fact, some product design agencies such as IDEO promote the benefits of professional diversity in NPD team (Ulrich & Eppinger, 1995). In terms of research, this diversity has generated various view points from witch NPD activities can be explored. Regardless of research aspect, the process itself can be seen as a core of efficiency and innovation in product development context (Ulrich & Eppinger, 2012). NPD process consists of several stages of activities that will lead to implementation of new product or service that can be brought to the market (Ulrich & Eppinger, 2012).

According to previous studies as well as more current research in NPD, various different kinds of models have been generated to illustrate product development process. Conservative models illustrate the product development as a linear process (e.g. Cooper, 1996; Ulrich & Eppinger, 1995) whereas more recent models regularly see product development as non-linear and iterative process (e.g. Bhuiyan, 2011; Howard et. al., 2005; Kahn et al., 2013) Additionally, design-thinking model is widely applied and researched in NPD context (e.g. Cross, 2008; Leborg, 2006; McKim, 1972). Traditional product development process (Ulrich & Eppinger, 1995) is one of the most well known linear models of product development that describes required stages chronologically from idea to market launch. Figure (1) presents linear product development model as presented by Ulrich and Eppinger (1995).

**Figure 1- Traditional product development process model inspired by Ulrich & Eppinger, 2004**
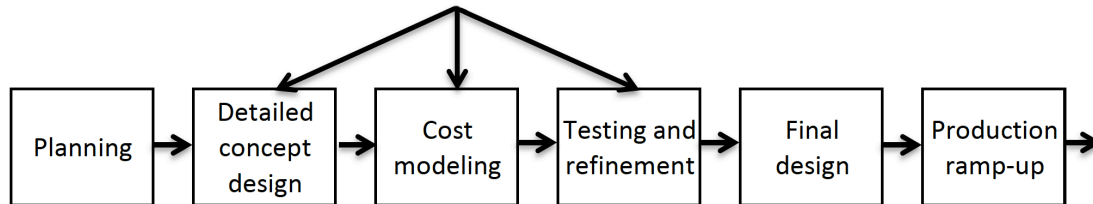


The model (Figure 1) also allows iteration during concept design phase. However, especially big industrial companies have adapted this model and are often following it chronologically without taking any steps backwards (Ulrich & Eppinger, 2004).

As an example of non-linear product development model, Larman et. al. (2010) describes iterative product development as cyclical process where learning's from earlier development phases can be considered and contributed to the concept. Those learnings rise from both development and testing of the concept. All iteration cycles add or enhance the functions of preliminary concept as presented in figure 2 below. This kind of iterative model has been used particularly in software development but it has been also applied to development processes of tangible products as well as services.

**Figure 2- Illustration of an iterative product development process model**
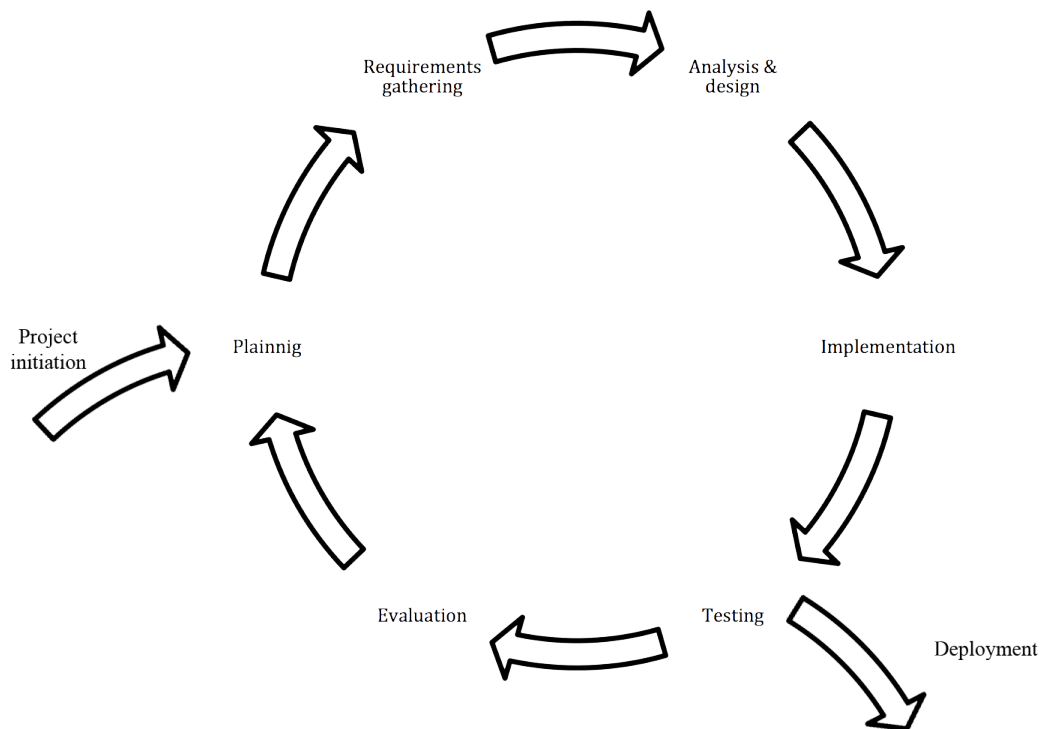


As mentioned, also design-thinking practices have been used and studied as a guideline of product development process. Design-thinking methodology highlights the importance of solution-based design that is based on building up ideas with few or no restrictions (Cross, 2008). This kind of thinking is emphasized especially in early ideation phases. Solution based design approach starts often by vague definition of goal rather than solving a one particular problem (Buchanan, 1992). Design-thinking can be also seen as an iterative process meaning that wild or fuzzy ideas can be used as a base for more detailed solutions by taking the leanings from research and testing as a part of final design.

**Figure 3- Illustration of design-thinking process model inspired by Hasso Platner institute**

INSPIRATION    IDEATION    IMPLEMENTATION

UNDERSTAND | OBSERVE | DEFINE A POINT OF VIEW | IDEATE | PROTOTYPE | TEST | STORY TELLING | PILOT | BUSINESS MODEL
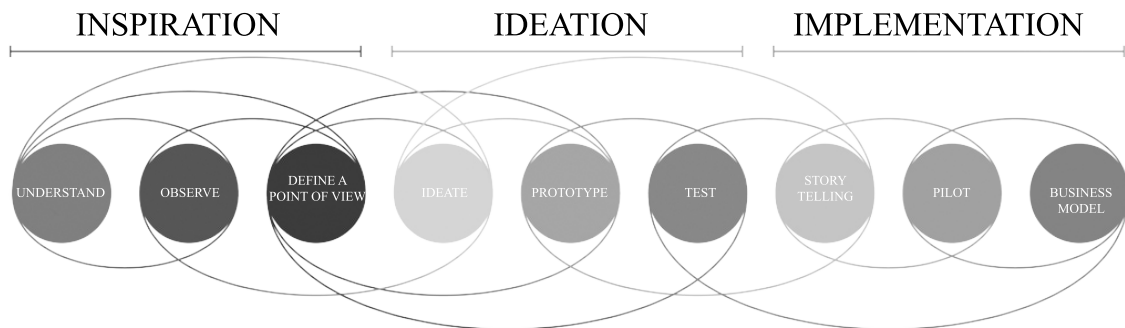
As illustrated in figure (3) above, design-thinking process allows limitless amount of steps to be taken between different stages (Buchanan, 1992). This way, design-thinking approach in product development can be time-consuming but also intensive process that results concepts that are thought thoroughly (Cross, 2008). Therefore, deadlines and careful scheduling need to be considered when this approach is followed in NPD process.

## Bandura's theory of Self-efficacy

To be able to gain comprehensive overview about the self-efficacy theory, we have to go as far as Stanford University department of Psychology in the late 70's where Albert Bandura (1977) created a theory about beliefs that the people have about their own ability to organize and accomplish tasks. The self-efficacy theory was introduced first time in 1977 at Banduras article: "Toward a Unifying Theory of Behavioral Change". Regarding to Hampton and Mason (2003) Self-efficacy is one of the cornerstones of motivation research. Banduras theory of self-efficacy (1977) is part of his greater socio-cognitive theory. More precisely the self-efficacy theory defines how people feel, think and motivate themselves and therefore behave accordingly to these factors (Bandura, 1997). High perception of self-efficacy also increases the level of human accomplishment and also level of personal well being

in various ways. For example, self-efficacy can be seen as one's belief on his or hers ability to succeed in University studies. It has been also suggested that person possessing a high level of self-efficacy tends to think tasks being more like a though challenges that he or she has a capability to complete (Pajares, 1997). One the other hand, person with a low perception of self-efficacy sees those challenges extremely difficult or even impossible to complete. Therefore, level of self-efficacy also determines how much power and willingness a person posses in order to be able to complete the assigned task (Zimmerman et. al., 1996). Basically Banduras theory about self-efficacy defines that one's motivation and performance are highly dependable about the belief of completion of the task. This way self-efficacy can be seen as one aspect to architecture of individual's personality (Baumeister & Vohs, 2004).

Level of self-efficacy is determined by one's belief about his or hers own capabilities to achieve tasks and goals (Bandura, 1997). Therefore, the level of self-efficacy doesn't just measure the set of skills that a person has but rather his or her ability to utilize those skills. . When a person believes that his or her actions have an actual effect on reaching the targeted objective, the person has an incentive to achieve that goal (Bandura, 1997). On the other hand, if the person doesn't believe on sufficient results on completing the task, the person doesn't feel like having a reason to work on it efficiently. This way self-efficacy can be also seen as a base for one's behavior and actions (Zimmerman et. al., 1996).

When one believes on his or hers own abilities, he or she doesn't try to avoid tasks that might feel difficult (Ormrod, 1999). In this case, the level of commitment on completing the task is very high and setbacks during the process tend to consolidate the willingness to achieve the goal. According to Bandura (1997) this kind of high self-efficacy can be also seen as a factor that fosters behavior towards achieving the tasks successfully. This creates a sense of control in own life and well being which can for example have a positive impact of level of stress and level of depression (Bandura et al., 1980). Therefore, if thinking about education, it is

important to avoid providing all the solutions straightforward but rather to give tools which might open new paths for achieving goals trough self-realization (Pajares, 1997).

Regarding to Bandura's theory of self-efficacy, one's behavior is a result of interaction between individual and the environment. This means that the actions and behavior of an individual affect the environment as well as the environment influences the human behavior in any kind of context (Bandura, 1997). This kind of interaction is called reciprocal determinism. Inspired by Bandura this kind of interaction can be seen as a very important factor in human behavior in this constantly changing and fastly globalizing world (Van Dinther et al., 2011).

As mentioned before, Banduras theory of self-efficacy was originally a part of his social cognitive theory (1986) that concentrates on exploring the consequences of reciprocal interactions. Trough this theory Bandura was able to point out the influence of interactions in individuals' self-efficacy beliefs. Since the theory claims that these beliefs are the base of individual development, the theory has inspired many researchers in the field of motivation research but it has also gained a vast interest in various other fields such us pedagogy (e.g. Peltonen, 2008; Van Dinther et. al., 2011; Zimmerman et. al., 1996) and entrepreneurship (e.g. Boyd & Vozikis, 1994; Bagheri et al. 2012; Barbosa et al. 2007; Izquierdo et al. 2011) which will be discussed later on.

According to Bandura (1997), individuals' self-efficacy beliefs are affected by four different factors: enacted mastery experiences, vicarious experiences, social persuasion and emotional arousals. These different categories are explained in more detail below:

*Enacted mastery experiences*

Enacted mastery experiences refer to individual's former significant experiences that are influential to his or hers behavior. This means that the individual assesses his or hers ability to act based on the reflection of these experiences. Former positive experiences of success enhance individual's self-efficacy beliefs. Basically the person could think that: *I have succeeded in this before. Therefore, I can do it again.* On the other hand, previous negative experiences can weaken individual's self-efficacy beliefs. In this case the person could think: *I couldn't succeed before so why should I succeed this time.* According to the Banduras theory of self-efficacy the former experiences have a major role in the development of self-efficacy beliefs. Therefore, it is very important to discover how one's self-efficacy beliefs are influenced to better understand how individual sees his or hers own capabilities today (Van Dinther et. al., 2011)

*Vicarious experiences*

In addition to former experiences, vicarious experiences play an important role on development of self-efficacy beliefs. Vicarious experiences can be defined as situations related to social comparison. Therefore, these experiences occur when an individual compares his or her own skills to reference group. In other words, individual evaluates his or hers own capability by comparing the level of skills and performance to other people (Bandura, 1977). More specifically, people tend to compare themselves to other people in similar situation. Hence, the self-efficacy beliefs of the individual tend to increase when he or she believes being more capable to better succeed in the task than the reference group. On the other hand, if the individual sees the reference group being more capable to succeed in the task, the self-efficacy beliefs are likely to decrease (Bandura, 1977).

When thinking of Bandura's theory, it is important to understand that individuals' self-efficacy beliefs are not only dependable on his or hers capability to evaluate the skills and performance of the reference group but also about evaluating his or her own skills and competences in the first place.  Consequently, the less knowledge the individual has about the reference group the more sensitive his or hers self-efficacy beliefs are to change (Bandura, 1978).

*Social persuasion*

Shortly, social persuasion refers to encouragement or discouragement that one receives from another person. Basically one's self-efficacy beliefs can be influenced by verbal or non-verbal interaction. (Bandura, 1977; Hutchison-Green et. al., 2008) Like the two former sources of self-efficacy, also social persuasion is working both ways, meaning that negative feedback or discouragement tend to weaken the perceived self-efficacy and vice versa. However, Bandura (1997) states that negative persuasion has a stronger effect when compared to encouragement.

Social persuasion is especially meaningful in situations where the individual faces problems that affects his or hers capability to achieve set goals. Additionally, if other people are questioning one's skills or level of performance, that tends to affect self-efficacy beliefs decreasingly (Bandrua, 1977). In his book, Self-efficacy: The exercise of control (1997), Bandura also highlights that the positive encouragement has to be realistic and it is most reasonable for individuals who constantly aim to higher performance level (Bandura, 1997). In case the encouragement is exaggerating and unrealistic it can easily generate too high expectation that often lead to disappointments and in the end decreases self-efficacy beliefs. In this case, that person has lower level of self-confidence to overcome similar tasks in the future (Zimmerman et. al., 1996).

*Physiological & emotional arousals*

The fourth factor that Bandura claims to be affecting self-efficacy beliefs is physiological and emotional arousals. As an example one's perceived self-efficacy can be influenced negatively in case one feels stress, anxiety or fear in certain situations or environments. One might even experience burnout or insomnia when perceived self-efficacy is damaged. These conditions can be seen as physiological arousals. Strong emotional and psychological arousals can potentially have a very robust influence on self-efficacy beliefs. As an example of such a strong arousal, avoidance behavior refers to active or passive resistance to complete certain tasks due to negative emotions (Bandura & Adams, 1977). Learned helplessness is also a similar condition that occurs in situations where individual avoids even trying or starting the process of completing task due his or hers feeling of not having necessary skills or other capabilities required on that (Bandura, 1977). In contrary to learned helplessness, learned optimism refers to situations where one intents to face challenging situations with optimistic mindset (Seligman, 1991).

These four sources: *mastery experiences, vicarious experiences, social persuastion* and *psychological and emotional arousals* are affecting one's self-efficacy beliefs. As mentioned both internal and external factors including own thoughts, experiences and physical as well as social environment are included in the theory. Figure 4 below depicts the process of different factors affecting one's self-efficacy beliefs and how these factors change behavior and performance.

**Figure 4- General model for successful training of self-efficacy inspired by Carsrud & Brännback, (2009)**

| Sources of self-efficacy | Feedback | Behavioral patterns | Results |
|---|---|---|---|
| Mastery experience<br><br>Vicarious experience<br><br>Social/verbal persuasion<br><br>Physiological & emotional arousals | Conviction of self-efficacy | • Meeting challenging situations with a positive attitude<br>• Learning from mistakes<br>• Continuous and persistent effort in the face of hardship<br>• Learning from others<br>• Visualizing success<br>• Making own decisions about what is acceptable behavior<br>• Solving problems creatively<br>• Learning to handle stressful situations | Success |

**Sources of self-efficacy for students**

As a part of Banduras social learning theory self-efficacy is in a central role in any kind of learning processes. Self-efficacy beliefs were originally studied mostly on clinical problems and phobias, recently growing number of research has been carried out in a field of education (Van Dinther,2011). Many researchers have confirmed that self-efficacy beliefs are strongly linked to learning processes of different subjects at school, creation of motivation, academic success or even for career selection of an individual (Bong, 2001; Schunk, 1991; Zimmerman et. al., 1996). Over the last decades, self-efficacy theory has been also applied in the field of engineering and product development, which is especially interesting if thinking about this research. In 2008, Green et al., studied sources of self-efficacy among the students of freshman engineering course. Differing from the mainstream, the study used qualitative research approach to understand better the construct of self-efficacy beliefs of engineering students in more personal level. Consequently, in this particular research Banduras theory has been used to study situations affecting the self-efficacy beliefs of the students in NPD course context.

Self-efficacy beliefs play a central role in individual's self-development. By reflecting those beliefs a student evaluates him or her self as a learner (Partanen, 2001). However, development of self-efficacy beliefs does not happen only at school or other learning environment but it lasts trough the lifetime. Regarding to Bandura (1977) the development of students self-efficacy beliefs are affected by social environment and his or hers ability to regulate own actions. Additionally, understanding cause-effect relations and capability to self-reflection are significant in development of self-efficacy beliefs (Bandura, 1977; Hoyrup, 2004).

Regarding to Bandura (1977), self-efficacy occurs as efficacy expectations (EE) and outcome expectations (OE). Efficacy expectations refer to one's beliefs on his or hers capability to achieve certain level of performance whereas outcome expectations are related to one's estimations of causalities caused by actions that one takes. If we think about the member of NPD team, his or hers efficacy expectation could be that he or she is capable to work effectively in a team resulting a working prototype. The outcome expectation on the other hand could base on the belief of gaining appreciation from the project sponsoring company. This way efficacy expectations occur in the first place followed by outcome expectations a as illustrated in Figure 5 below.

**Figure 5- Difference between efficacy expectations and outcome expectations (Bandura, 1997, p.193)**
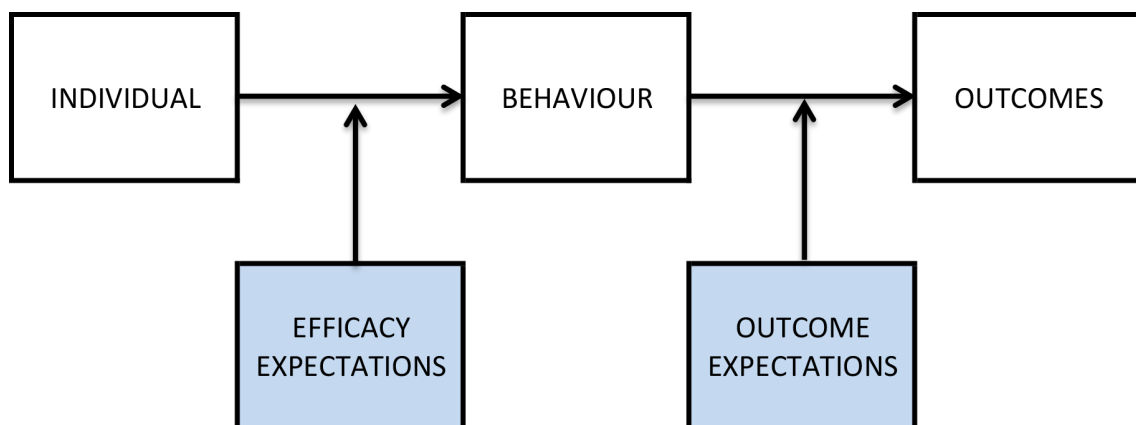
Efficacy expectations vary in strength, magnitude and generality (Bandura, 1999). If thinking about learning, these aspects should be considered in order to make interpretations about how meaningful the experience could be in long term. Bandura described these three different measures in a following way. Additionally examples are given in PBL context.

- Magnitude of efficacy expectations (EE) means the level of certainty related to one's belief on success. Therefore, the magnitude of EE depends mostly about how risky and difficult the task is perceived. For instance, in problem based learning there are always different solutions to given problem involving different levels of risks. In context of PDP as PBL –course this is also evident since both project progress and direction are affected by evaluated risk and difficultness of different concepts.

- Secondly, the strength of EE means how long one sticks on his or hers beliefs to succeed even if conflicting events may occur. The stronger the EE is the more one can tolerate setbacks. In PBL setbacks are evident since learning is mostly based on doing and trying of different kinds of solutions. Therefore, in PBL setbacks are rarely called failures. Instead those are rather turned to positive learning experiences.

- Finally, generality of EE means how one is exploiting SF beliefs in similar situations. One might limit efficacy expectations only to the tasks that are closely relatable where other might generalize these expectations to wide range of different kind of tasks. In PBL context this could be an interesting aspect to map out; How positive learning experiences from earlier project phases could be carried throughout the project process?

Current research literature has numerous cases where self-efficacy has been studied by quantitative methods in the field of engineering and NPD (eg. Marra et. al., 2009; Carberry et. al., 2010) and less attention has been paid on qualitative

research approach. These quantitative studies show the statistical relation of self-efficacy to achievement, persistence and interest towards the given task. Study of Workman and Podner (1996) stated that quantitative studies of self-efficacy are limited since those don't provide much information of individuals from whom the data was gathered. This is the main reason why the qualitative approach was selected for method of this research. As suggested by Green et al. (2008) it would be highly beneficial for education research to understand how PD students form their SE beliefs in a first place.

As discussed earlier, self-efficacy beliefs are formed from four different factors; mastery experiences, vicarious experiences, social persuasion and physiological and emotional arousals. Mastery experiences are the strongest source of efficacy for the students since those experiences make them to believe on their capabilities to succeed on their study related tasks (Palmer, 2006). Positive experiences of success enhance the level of self-efficacy and experiences of failure act vice versa. However, Bandura (1997) also highlights that the strongest self-efficacy beliefs occur through overcoming problems and challenges and tackling difficult situations. Due to ambiguous nature of NPD projects, these kinds of events are especially interesting in this particular study.

The second most influencing factor in self-efficacy formation of student is vicarious experiences, which can be also referred as social modeling. Especially when students are facing new situations that they have no prior experience about, vicarious experiences play a major role (Green et al, 2008). In PDP course context social modeling may occur in a situation where project teams are comparing their progress to others. However, it is important to understand the tone difference in modeling to performance comparison (Bandura, 1997)). When social modeling, student is relating to potential model by focusing on similarities in capabilities. On the other hand in performance comparison student tends to think how much better or worse he or she is compared to the potential model.

Social persuasion is the third most influencing factor of self-efficacy beliefs of students. Bandura (1997) states that students that are socially persuaded about their skills and capabilities to succeed tend to put more effort on given tasks and can tolerate setbacks more than others. In terms of this study, social persuasion is mainly gained from the sponsoring company, teaching team, project stakeholders and students social environment such as friends and family.

Finally, psychological and emotional arousals affect students' self-efficacy beliefs when strong feelings occur (Bandura, 1977). Such arousals are usually related to emotional states such as excitement, stress and anger. For example, student that feels stressed about exams has lower self-efficacy in exam situations when compared to student that doesn't feel stressed. In project team context, we can imagine a situation where one team member feels always anxious during team meetings. This lowers his or hers self-efficacy in team meeting situations and depending about the generality of his or her own efficacy expectation, the self-efficacy towards the whole project might be affected.

**Entrepreneurial intentions and entrepreneurial self-efficacy**

As said, since it's introduction in 1970's Bandura's theory of self-efficacy has been applied in various fields. Inspired by Kelley brothers, creators of IDEO (famous product design agency), the high relation between self-efficacy and creative confidence in NPD is evident. In addition creative confidence studies, there is another well-studies topic that is relevant for this particular research. A vast amount of research has been carried out to discover the relation of self-efficacy to entrepreneurial behavior and intentions (Bandura et al 2012; Bagheri et al. 2012; Barbosa et al. 2007; Izquierdo et al. 2011; Kautonen et. al., 2009). In context of this research, product development and new venture creation processes are considered to be very similar. Therefore, the topic of entrepreneurial self-efficacy

with its implications is introduced that the study results can be reviewed also from the perspective of entrepreneurship research.

Self-efficacy refers to one's belief of successful performance in occurring challenges and situations. Therefore, self-efficacy plays an important role in the life of an entrepreneur who has or is in process of forming an own business. However, first it is necessary to understand how these beliefs influence one's intentions to become an entrepreneur (Kautonen et. al., 2009). Even though, self-efficacy and it's relation to entrepreneurial intentions has been commonly accepted, the researchers have had a hard time to specify the exact mechanisms on how behavioral changes lead to events that enhance entrepreneurial mindset (Pihie & Bagheri, 2013). In this context entrepreneurial intentions mean one's capability and willingness to start own venture and it consists of organizational and individual factors (Lee et al., 2011). On the other hand, entrepreneurial behavior refers on one's capabilities on recognizing and exploiting discovered opportunities when creating new ventures and products (Bird & Schjoedt 2009). Entrepreneurial intentions can also mean one's cognitive state prior to action in entrepreneurial process and new venture creation (Carsrud & Brännback, 2009). Yet, in this study entrepreneurial mindset means a state of mind where a person sees him- or herself being capable to exploit discovered opportunity that the others see too risky to exploit. Therefore, a person with entrepreneurial mindset tolerates ambiguity and takes carefully calculated risks in potential opportunities that are seen (McGrath and MacMillan, 2000).

Entrepreneurial intentions and the relation to self-efficacy have been already studied vastly for few decades. After the release of Bandura's socio-cognitive theory self-efficacy was applied for management studies by Gist (1987). This event turned a new page in entrepreneurship research leading to application of psychological themes e.g. in fields educational-, organizational- and behavioral studies (Bird, 1988; Gartner, 1988; Scherer et al., 1991). This was the true start of the interdisciplinary discussion on the field of entrepreneurship. Also relevant for

this current study of PDP teams and finding the relationship between entrepreneurship and the new product developers, the key was the aptitude of Bandura's "modeling" concept to entrepreneurial career choice. Bird (1989) discovered that child's entrepreneurial career expectancy that was later on named as "entrepreneurial intentions" was highly depended about modeling of family, peers and the environment. This finding guided the entrepreneurship researchers to focus on one's psychological capabilities of becoming entrepreneurs that led to introduction of entrepreneurial self-efficacy. One of most influential studies at that time was done by Boyd & Vozikis (1994). They developed entrepreneurial self-efficacy –scale or as it was called "ESE". This scale played the central role on understanding one's capability and competence on turning failures to positive learning experience. This kind of thinking is still thought as one of the core competences of an entrepreneur and highly promoted in learning environments such as Stanford d.school and Aalto Design Factory (Graham, 2014).

It can be said that there is two main reasons that act as the main drivers for today's entrepreneurship research. The most obvious reason is to generate more entrepreneurs to this world because entrepreneurship is shown to have positive affect on economics. Second reason is that the entrepreneurship researchers haven't so far been able to identify specific personality features that could differ them from the others. Therefore, entrepreneurship research is nowadays vastly focusing on psychological aspects of entrepreneurial mind including its affect on one's behavior (Carsrud & Brännback, 2009).

Majority of entrepreneurial self-efficacy research has been using quantitative approach to develop various scales and metrics to measure the level of one's self-efficacy (Chen et al, 1998; Hmieleski & Baron, 2008; Hmieleski & Corbett, 2008). By combining the knowledge gathered from previous research, Chen et al. were able to popularize the study of entrepreneurial self-efficacy as a main requirement for entrepreneurial intentions, which led to common approval of the theory. In Chen et. al., (1998) 26 items were identified to symbolize  the domain of

entrepreneurship and 5 out of those turned out be the main categories. Those five factors are: Innovation, management, financial control, risk taking and marketing. According to this study, by measuring these factors it is possible to differentiate managers from founders but both may have high score in marketing, management and financial control. Therefore, the study concluded factors of innovation and risk taking being the most important things that differ entrepreneurs from the others.

**Conclusions of reviewed literature**

Regardless to used NDP process model, teamwork in product development project provides variety of situations in different project phases that can potentially affect team member's perceived self-efficacy. All the introduced approaches promote the engagement of users and stakeholders to development process (Cross, 2008; Larman et. al., 2010; Ulrich & Eppinger, 1995) Product development projects involve lots of interaction within the team as well as with external parties. Therefore, this kind of project work in University context can be interpreted being more influential than traditional in-class courses since Bandura's socio cognitive theory (1997) claims that self-efficacy beliefs are constructed from; individually experienced successes and failures, vicarious experiences and modeling as well as social persuasion. Consequently, team members perceived self-efficacy can expected being influenced by all of these sources during the project work. According to product development process models, teams are defining an end goal that outlines whether the project was perceived as a success or failure (Ulrich & Eppinger, 1995).

As mentioned earlier, goals are in a central role in formation of self-efficacy beliefs (Bandura, 1997; Schunk, 1991) . Goals are also drivers for motivation to take actions and this way those affect on one's behavior ( Bandura, 1994; Bird & Schjoedt, 2008). Both efficacy expectations and outcome expectations can be seen as drivers of actions in product development teams. More precisely the project

goal sets the level for required performance that is required to achieve desired outcome that in turn is determined by the intention to satisfy users and project sponsor. However, the project work also provides variety of influential experiences that might have a long lasting effect on perceived self-efficacy even though the project success would be experienced being meaningless. Following table 1 concludes some of the suggested advantages and disadvantages that can be achieved through experiences during the project work:

**Table 1- Positive and negative influences of perceived self-efficacy**

| **POSITIVE ASPECTS OF SELF-EFFICACY** |
|---|
| Increased self-efficacy encourages individual to set the outcome expectations higher meaning that also higher level of performance is necessary |
| High level of self-efficacy helps remaining calm and rational even when unexpected problems occur |
| High level of self-efficacy enhances capability and willingness to pursue new ideas |
| Gaining high level of self-efficacy in multiple areas (e.g. sports, career) also increases confidence to succeed in new extents |
| Increased level of self-efficacy doesn't just enhance one's performance level but also generates better mood and comfort in life |
| **NEGATIVE ASPECTS OF SELF-EFFICACY** |
| Failures can lead to decreased self-efficacy resulting increased stress and giving up |
| High self-efficacy doesn't always guarantee successful outcome |
| Distortion in previous experiences and memories can have a negative impact on self-efficacy beliefs |
| Low level of self-efficacy can lead to avoidance behavior meaning prevention of new or difficult tasks |

In addition, self-efficacy is evidently linked to different aspects of entrepreneurship (e.g. Chen et. al., 1998; Hmieleski & Corbett, 2008). Previous studies claim that individuals with high level of self-efficacy are more potential to take actions towards entrepreneurial intentions (Barbosa et. al., 2008). On the other hand, entrepreneurial behavior is determined as one's capability to recognize opportunities and as a capability to take calculated risk to exploit those opportunities to be able to answer market demands (McGrath & MacMillan, 2000). This kind of entrepreneurial thinking is also practiced and promoted along new product development process. Hence, it is noteworthy to reflect the research findings in terms of entrepreneurship to make interpretations whether working in NPD team can enhance ones entrepreneurial capabilities or not.

## 3. EMPIRICIAL RESEARCH

This chapter introduces the process and methods used in this study. First, the research approach and methodological choices are discussed and rationalized including the importance of triangulation. Next, the data collection method and process are explained including the selection of participants and the usage of other material. Then, the process and methods used in data analysis are described. Finally, reliability and validity of the study are discussed.

## Research approach and methodology

Empirical part of this study is conducted by following qualitative single case study approach. As mentioned by Eriksson and Kovalainen (2008), qualitative research is a constantly transforming process, which is challenging to be defined in a way that all researchers would agree on commonly. However, Gronhaug & Ghauri (2005) describe qualitative research process being best suitable for exploring and increasing understanding on events of which very little is known about. When considering the research questions used in this study, it is evident that the topic has a strong research background even though self-efficacy has only rarely been studied as a phenomenon in NPD teams.

Miles & Huberman (1994) claim that qualitative research approach is especially suitable to be used to study a set of daily events on their natural surroundings due to the general richness of the qualitative data. Considering the original research questions, it can be stated that qualitative approach that seeks answers to questions "how" and "what", is more appropriate selection to this study instead of quantitative approach. This is also seconded by Yin's (2009) description of case study, which justifies the approach of this research. Additionally, Yin's (2009) case study inquiry was used to validate the case study method. This three-step Case study inquiry conceptualizes technical characteristics of case study as follows:

a. Case study describes technically distinctive situation in which there will be many more variables of interest than data points.

b. Case study relies on multiple sources of evidence, with data needing to converge in a triangulating fashion.

c. Case study benefits from the prior development of theoretical propositions to guide data collection and analysis.

Referring to Yin's case study inquiry, multiple sources of evidence are needed in qualitative research, which highlights the importance of triangulation. Yin also states that the use of secondary data decreases the chances of misinterpretations. Therefore triangulation indeed plays a central role in case studies (Marschan-Piekkari & Welch, 2005; Yin, 2009) Additionally, Stake (2005) states in his book that using multiple sources of data consolidates creditability of the research in the context of case studies. Usually, vast amounts of textual data exists naturally due to documentation of daily activities such as meeting memos, study notes and workshop materials (Silverman, 2006). Considering these former statements, triangulation has been used to support the primary data and to increase the creditability of this research. Bearing these things in mind, the secondary data sources are reviewed and validated as an own section.

Case studies always involve many levels of analysis and consist of one or multiple cases (Eisenhradt, 1989). Yin (2003) also separates case studies to single and multiple case designs, depending on the context of the research. The number of cases is defined by the tenacities of the study, which is mainly outlined by the used research questions (Fletcher & Plakoyiannaki, 2011) Erikson and Kovalainen (2008) state that single case study aims primarily to discover and understand a certain phenomena or a set of actions in a context, whereas Yin claims that multiple case study approach is relevant to be used in situations where the

research target is not rare but more common phenomenon and the aim is to find general explanations by using inductive approach.

Single case study method was selected to be used in this research due to its suitability for gathered data. More precisely, self-efficacy has rarely been studied as a phenomenon in NPD teams, which qualifies intensive qualitative research approach to be appropriate choice for this study. Aalto Design Factory is running numerous of product development courses out of which PDP was selected as a study case to be further investigated. In this research, three teams are studied to understand how their perceived self-efficacy is influenced during the product development project work over one year. Since the study is carried out in a specific context of a capstone course, a single case study was seen appropriate method to be used. Additionally, since the study concentrates on exploring self-efficacy beliefs in an individual level, generalizations are difficult to be made. This is typical for intensive study that aims to gather specific info around one or few cases oppose to extensive approach that aims to make generalizations from the studied data (Eriksson & Kovalainen, 2008). Consequently, this study aims to explore how people experience same or similar events during the product development project so the project work could be better understood as a self development experience. Therefore, this research can be defined as an *intensive single case study*, which concentrates on discovering individually faced experiences and inspects their occurrence among bigger group of people in the same setting (Gerring, 2004).

**Data collection**

In this study, interviews were used to collect primary data. Ghauri & Gronhaug (2005) underline that an interview enables the interviewee to answer to the proposed questions according to his or hers own beliefs. This method engages students to describe their experiences over the project work. Moreover, interview allows the respondent to describe his or hers perceived feelings related to

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discussed topic (Eskola & Suoranta, 1998). This was especially considered whilst deciding the data collection method selection, since the personal feelings are in the core of this research.

More precisely, interviews were conducted by using semi-structured approach. This approach is especially suitable for studies that aim to answer "what?" and "how?" questions, which was the case in this study (Hirsjärvi & Hurme, 2000). In addition, semi-structured interviews allow the interviewer to ask further clarification from the interviewee to obtain deeper understanding when necessary (Eriksson & Kovalainen, 2008). Literature review was used as a base for interview structure. Relevant topics and issues in terms of self-efficacy were embedded to interview guide in order to engage discussion in indented matters. The used interview outline is attached as Appendix I. Semi-structured interviews allow interviewees to emphasize topics that they find the most relevant. However, pre-determined topics help the interviewer to ensure that all the necessary topics are covered during the interviews. This also increases the reliability of the research results (Eriksson & Kovalainen, 2008).

The three teams and three team members from each of teams were selected by e-mail invitation. Emails were sent to four teams out which three were selected based on availability and interest of the students. Students had to be attending the PDP class 2014-2015 as a part of any project team in order to participate the interviews. Additionally, the students had to be conducting their master's degree in any of the schools of Aalto University.

Secondary data sources were used to increase the reliability of the research. Course lecture material and slides were used to understand better the pedagogical methods used in the course. In addition, interview of Kalevi Ekman (author of PDP-course) was used to understand the indented learning goals of the course. These secondary sources are briefly described in the end of the methodology chapter as an own section.

**Interview process**

During the interview, the participants were given time to explain in more detail topics that they found more important to be discussed. If necessary, complementary questions were made to gain more detailed answers around the topics that were found more insightful for the research. This was done due to fact that the more unstructured the interview is the more perceptive and valuable the data is (Corbin & Strauss, 1998). Since motivation and self-efficacy beliefs have not been studied previously in the context of PDP process the interview frame was structured to explore project phases step by step and to discover events that were most meaningful to interviewees regarding to changes in motivation and enthusiasm. Therefore, the rudimentary requirement for the interviewees was that they were currently in the middle of the last phases of the PDP –course but had not yet completed the course. This was due to the assumption that PDP students might forget the most ambiguous phases of the project after completing the project work. Thus this research, it is presumed that interviewees are more capable of reflecting their project work experiences more accurately before the project ends.

The interviewees were working on three different PDP projects during the semester 2014-2015 and the interviews were conducted approximately two months prior to the deadline of the project. For more precise interview dates see the Table 2 below.

**Table 2- Interview participants**

| Student | Field of Study | Role | Day of interview |
|---------|----------------|------|------------------|

Team1

| Student | Field of Study | Role | Day of interview |
|---------|----------------|------|------------------|
| PM1 | Business Marketing | Project Manager | 13.3.2015 |
| S1 | Industrial Engineering and Management | Team Member | 9.3.2015 |
| S2 | Industrial Engineering and Management | Team Member | 9.3.2015 |

Team2

| Student | Field of Study | Role | Day of interview |
|---------|----------------|------|------------------|
| PM2 | Chemical, Biochemical and Materials Engineering | Project Manager | 14.3.2015 |
| S3 | Mechanical Engineering | Team Member | 15.3.2015 |
| S4 | Mechanical Engineering | Team Member | 17.3.2015 |

Team3

| Student | Field of Study | Role | Day of interview |
|---------|----------------|------|------------------|
| PM3 | Corporate Finance | Project Manager | 23.5.2015 |
| S4 | Mechanical Engineering | Team Member | 16.5.2015 |
| S5 | Business Technology | Team Member | 17.5.2015 |

The project manager and two team members were interviewed in order to gain a comprehensive overview of the project work. During the interviews, the participants were provided with a paper sheet depicting the project timeline (Appendix II). The participants were asked to mark the most remarkable events both good and bad to the sheet. Additionally, the interviewees were asked to visualize different phases of the project in terms of motivation and enthusiasm in order to examine the changes in perceived self-efficacy. This was done also to enhance discussion about these topics; to get better understanding of one's confidence and self-efficacy beliefs towards the project work, its source and how it affects the project progress. The interview guide (Appendix I) was based on three rounds of reflection to discover the most meaningful experiences.

All the interviews were audio recorded and later transcribed word to word. The length of the interviews was between 62 and 86 minutes and on average the length was calculated to be 73 minutes. The amount of the transcribed raw material is 121 pages with font size 12 and default MS word settings. The interview sample consists from both male and female students. To maintain the anonymity of the interviewees in the study, persona pronoun 'he' is used throughout the thesis, when describing the analysis. All the interviewees were fluent in Finnish thus all the presented interview excerpts are translated to English word to word in a way that no names of students or companies have been revealed.

For the most part the interview sessions went smoothly. However, in few cases it took some time before the interviewee was able to relax and answer more precisely to asked questions. However, the most of the interviewees were capable to have a casual discussion even though the interviewer was the PDP course assistant. The goal was to discuss people's personal experiences of product development project through reflection. In this sense the interviews provided valuable material. Interestingly, reflection of ones own experiences has also an important role on one's self-efficacy beliefs. Therefore, it can be stated that the

interviewing experience can be thought as a constructive self evaluation point as mentioned in the literature review chapter (Bandura, 1977).

**Secondary data sources**

When inspecting the secondary data sources, it is relevant to consider the primary purpose that the data was originally gathered for. For instance, the secondary data might not be able to answer the research questions and therefore making interpretations can be challenging (Saunders et al., 2007). However, whereas the suitability of secondary data has to be carefully evaluated fewer resources are needed when compared to primary data (Ghauri & Gronhaug, 2005). Saunders et al. (2007) additionally speak about the importance of understanding the quality of the data. However, as it is important to evaluate the appropriateness of the secondary sources of data but usually it is impossible to influence it directly. Especially, large amounts of textual material can be hard to exploit since it can take overwhelmingly long time to evaluate the quality of the data (Saunders et al., 2007).

In this research, secondary data sources consists of course description, lecture slides & materials, workshop slides & instructions used in PDP course and Design Factory & DFGN annual reports. This material was also available for the PDP students. The material is used to provide better understanding of the environment, in which the study was carried out. Moreover, the material is used in the discussion section to interpret the data in the context of intended learning outcomes of the PDP –course (Appendix III). The secondary data sources can be seen as valid data sources and to promote the triangulation in this study, since those have been originally used to provide information about PDP –course- and Design Factory practices.

Additionally, an access to transcribed interview with prof. Kalevi Ekaman was requested from Erika Rautavaara, who formerly had conducted the interview for

her Master's thesis. The permission to use his interviews was gained from prof. Kalevi Ekman.  This interview provides the educators perspective to the PDP course and it is used in the reflection of results as well as to better understand the pedagogical methods used in the course. . Therefore, it can be seen as an appropriate material for this particular study as well.

**Data analysis**

Data analysis can be defined as "the process of bringing order, structure and meaning to the mass of unstructured data" (Dymon, 2002, p.231). On the other hand, the data needs to be organized through analysis to make meaningful interpretations (O'Leary, 2004). The analysis of this research was carried out by following thematic analysis process presented by Braun & Clarke (2006). Even though this process is followed in the analysis section, the data was examined multiple times and also steps were taken backwards when necessary to construct valid categories.  As suggested by Miles & Huberman (1994), analysis shouldn't be restricted as a linear process but rather thought as a cyclical process. This kind of openness is considered and exploited during the analysis phase. However, the six main steps of thematic analysis suggested by Braun and Clarke have been used as a base in this study. Those six steps are:

1. Familiarizing with the data
2. Generating initial codes
3. Searching themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report

In this study, the mass of  "raw" transcribed data was first split into separate events in chronological order out of which preliminary notes were made (Miles &

Huberman, 1994). The analysis is grounded to Bandura's theory of self-efficacy meaning that the first level breakdown of data was conducted to match with the categories presented by the theory: to mastery experiences, vicarious experiences, social persuasion and physiological and emotional arousals.  Therefore, the preliminary analysis was based on theory-driven coding, which is claimed to be useful especially for testing hypotheses (Schreier, 2012). The criterion used in the first level categorization of data is presented in Table 3.

**Table 3- Criterion for theory-driven coding**

| SOURCE OF SELF - EFFICACY | DEFINITION | EXERPT |
|---|---|---|
| Mastery experience | • Experiences of success or failure<br><br>• Definition of success or failure that doesn't base on comparisons | "…The day that we built our first prototypes was super much fun! I would have never believed being capable of doing something like that!…" |
| Vicarious experience | • Comparison of oneself to another(s)<br><br>• Modeling behavior | "…During the halfway presentations I realized that we actually proceeding pretty well comparing to other projects…" |
| Social persuasion | • Verbal or non-verbal feedback from another person or group | "…Discussion with the sales manager of the company made me confident that we were on a right track with our project…" |
| Physiological & emotional arousals | • Physiological or emotional reaction to an experiences | "…I feel frustrated when people come late to our meetings and we have to start all over again from the beginning. It even makes me angry…" |

Pattern coding (Miles & Huberman, 1987) was conducted to construct categories around the reported phenomena. These categories were later organized into themes depending on how the self-efficacy source was experienced and how the

interviewee had described its influence to his or hers confidence. After the coding and generation of categories phases, linkages and relations within the data were reviewed. This can be thought as a core of the research since this phase reveals the most meaningful outcomes (Hirsjärvi & Hurme, 2008).

Several themes were formed under each source of self-efficacy. Those themes are analyzed separately and clarified with interview excerpts. However, the research data showed that the emotional and psychological responses were always related to the other sources of self-efficacy. Therefore, findings from that theme are presented within the analysis of other sources but also individually by few examples.

## Validity and reliability

The quality of research is often determined by two concepts; reliability and validity. These two concepts base on questioning researcher's capability to objectively provide understanding of the particular research topic and those are traditionally used to measure the quality of results (Eriksson & Kovalainen, 2008). On the other hand, when interviews are used as a data source, the quality of research should be measured through the whole process from data collection to processing of gathered material (Eriksson & Kovalainen, 2008).

According to Hirsjärvi & Hurme (2006), validity of the study can be claimed to be good once the correct questions are asked from right persons in a way that collected data can be used to respond the purpose of the research. Therefore, validity can be said to measure the suitability of the research strategy. A single case study often aims to answer to the questions "How?" or "why?" However, Yin (2009) argues that single case study can be also used to answer to the question "What?" when the goal is to engage in explanatory research. Relating to this, a

single case study can be qualified as a correct approach for this study and as a valid way to carry out the research.

The reliability in the context of qualitative research measures trustworthiness, usefulness, coherence and consistence of the study (Eriksson & Kovalainen, 2008; Hirsjärvi & Hurme, 2006; Yin, 2009). Reliability can be said to be good if similar conclusions could be made when repeating the study (Hirsjärvi & Hurme, 2006). However, this definition is more applicable for quantitative research (Hirsjärvi & Hurme, 2006). In qualitative research, reliability of the study can be enhanced by documenting the research process carefully (Eriksson & Kovalainen, 2008). This kind of transparency enables the reader to follow researcher's thinking process throughout the study. The documentation should describe the reasoning behind the decisions made during the research as well as the reasoning of interpretations to enhance trustworthiness (Eriksson & Kovalainen, 2008). Suggested by Yin (2009), the case study protocol was used in order to increase the reliability of the study. In addition, the prior research on self-efficacy was carefully examined and used in the generation of the interview guide (Hirsjärvi & Hurme, 2006). Additionally, it is important that the sample size is appropriate and correct topics would be covered in all of the semi-structured interviews (Hirsjärvi & Hurme, 2006). To ensure that the gathered data would be objective, three teams were interviewed for this study.

To strengthen the reliability of this study, personal interpretation and experiences of the researcher will be considered in the analysis part based on former expertise of PDP –class and by triangulation with related course material. The interviews have been carried out at the Aalto Design Factory, the data has been handled confidentially and without changing any of the information. To enhance the reliability, the recorded interviews were transcribed word-to-word after the interviews (Silverman, 2006). Furthermore, same interview guide was used in all of the conducted interviews and the research procedures were documented throughout the process (Yin, 2009). The reliability of the research can be claimed

to be good since the desired information was successfully gathered by semi structured interviews and since it was possible to answer the research question with the collected data. (Eriksson & Kovalainen, 2009).

## 4. PRODUCT DEVELOPMENT PROJECT –COURSE AS A CASE STUDY

This chapter introduces the Product Development Project –course as a case used in this study. The chapter starts by presenting pedagogical principles used in the PDP–course as well as the course schedule to provide basic understanding around the context of this study. However, it should be noted that the provided course schedule includes only the activities organized by the teaching team and the teams themselves have done the project scheduling for the most part.

### Pedagogical principles of PDP -course

PDP, the Product Development Project, is an interdisciplinary product development course primarily targeted for master's level students from any academic field. During the course, student teams tackle product design problems set by sponsoring industry partners. In addition, teams also include 1 to 4 students that are located in partner universities aboard. Methods used in the course are mainly based on Steven Eppinger's "Product design and development" –book.

"PDP is aimed at students interested in developing new products, solutions or consumer goods. The problems are given and sponsored by both domestic and foreign industrial companies, who are searching for innovative cooperation with next generation of product developers. Over the recent years students have also pursued their own projects and startup ideas in PDP." (ADF Annual Report, 2015, p.21)

PDP-course follows Problem-Based Learning (PBL) philosophy. Thus, the teaching team is considered more as mentors that facilitate the process and learning environment for the student teams (Fry et. al., 2003). Consequently, teamwork is an essential part of learning experience and problems never come with direct

solutions. PBL method utilizes individual's capability of restoration of data, processing of information and the organization of a semantic network. It is stated that problem based learning develops students' self-direction, meaning proactive search of solutions set problems, and also enhances general readiness to working life (Boud & Feletti, 1997). Throughout the learning process, students have to evaluate not just their own but also the work of the fellow students. This kind of reflection of progress and performance is in in fact the key element for learning by doing (Boud & Feletti, 1997).

**PDP –course schedule**

PDP–course lasts the whole academic year meaning about 9 months and the students gain 10 ETCS credits for when successfully passing it. The following table 4 illustrates the overall schedule of PDP project during the academic semester autumn 2014 and spring 2015 when the interviews for this research were conducted.  The schedule is gathered from PDP course materials presented in Noppa (Aalto University course management system) and PDP.fi course website

**Table 4- PDP -course schedule 2014-2015**

| | LECTURES & MENTORING | | PRESENTATIONS | DEADLINES | TRAININGS & WORKSHOPS |
|---|---|---|---|---|---|
| **SEP.** | Lecture 1<br>Lecture 2<br>Lecture 3<br>Lecture 4 | | | Design Brief DL | Project Manager training I |
| **OCT.** | Lecture 5<br><br>Lecture 6<br>Lecture 7 | CPM #1 | | Project Plan DL | PD6 Workshop<br>Basics of Creativity Techniques workshop<br>DF Safety Training<br>Economy officers training |
| **NOV.** | | CPM #2 | | | PM Power Punch workshop<br>Facilitated feedback sessions<br>Crash course in electronics |
| **DEC.** | | CPM #3 | | | Performance training 1 |
| **JAN.** | | | PDP Halfway Show | | Performance training 2 |
| **FEB.** | | CPM #4 | | | Project Manager training 2 |
| **MAR.** | | CPM #5 | | Team promotion material DL<br><br>Patent application DL | |
| **APR.** | | CPM #6 | | | Performance training 3<br><br>Performance training 4 |
| **MAY** | | | Product Design Gala 2015 | Team poster DL<br><br>Project Documentation DL | |

The course is based on self-organized teamwork. Throughout the product development process, the project teams are given certain tasks that they have to accomplish by given deadlines. However, during the autumn semester lectures are held for all students and also throughout the whole course the project process is evaluated every month in meetings where the team and teaching team discuss the current progress and problems issues. Sometimes the sponsor is participating these meetings as well. Additionally, wide range different kind of workshops and supporting events are organized to enhance the teamwork during the project. Below the most critical events are described in more detail.

*Lectures & mentoring*

Teaching period of the PDP–course lasts from the beginning of September till the end of October and it includes 7 lectures covering topics from various aspects of product development and interdisciplinary teamwork. During the lectures also the sponsor companies are introduced. Students form the project teams themselves, including finding the most suitable project for the gathered team. Persons that are willing to act as project managers pitch themselves during the team formation lecture to gain interest of other students. The only restriction in team formation is that all the teams should have 8-10 local members (plus remote sub team of 1-4 members) and each of the team has to have a designer and a business enthusiast. Other than that the students have total freedom in team forming. After this the student team meet the representatives of each sponsoring companies. Based on the discussions with different sponsors students make a wish list of the most appealing companies and also the one's that they are less keen to work for. Additionally, the companies deliver a wish list of the most potential teams from their point of view. In the end, the PDP teaching team matches the sponsors and teams regarding to delivered wish lists.

Once the introduction to product development including the team formation and sponsor matching is done, the lectures are used for providing knowledge about the project work. Former projects are presented as sample cases to provide practical examples about successful projects and what kind of obstacles and issues may occur along the way. Different phases of the projects are introduced for the teams but unlike many other courses, no direct solutions are provided since in PBL is very difficult give right or wrong ways of doing things (Fry et. al., 2003). The learning's are gained trough the variety of different kinds of experiences. Even though the course enable students work for the projects that are almost identical for the real life projects, the actions still happen in university environment. According to PBL philosophy, it can be said that whether the reflection happens through a positive or negative experience and leads for an experience, something has gone right (Fry et. al., 2003).

Once the lecture period is over the teams start following their project plans. Also, the interaction with teaching team decreases towards the end of the project. However, once a month teams are presenting their progress for the teaching team in checkpoint meetings (CPM). In the CPMs project progress is evaluated. The teaching team advises and helps the students among others in cases of issues or challenges in the progress. Checkpoint meetings are organized all together 6 times and each of those have different agenda. Also the sponsoring company is present in one of the CPMs and the last meetings are mostly organized to plan necessary practicalities to finalizing products so those get ready before the Gala day that is the end date for the projects.

*Presentations*

Student teams are presenting their current progress and product vision for the fellow teams in the beginning of January straight after the winter holidays. This is also the first time when all the students are physically in same place after the

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lecture period. The course climaxes to the Product Design Gala that is organized always in the end of course. During the two day Gala event the teams are presenting their final prototypes and solutions for the audience. Gala is much like an exhibition where products are visible and often testable in team stands. Additionally, media representatives and visitors are invited to the event to acquire more visibility for the projects.

*Deadlines*

Even though the project teams are self-scheduling their process, the course staff has set certain deadlines and tasks that they have to meet during the course. The tasks are given straight in the beginning of the project and the deadlines are visible in the course website for the teams. The deliverables naturally affect the project evaluation but still the teams are told from the beginning that the tasks are not done to satisfy the teaching team but actually to enhance their project learning and results.

First task for the freshly formed teams is to reform the design briefs given by the sponsoring companies. Like mentioned, the companies are asked to deliver visual one page design brief where they introduce the company as well as the occurring design problem to be solved. Ideally the problems are vague and open-ended which usually makes them difficult to understand. Therefore, it is important that the teams sit down with their sponsors and discuss the issues behind the problem. Before starting actual teamwork project team reformulates the design brief into a more sense making form so they can start working on it.

Once the design brief is reformed the next task is to make a first draft of the project plan for the year. No certain criteria are given for the teams so they are free to make a plan in a way that helps them the most. Team specific project plans are gone trough together with the teaching team in the first checkpoint meeting, and

even though no official evaluation is done, the teams are advised to make changes or otherwise enhance their project plans when necessary. As said, this is only the first version of the project plan and the teams are encouraged to update it along the project so it helps them out the most. Project plan is also a great way to reflect the process on the go to see if they are behind or ahead of the schedule.

Teams continue working based on their project plans and process is checked along the way in checkpoint meetings on a monthly basis. Over the spring the deliverables are mostly concerning different kinds of promotional material that is required for the marketing of the Product Design Gala and so the product is manufactured and demonstrated in a best possible way. Project teams also are asked to deliver a final documentation that covers their product development process and description of the final product meaning the story of how did they got there. Like the other deliverables, also the final documentation doesn't have specific criteria from the university side. Documentation is good when it satisfies the sponsor's needs. Additionally, the documentation is used as a part of the course evaluation.

*Trainings and workshops*

Although the lectures are organized only during September and October, different kinds of workshops are organized for the PDP students along the way. Different kinds of tools and methods are provided for project managers in a PM training Saturdays once in autumn and once in spring period. Depending about the given role in the team also team members are expected to participate the certain workshops and trainings.

Each team nominates an economy officer who takes care of the financials and book keeping during the project. In the economy training, these officers are taught how different costs can be claimed back from the project budget. Additionally they are

explained, which kind of costs can be claimed and which kinds of transactions cannot be done within the course circumstances.

Additionally, each team is required to nominate a safety officer that takes part in the safety training organized by the DF personnel. In the training the officers will learn the methods of safe working in DF including, different spaces, tools and machinery. Once the training is held, the officers are asked to share their knowledge to fellow team members.

One of the most important workshops organized from the course side is the PD6 workshop that acts as a kick-start for the project work. PD6 means "product development in 6 hours" and as Kalevi Ekman, the professor of machine design and the main author of PDP –course, describes it: the workshop is designed for learning by simulating the product design process in short time and it fits for novices and experts and it is not depending on the level of expertise. The basic idea of the workshop is that the project teams go trough the whole product development process together with their sponsor and produce the first rough or probable prototype or demonstration as a solution for the given design brief.

On top of the workshops mentioned above, variety of other trainings such as "basics of creativity techniques", "performance training", and "the crash course in embedded electronics" are provided for the students to increase their knowledge in such fields. Additionally, Facilitated Feedback sessions are provided to each team to maintain team dynamics and to enhance the teamworking ability through better communication. Facilitated feedback session uses "I like I wish" method was developed by Satu Rekonen (Industrial Management Researcher in Aalto University) inspired by methods used in d.school of Stanford University to avoid misassumptions within the project team.

"Team members should have the ability to provide feedback to each other. Without feedback people might not know whether they are doing things right or doing the

right things. The risk is that the team's behavior starts to build on assumptions. If assumptions are never spoken aloud, efforts may be focused and energy spent on things that never existed in the first place." (ilikeiwish.org, 2014)

Regarding to student reaction, facilitate feedback sessions have been commonly loved method to be used to improve team communication and the sessions have been organized in PDP -course since 2010 (ilikeiwish.org, 2014)

**5. CHANGES IN SELF-EFFICACY DURING THE COURSE**

Interview results cover the analysis of nine interviews that were carried out with three different product development teams of PDP class 2014-2015. The analysis describes how self-efficacy beliefs of the interviewees were influenced over the project work in the class. The aim was to find similarities as well as differences on how the experiences were perceived. Additionally, experience related emotions as well as interactions are examined to get better understanding of their role in situations were self-efficacy beliefs are influences. First, the analysis describes how the students perceive self-efficacy prior the start of the course. Later each theme under four sources of self-efficacy is discussed. However, psychological and emotional arousals will be discussed when those occur due to direct linkage to other sources of self-efficacy.

**Prior to beginning of the course**

Even though, this research was designed to explore how students self-efficacy beliefs are influenced over product development projects, the data was also capable of showing examples of how interviewees constructed their confidence prior to start of the course. Students reported positive experiences strengthening their confidence and capability to participate and succeed in PDP project. Those experiences fell in to themes of former *mastery experiences*, *direct feedback* and *vicarious experiences of performance comparison*.

Based on the data former *mastery experiences* were related to experiences of success in university environment or former work experiences. University related experiences covered both former course work as well as extra curricular activities such as international company excursions. However, most of the students seemed to base their efficacy-belief to experiences of former students that had completed

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the course. None of the reported experiences were seen as a negative. For example, students were reporting that they had gained confidence after discussing the project work experiences with course alumni:

*"…Two friends of mine participated this course last year. I had heard about it but I wasn't sure if would be capable to commit for such an intensive project. In the end, those two friends encouraged me to participate the course and here we are now…"*
  - *Project Manager 1*

This kind of direct feedback clearly has a huge influence on students' confidence of success prior the course. Nevertheless, capability comparisons can be seen at least as an influential source to self-efficacy beliefs in this study. The data also shows how some of the students were comparing their capability to succeed during the project to the experiences they heard from the alumni. In these cases self-efficacy beliefs are not based on verbal encouragement but rather to comparison of skills. As an extreme case some students reported that PDP –course was the only reason why they had applied to product development minor as a part of their degree:

*"…I had understood that PDP couldn't be included to my studies. Last spring I heard that one student had participated the course. He had just gone to the first lecture and that way got involved to one of the projects. I was wondering that if students from my study program are welcome to the course I want to make it officially part of my studies. After a little research and few discussions I got product development officially applied as minor in my studies just so I could participate this particular course…"*
  - *Team member 6*

These findings together consolidated the fact that most of the students were highly motivated to participate PDP already prior the start of the course. The confidence to success in most of the cases was based on discussions or stories told by course

alumni. Secondly, former success in university studies or extracurricular activities had a positive influence in construct of self-efficacy beliefs prior the course. However, it is necessary to remember that PDP course is mandatory for master students of mechanical engineering program covering roughly half of the class. Few interviewees were studying mechanical engineering as their major. These students based theri confidence of success to the fact that the course was mandatory for them and they also saw former work experience as positively influencing factor for belief of success in project work.

**Mastery experiences**

Analysis of interview data revealed vast amount of different events where students described their self-efficacy beliefs being influenced by mastery experiences over the project work. These events can be divided to *soft* or *hard skill mastery* experiences that were faced *individually* or *collectively* as a team. Since this study focuses on exploring how self-efficacy beliefs are influenced in an individual level the collective mastery experiences will be analyzed from interviewed person's perspective. It is also worthy to mention that mastery experiences were the most discussed source of self-efficacy with the interview participants.

*Soft skill mastery*

Interview data clearly stated that all the interviewed students had faced situations where their perceived self-efficacy had been influenced by soft skill mastery. Soft skills in this context can be seen as different kinds of interaction and teamworking skills required in product development teams. Three categories clearly stood out; *external communication, time management* and *project management.*

The first category, *external communication*, covers reported events of success or failure related to communication around the project with people outside the project team. All students described numerous events of this kind and both positive and negative influences on self-efficacy came up from the data. When thinking about the confidence towards the success of the projects that the interviewed students were working on, a strong influence to self-efficacy seemed to be gained from interaction with potential users and project stakeholders. Interestingly this kind of events also seemed to have long lasting effect on self-efficacy since students often described how their projects had been proceeding more fluently after such experiences. For example one student told about his successful mastery experience when interviewing a project stakeholder in a following way:

*"…We had managed to organize an interview with a potential user of our product that I was supposed to conduct. During the interview I felt relieved when I realized that we had actually been considering real problems of user. Suddenly I realized that I essentially have already pretty good understanding of our topic! The interview resulted approval to our proposed concepts and enabled us to take next steps towards to final design of our product…"*
- *Team member 5*

Additionally, mastering storytelling and presentation skills were mentioned as a key to external communication. Unlike in previous excerpt, positive influence on self-efficacy was also gained trough interaction with people that had nothing to do with the whole project. However, this kind of positive influence did not seem to be as long lasting as the influence of interaction with project stakeholders even to though the emotional response would be strong. Good example of this can be seen in excerpt where student tells about his mastery experience of storytelling when he got to meet the King of Sweden:

*"…In the beginning of the PDP course we were told that during the year we would learn to tell about our projects. At that time, I couldn't imagine that within two months I would have a chance to present our project to King of Sweden! It was like wow… we must have been doing something kind of cool for real since I got this chance to meet the King. It really boosted my feelings and motivation towards our project…"*

- *Team member 4*

On the other hand, interview data includes various examples where students describe negative mastery experience where they feel that they have failed. Interviewees described that they had had difficulties or failed with *time management* at some point during the project. Negative experience with time management also seemed to be much more influential than a positive experiences. Problems with time management were in many cases based on the feeling of failing to contribute to the project work. In the end, most of the students are conducting multiple other courses on top of the PDP class. Negative experiences of time management were directly linked to increased feeling of stress and incompetence, which can be seen as physiological responses. As an extreme case one of the students reported that he had faced burnout since he had had difficulties to share time between project work, other courses and personal life:

*"…Before Christmas my stress started to turn into a minor burnout. There just didn't seem to be time to do everything, which felt overwhelming. I just had to start prioritizing tasks and of course it felt bad not to be able to contribute to this project so much anymore…"*

- *Team member 2*

Last category under soft skill mastery is experiences related to *project management.* Obviously these experiences mainly occurred in the interview data of project managers but also few team members reported their self-efficacy beliefs being influenced by the project management experiences related to management

of divided sub teams or remote teams. Where project managers described various influential project management experiences throughout the year, team members' project management experiences only occurred in the later phases of the project. The strongest influence to self-efficacy beliefs was gained in situations where responsibility was shared with other team member(s) as a result of trust. In contrary, lack of trust in some cases damaged badly project managers self-efficacy. Sometimes, project managers also seemed to base their management skills on assumptions. Especially negative assumption can cause stress and uncertainty. One project manager describes negative project management event as follows:

*"...Then one of our team members disappeared. I don't know what happened and no one was able to contact him. Few weeks later one team member had seen him briefly at campus and he told not being able to continue anymore. I kinda felt bad... what had gone wrong... could this have been prevented somehow..."*
- *Project Manager 2*

In this situation project manager was reflecting his management skills and felt responsible of the disappeared team member. Even though there was no clear reason why the team member had decided to quit the project, manager's self-efficacy belief was negatively influenced as a result.

### *Collective soft skill mastery*

It became clear that mastery experiences should be separated to individually experienced events and situations where individual's self-efficacy belief was influenced by a collective experience. In context of this research, this kind of influence of collective experiences was always rooted to interviewee's own team. When looking into collective soft skill mastery experiences, two categories stood out from data: *teamwork* and *team dynamics.*

First theme, *teamwork*, consists of topics related to *creativity, activeness* and team *performance*. Clearly, physical presence and "hackathon-style" of intense working seemed to have the strongest influence on perceived self-efficacy since all the interviewees reported such an experience. In most of the cases that were describing active and creative teamwork, PD6 workshop was quoted as a unifying and collective experience where the projects got kick started and the students realized their potential capability by working together for the project for a whole day as a team. This type of teamwork was seen as enhancing factor for team performance. One interviewee defined his PD6 experience in the following way:

*"…PD6 is the most memorable day in our project so far! Best thing was being together as a team since also the remotes were able to participate. It also increased my confidence on our project. Everybody was super motivated and working really hard for that day. That kind of efficient and positive sprit was "contagious" and I think our team hasn't been that effective ever since. It would be difficult to exceed that performance…"*
- *Team member 2*

Interestingly, other interviewees reported similar experience on "contagious spirit". Especially when referring to the PD6 workshop the self-efficacy beliefs seemed to be influenced the most when the student did not have any expectations about the workshop beforehand. At the later phases of the projects, interviewees were also looking back to that workshop and comparing their current performance to that prior experience. When looking at the interview data of one particular team, the influence of the PD6 workshop seemed to be so strong that they were purposely trying to mimic it to increase the performance and team spirit during the concept evaluation and selection phase that they found difficult.

Closely related to teamwork and performance, *team dynamics* were described as an influential factor for perceived self-efficacy. In this case, team dynamics refers to internal communication and team building related experiences. Obviously, when

team dynamics were perceived well established also the team members felt more confident within the team. However, good team dynamics seemed to be often taken as a given and therefore bad group dynamics have much stronger influence to team members. Either way the influence lasts throughout the project so team dynamics can be seen as a one of the most vital sources for the whole teams motivation through their belief of capability to succeed. Following excerpt illustrates an example of a negative influence of bad team dynamics in the last phases of the project:

*"I don't think we have done any teambuilding as a team. That's lacking from us. I haven't even seen one of our team members more than twice. I think people don't realize or even know what should be done now. I mean we have the core teamworking for the final prototype but if we cannot get the whole team activated the responsibility will be divided only between three of us and that's goanna be stressful. I don't wanna get ashamed at Gala but I'm not sure if we can succeed if we continue working this way..."*

- *Team member 1*

As seen in this example, team dynamics are often directly linked to team communication. On the other hand this excerpt could be categorized as a comparison of performance since the interviewee is feeling that their team performs worse than other teams. However, it seems that the lack of communication decreases awareness of project progress and this reduces team member's ownership towards the project. Through team building and active communication that ownership can be increased resulting as better motivation and perceived self-efficacy towards the project.

### *Hard skill mastery*

Opposite to soft skills, *hard skills* are more specific technical capabilities. Most interviewees described a situation where mastering a hard skill had been influencing his self-efficacy beliefs in terms of the project. In all of the described situations, hard skills mastery was always related to prototyping, which can be seen pretty obvious to product development process. Additionally, it is not too surprising that students' self-efficacy beliefs were positively influenced in situations where they were able to utilize hard skills that they already mastered. More interestingly, some cases showed strong influence to self-efficacy beliefs being assessed in situations where new hard skill was exploited even though the result wouldn't have fulfilled the expectations. In other words, none of the interviewees can be interpreted having experienced a decrease in self-efficacy due failure in prototyping. In case of failure rather positive effect seem to be gained when turning failure into positive learning experience. Those cases especially reflect resilience and growth mindset. As an example one student describes his prototyping experience in a following way:

*"...I am just super happy about our quick 'n' dirty prototype that I built taking into account the fact that I didn't have any required skills once we got the idea. It looks ugly and it is not close to anything that I would have hoped but I am just so happy that it actually works!.."*
- *Team member 4*

Data shows that perceived growth mindset that occurs when students speak about prototyping has direct linkages to course surroundings including, Design Factory personnel, related course work and the Design Factory space itself. Those experiences are viewed under the social persuasion theme.

### Collective hard skill mastery

Just like on an individual level, collative hard skill mastery was in most of the cases related to mastery experiences in prototyping. Yet, in a collective level only few students reported that their self-efficacy beliefs had been influenced by hard skill mastery. In none of these cases specific skills were described. Collective hard skill mastery was rather seen as an exciting and motivation boosting activity that increased team spirit and unity. For example, once one of the teams started building an exhibition platform for their final concept the team members started proactively utilizing their skills so that the best possible outcome could be achieved. One team member described this as follows:

*"...My motivation got totally re-boosted once we started building! Everybody was present in project after a long time. That raised at least my spirit and it felt actually really good to work together even over long nights..."*
- *Team member 4*

Collective hard skill experiences were always described having a positive influence to self-efficacy beliefs on an individual level. On the other hand, prototyping and tangible results can be clearly seen as a good source for collective motivation and perceived self-efficacy but these experiences are not usually easily generated. To determine this difficulty, one project manager was describing that his team was facing feelings of uncertainty during the concept generation phase. He assumed that this uncertainty could have been removed with collective prototyping experience but since they did not have clear direction for the concept they did not dare to start prototyping. However, right after he reflected that the team later had realized best opportunities being identified by prototyping.

**Vicarious experiences**

This source of self-efficacy consist of situations where students where comparing themselves to others in terms of *capability, attitude* and *performance.* As said, the experiences of course alumni were in few cases used as a basis of self-efficacy prior the start of the course. However, comparisons were made mostly within the own team as well as to other teams over the project work.

*Comparison of capability*

The first theme consists of experiences related to *comparisons of capability.* In context of this research, capability is related to comparison of *professional skills* and comparisons of different kinds of *working methods* used in a project team. These comparisons were in most cases made within the project team and had mainly positive influence to self-efficacy beliefs. However, the strength of the influence was defined mostly low. For instance, one interviewee described that he had felt increased confidence on concept ideation when the designer of the team had made a well-detailed sketch out of the concept that he had proposed. In fact, all the interviewed teams reported increased motivation and confidence gained trough visualization of concepts. In these cases drawing and 3D modeling skills of fellow team members had a positive influence on perceived self-efficacy. Additionally, interview data reveled two cases where capability was compared to assumed outcome expectations of the sponsoring company or the sponsor representative itself. In both of these cases self-efficacy beliefs were damaged by personal assumptions and the strength of the experience is seemingly high. For example, unexpectedly the sponsor representative of one team stopped working for the company and therefore could not help the student team anymore. One team member made assumptions around this event as described below:

*"…I'm not surprised that he (the sponsor representative) quit working for the company. I found his product designs cool but those never went to manufacturing. If you are an industrial designer, that must be frustrating. How could we ever design anything meaningful if even he couldn't do it?.."*

- *Team member 1*

In this example, the team member was comparing his and the whole teams capability to succeed with the project to the assumption that the sponsor representative had stopped working for the sponsoring company due to lack of appreciation. However, other team members of the same team had very different viewpoints on this same event. Therefore, self-efficacy beliefs of this quoted team member might not have been negatively influenced by performance comparison if he would have known the true reason why the sponsor representative stopped working for the company. For instance, project manager of the team experienced this same event as a positive impact on his self-efficacy beliefs since he had totally different aspect to it:

*"…The company has now outsourced product design for an external design agency. Our sponsor contact used to be the only designer in the company but through outsourcing the company has much more recourses in hand. I believe we have been able to provide better understanding about the value of the design and that feels just awesome! We are really doing something meaningful for the company!.."*

- *Project manager 1*

As seen in the previous quotes the perception of the same event can be totally opposite for different people. Although, the team member in this case was comparing his capability to skills of a sponsor contact and the project manager was experiencing the event as a mastery of project management.

### *Comparison of attitude*

Second theme, comparison of attitude, contains experiences where students were comparing themselves in terms of *commitment activity* and *contribution* and towards the project. These situations were reported occurring solely within the team and had both positive and negative influence on perceived self-efficacy. Based on the data, comparisons of attitude were the most linked theme to emotional physiological responses. For instance, one student was experiencing a low commitment within the team as follows:

*"…I got super frustrated because some team members got late to our meeting and we had to brief them about our current progress. How can we ever manage to complete our project if people don't even bother to read meeting memos!.."*
- *Team member 1*

In this case, low commitment and activity of the fellow team members could be seen as frustrating and a stressful experience. It seems that the team member did not feel any sympathy towards inactive team members. On the other hand, proactive contribution had a totally opposite effect like one of the managers described:

*"…It was huge relief and help for me that one of our team members started taking care of communication with our remote team. I was super stressed since I sometimes felt that I had been lacking on communicating with them. Now I don't have to be worried and I also started feeling that people really care about our project…"*
- *Project Manager 3*

Therefore, it is clear that the attitude of the project team has notable influence on perceived self-efficacy on an individual level. As it can be interpreted from the excerpt even small things can have positive impact for team members as well as for the whole project. Sympathy has a notable role also in this experience.

Basically, feelings of sympathy seem to have positive influence on team dynamics resulting as enhanced self-efficacy. However, sympathy could be categorized as a soft skill experience.


### *Comparison of performance*

The last theme under vicarious experiences, *comparison of performance,* includes situations where students were comparing their project work performance to other teams or to the course schedule. Therefore, the categories in this theme are linked to descriptions of *progress, speed, amount of work* and *delivered results.* These kinds of comparisons had the lowest influence on self-efficacy beliefs on an individual level. On the other hand, comparisons of performance seem to generate minor but constant stress that motivated teams to aim for better project performance. Therefore, comparisons of performance can be interpreted having a bigger influence on team level rather than on individual level. Interviewees described comparison of performance and its influence experienced in halfway presentations. One of the project managers described his motivation being enhanced in a following way:

*"…I guess I wasn't the only one who realized how big deal this course is when I saw the presentations at halfway show. I understood that this is not easy for anyone. In the end, we will all learn from this experience. Being frank, everybody seemed to be more or less lost still so we shouldn't just give up the project now…"*
- *Project manager 1*

More interestingly many interviewees were comparing their own team's performance to other teams in terms of difficulty of design brief. In all of these cases own project was always seen more complex and demanding than others'. Knowledge gained around own design brief was seen as limiting factor for concept design rather than as an achievement. Therefore, mastery of given design brief was

experienced having a slightly negative influence to self-efficacy. This kind of comparison is demonstrated in excerpt below:

*"…We have so many aspects that should be considered in our concept. If thinking about others, their design briefs often clearly state one path to be followed. We have to explore several directions, and if we cannot fulfill all the discovered requirements, does it make our project unsuccessful? It makes wonder how should we proceed…"*
  - *Team member 6*

In terms of these cases, team members seemed to undervalue the work and research that team had carried out around their topic. Gained knowledge obviously sets certain criteria for the projects but this was rarely seen as a positive thing even if the benchmarking and research would have been properly done.

**Social persuasion**

Social persuasion, as a source of self-efficacy, was divided in the analysis to three different themes; *direct feedback, indirect feedback and lack of feedback.* Direct feedback refers to situations where self-efficacy beliefs are influenced by direct *verbal encouragement* or *criticism* whereas indirect feedback refers to non-verbal influence such as *body language* and *behavior*. Additionally third theme was generated from experiences where interviewees were wishing for more feedback or felt that they were not receiving any feedback at all. In context of this research, peers, stakeholders, and university personnel were seen as main sources of persuasion.

***Direct feedback***

Out of the three themes under social persuasion, the influence of direct feedback was the most discussed topic among the interviewees. More precisely the feedback from sponsor contact and project stakeholders, meaning the potential users and customers, were mainly reviewed in interviews. Unexpectedly social persuasion in many cases seemed to be the driving force for the perceived self-efficacy due to its direct link to project progress both on a team level and on an individual level. Like mentioned before, influence of feedback given by sponsor contact was vastly discussed and it had both positive and negative effects in the long run. For instance, when teams received feedback about the concepts they had generated it always helped them to proceed with their project. However, even critical and negative feedback was in the end considered to have a positive effect but these cases required resilience and growth mindset. This kind of situation was well reported by all three interviewees in one team. In a following quote, one team member describes such a situation where he was presenting project progress for the sponsor right before the end of the autumn term:

*"...I think it (meeting the project sponsor at CPM3) was one of the turning points for the whole project! Our sponsor contact really woke us up by criticizing our results that we had at that point. It first felt like he was really questioning our competence to succeed. On the other hand, that push made as really motivated to proceed to the next phase and start working on our prototypes. Luckily we still had the holidays to digest all that feedback..."*
- *Team member 5*

The data shows that all the students were reporting an event where they were having difficulties to proceed with their projects due to uncertainty around their concepts. In these situations interaction with sponsor contact and stakeholders seemed to be the solution to either proceed or change direction. Many interviewees were describing that in those situations they were lacking a

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"confirmation" or "appreciation" that would have been necessary so they could proceed. If this confirmation was gained it was described having a positive influence on confidence towards the project ant therefore also to perceived self-efficacy.

In addition to direct feedback among the people involved to the project, at least one person from each team was reporting their self-efficacy beliefs being influenced by the support from the university personnel. Research data showed that students were positively surprised by the easiness of finding technical support from Design Factory workers especially when professional skills and opinions were needed. Surprisingly most students also described a positive influence gained from integration of course work by using their PDP project as a study case. Ultimately this kind of integration of course work was also experienced as enhanced study motivation since working for the real project was seen more meaningful and practical. One team member reported this kind of positive influence of course work integration in a following way:

*"...I got super excited when I got to take our project to Venture Formation course! So far in our project we have been focusing on our service concept and user experience in PDP and now I will also making a detailed 5-year financial plan for this project in Venture Formation –class. Actually it's kind of funny that when I'm nowadays working for our project, I can't always separate which class I am working for. Due to this combination of course work I'm also able to get feedback from our professors related financial aspect, which is also super important boost so we can make this happen for real!.."*
- *Team member 3*

According to interview material, students used their PDP projects at least in four different classes as study cases covering business planning-, marketing- and product development courses. These experiences had solely positive influence on

perceived self-efficacy including enhanced study motivation as well as a good contribution for the projects.


***Indirect feedback***

Second theme, indirect feedback, covers events where interviewees reported their self-efficacy being influenced by non-verbal support or criticism. Just like direct feedback, this kind of influence was based on interaction with sponsor contact but also on working environment at Design Factory and in few cases with project manager or the team itself. However, indirect influences seemed to be often linked to assumptions and interpretations of different actions. For example, actions taken by sponsor contact seemed to be always observed and analyzed by all three teams when those occurred. The influence was experienced both in positive and negative way. Especially, interaction with the sponsor contact during the early phases of the project seemed to be very influential for perceived self-efficacy. Basically the more active the sponsor was the better influence it had. For example, students were reporting positive influence on confidence gained if the sponsor representative(s) had actively participated the PD6 workshop with the student team. Moreover, if the student teams felt gaining appreciation from their sponsor(s), positive influence on self-efficacy was obtained. As an example, one of the interviewed project teams was visiting the company premises few weeks after the project launch. Positive influence of indirect feedback was described as follows:

*"…We really felt welcomed during the first factory visit. All the big bosses, including the CEO and the Head of R&D, came personally to greet us. It made me to understand that our work is really valued at the company, which gave an extra spark for my motivation…"*
- *Project manager 1*

According to the excerpt above, it can be interpreted that project manager was feeling appreciated and valued by the attention that the team had gained during the first company visit. Indirect feedback, from sponsoring company and sponsor contact person was clearly the most discussed topic of this theme among the interviewees but also other surprising topics were brought up. One of the teams was actively using social media channels, including Facebook, Twitter and project blog to share information around the topic that they were working for. The project manager of the team explained how surprised they were about the attention that they gained trough those channels. Just the fact that they attained over 500 followers for their blog within few weeks was experienced as a positive influence on self-efficacy:

*"...It felt amazingly good (gaining over 500 followers)! Of course, many of them were our friends, but I felt that most of them were honestly interested about our project. We also got some general "good job" comments but just the facts that our postings were shared gave me power and confidence towards our concept. I just felt so proud of us..."*

- *Project manager 2*

Like seen, even if the blog had gotten verbal comments, just the fact of it being shared and liked was especially experienced as an indirect support. Similar influences were described in situations where teams got to present their projects in different kinds of exhibitions and seminars. In those cases the attention of people were perceived as indications of appreciation and interest. Even if those people would have given verbal comments, the indirect feedback seemed to be more valued by gained/increased? feeling of appreciation and acceptance.

Last but not least, the course personnel and DF workers were also described as positive sources of indirect feedback. Especially in the early phases of the project, interviewees were describing feeling surprised by easiness to approach personnel at Design Factory. Five interviewees described their self-efficacy beliefs being

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positively influenced due to the DF environment in terms of easy communication and working culture. For example one interviewee spoke about DF as follows:

*"...Here (Design Factory) I don't have to worry about presenting wild ideas. I have seen that people here often wear a patch that says: "License to act differently". I think that really conceptualizes the community culture here. You are not judged by stupid ideas but people are actually more keen to help to make those possible..."*
- *Team member 2*

In most of the interviews it was clearly seen that the students were surprised and positively influence by DF's working culture and its people. However, these experiences occurred mostly in the early phases of the projects and surprisingly only few interviewees described similar experiences gained from the environment during spring term.

### *Lack of feedback*

In addition to direct and indirect feedback also an own theme was designated to experiences related to *lack of feedback.* This theme includes references to situations were interviewees were describing their self-efficacy beliefs being influenced by lack of feedback. Also, the students often referred to the situations where they would have wished for more feedback so that they could have proceeded with their projects. Though, only four students were reporting lack of feedback been influential to their self-efficacy. Holistically out of all the themes, lack of feedback was the least discussed.

Interestingly lack of feedback was always perceived in different ways. Therefore, shared experience can have a totally opposite influence on perceived self-efficacy when talking to different people. For instance, two members of the same team were describing having very minimal communication with their sponsor contact

after the launch of the project. The project manager experienced this as trust and responsibility gained from the sponsor side:

*"…Our remote sub team and me were totally happy about the freedom that we got from the sponsor side. We don't get any guidelines from the sponsoring company so we are not bound to any direction in our product concepts but we can rather do what we found useful…"*
- *Project manager 1*

On the other hand one team member was describing the same situation from different aspect:

*"…It's a bit difficult to get motivated since we don't get any feedback from the sponsor. I mean we have couple of potential concepts but at least I'm not confident to proceed since I don't know what the sponsor thinks…"*
- *Team member 1*

In this case the lack of feedback was interpreted in totally different ways. As described, some interviewees would have wished for feedback so the team could have proceeded with the project. Most of the interviewees perceived lack of feedback as a negative influence to self-efficacy. Usually these events were related to feelings of frustration and disrespect. Though, when feedback could not be received from the sponsor, the teams often intended to gain feedback elsewhere such from potential users and customers.

**Physiological & emotional arousals**

The last source of self-efficacy can be divided to *physiological-* and *emotional responses.* As mentioned earlier, these responses were always linked to other

sources of self-efficacy, which has been considered in the analysis. Only few physiological response-involving experiences were discovered from the interviews. Overall physiological responses only emerged in situations where students were describing perceived stress or nervousness. As an example one of the interviewees was describing his feelings during the halfway presentations as follows:

*"...I don't usually mind about giving presentations. Though, I have to say that I was super nervous when I was performing during halfway show. Standing at stage in spotlight made my heart beat and I was probably shaking. There was 200 people watching us which was both exciting but a bit scary at the same time..."*
- *Team member 2*

As the excerpt shows, this student was responding physically to feeling of nervousness. However, this same experience could be categorized as mastery experience of storytelling or presentation skills. Either way it can be interpreted that the physiological response made this experience much stronger that it probably would have been without the increased heart beat and shaky voice during the presentation.

On the other hand, emotional responses were often visible in the interview data and were linked to experiences affecting perceived self-efficacy both positively and negatively. Evidently, experiences of success were always related to positive emotions whereas failures were related mostly to negative emotions as seen in the analysis of former self-efficacy sources. Interestingly students seemed to gain growth mindset from experiences of failure if those were related to positive emotions. This kind experience is demonstrated in the following excerpt:

*"...Our team had come up with this awesome idea that would revolutionize our sponsors business. We were so happy and excited that we organized a meeting with company specialist so we could present this awesome idea. As soon as the specialist*

*heard about our concept he told us this idea being already implemented and widely in use in their field of business. We felt a bit ashamed but thank god we spoke with him directly so we didn't waste any more time for that idea..."*

- *-Team member 6*

According to this example the students were feeling ashamed since they had failed to generate a new solution to the given problem. However, the experience was related with positive emotions leading to growth mindset since the interviewee describes how they were able to proceed to a new direction quickly since they had presented their concept to a specialist in the first place. Again it can be interpreted that strong emotional response made this experience more meaningful though it could have been categorized as a collective soft skill mastery experience of creativity.

As a conclusion to the last theme, it can be said that the vast variety of emotional responses was identified from the interview data whereas physiological responses were much more rare. Moreover, these responses can be seen as enhancing factors to experiences that are influential to self-efficacy. However, these responses are rather meaningless on their own. The study did not reveal situation determining avoidance behavior or learned helplessness even many experiences involving negative psychological or emotional responses were discovered.

## 6. DISCUSSION

The aim of this study was to explore how the self-efficacy beliefs of team members were affected during the product development project work. The study was carried out in the context of interdisciplinary product development -course and nine student interviews were used as a primary source of data. This chapter discusses the results of the study and provides implications for further research.

### Teamwork and ambiguity as a basis of self-efficacy

The aim of this research was to find out: (1.) In what kind of situations the team member's self-efficacy is affected during new product development process, and (2.) how interaction and emotions affect team member's self-efficacy beliefs during the new product development process. Therefore the focus of the research was to identify specific situations in which the self-efficacy of team members was influenced as well as the role of emotions and interactions in those situations. The raw interview data was reviewed, identified with the corresponding main source of self-efficacy and categorized accordingly (see Table 5).

**Table 5- Themes and descriptions of categories discovered in analysis**

| SOURCE OF SELF - EFFICACY (first-level code) | MAIN THEME | DESCRIPTION OF CATEGORIES |
|---|---|---|
| Mastery experience | - Former mastery experience | Confidence affected by former experiences of success or failure |
| | - Soft skill mastery | Success or failure in mastery of soft skills during the project (e.g. storytelling, creativity methods, time management) |
| | - Collective soft skill mastery | Collective experience of success or failure in mastery of soft skill |
| | - Hard skill mastery | Success or failure in mastery of hard skill during the project (e.g. prototyping, coding, building) |
| | - Collective hard skill mastery | Collective experience of success or failure in mastery of hard skill |
| Vicarious experience | - Comparison of capability | Estimation of success or failure by comparing skills, working methods or team dynamics |
| | - Comparison of attitude | Estimation of success or failure by comparing activity, commitment and contribution |
| | - Comparison of performance | Estimation of success or failure by comparing progress, speed and gained results |
| Social persuasion | - Direct feedback | Direct verbal feedback, support or criticism |
| | - Indirect feedback | Non verbal feedback, support or criticism (communicated e.g. trough actions, behavior and body language) |
| | - Lack of feedback | Positive or negative perception of nonexistent feedback, support or criticism |
| Physiological & emotional arousals | - Emotional responses | Emotional reactions to experiences (e.g. frustration, anger or excitement) |
| | - Physiological responses | Physiological reactions to experiences (e.g. stress, shaking or crying) |

The data reveled that before taking the PDP -course, the interviewed students were basing their self-efficacy beliefs concerning their product development skills on their former professional experiences, study background and on the experiences of course alumni. Generally, the students seemed to be quite confident in their ability to succeed in the class. However, prior research has shown that self-efficacy beliefs affect people's choices in life, which was also confirmed in this study. More precisely, Bandura's self-efficacy theory predicts that students had selected the product development project -class due to their high belief of success in this matter. This has been also confirmed in other studies among university students (e.g. Hutchison-Green et. al., 2008; Pajares, 1997).

Moreover, the findings of this study indicate that the perceived self-efficacy beliefs changed during the project work for all interviewees. The experiences during the project work were much more influential for perceived self-efficacy than the former experiences prior to the course. Once the projects had started, the most influential sources of perceived self-efficacy were individually or collectively experienced mastery of soft skills, which often related to creativity and team working skills. In addition, efficacy-beliefs were vastly affected by the performance comparisons to other teams as well as the "contagious like" attitude of fellow team members.

The performance comparisons were often related to situations or project phases in which students felt uncertain or inefficient, which was based on assumptions concerning other teams' performance. Unfortunately, this kind of assumption-based comparison had solely negative effect on team's efficacy beliefs. Positive effects of performance comparisons were only experienced during the halfway presentations where teams were openly speaking of their project progress and difficulties encountered during the autumn term. Based on these observations, it can be stated that teams had a strong influence on each other in terms of perceived self-efficacy even though the effect was mostly negative. Thus, cross-team activities should be supported in order to enhance efficacy beliefs in all teams.

Interestingly, performance comparisons were also related to the feeling of own project being more complex than the projects of other teams and this was used as an excuse for the feelings of incompetence. In this case comparisons were also based on assumptions rather than facts or discussion with other teams. According to the interviewees, the feelings of incompetence occurred during the phases in which the teams had already gained a vast knowledge of their project topic, which restricted the generation of concepts and created a vast amount of new questions to be answered. These feelings occurred mostly before the holiday break in December when the projects reached the halfway point time wise. According to Bandura's description of comparison (1997), one could assume that the more expert one becomes, the better self-efficacy beliefs one has, but in the case of NPD teams it seemed to work vice versa.

On the other hand, the negative affect on perceived self-efficacy could also be based on a negative mastery experience of creativity that occurs in early project phases such a benchmarking, need finding and concept generation. Thus, this kind of mastery experiences often need some time to mature before the effects can be obtained (Bnadura, 1997). However, due to the length of the projects, students seemed to be capable of embracing the influence of mastery experiences already during the project through reflection such as the interview situation. Very often university course projects last only few months meaning that the learnings can be utilized only in upcoming projects or later in upcoming semesters (Hutchison-Green et. al., 2008). Contrary to this, the findings of this study show that a course that lasts for a whole academic year enables students to exploit the learning from the project within the process.

In the PDP-course students are experiencing feelings of uncertainty during the ideation and concept selection phases. Teams often seek for external confirmation that would determine the direction of the project. Therefore, social persuasion is fundamental source of self-efficacy in NPD team whereas Bandura's original theory

saw it as a least influential factor. The external support is in most cases gained or wished from the sponsoring company, other project stakeholders and from potential customers and users. Interaction with stakeholders had a strong influence that was either positive or neutral, whereas sponsor feedback was experienced as stronger in a positive but also in a negative way and it had a long-term effect. The Aalto Design Factory environment, including course staff and other personnel as well as the possibility to integrate other course work to the project, were seen as useful resources when technical guidance and professional opinions were needed. However, these sources weren't experienced as sources of confirmation for project direction but rather as a source for demand-based learning. The students seemed to gain much stronger influence to their self-efficacy beliefs once they realized that the course staff could not tell them right solution for the given design brief but rather would provide tools and mentoring to support their project. This kind of realization was a turning point for many students, which increased passion and enthusiasm for the project as well as perceived self-efficacy. On the other hand, for some students this realization caused difficulties with time management between PDP, other studies and personal life that led to increased levels of stress and feeling of ineffectiveness.

**Product development process leads to entrepreneurial learning**

As discussed in the literature review chapter the product development process is very similar to the new venture creation process. Both of these processes cover similar phases such as opportunity identification, benchmarking and need finding, market research and validation as well as prototyping and user testing. Entrepreneurs often describe these early phases of the process as stressful and relate them to the feelings of uncertainty. Similarly to PDP students, entrepreneurs strive for finding confirmation and appreciation towards their ideas and prototypes. Entrepreneurial behavior, which refers to one's capability to

recognize and exploit new business opportunities, is crucial part in construct of entrepreneurial intentions (Bird & Schjoedt, 2009). As the data of this study suggests, PDP students are practicing similar behavior while working with given design briefs. Therefore, students need to use variety of creativity methods to find the root causes of the given product design problem and to come up with innovative solutions. Since similar opportunities are explored in order to come up with creative solutions, it can be stated that entrepreneurial behavior is crucial for both new product development as well as new venture creation (Hmieleski & Baron, 2008; Kyrö, 2006, Ulrich & Eppinger, 1995). Consequently, positive affect on perceived self-efficacy during product development activities can enhance adaptation of entrepreneurial behavior.

Entrepreneurial intentions refer to one's capability and willingness to start own venture (Lee et. al, 2011). The prior research on entrepreneurial self-efficacy suggests that individuals with higher efficacy beliefs are more likely to take actions towards entrepreneurial intentions (Hmieleski & Corbett, 2008). This particular research of perceived self-efficacy among product development teams cannot show that the students would be more keen to start their own ventures after participating the Product Development Project –course. However, the research reveals various events during which students' entrepreneurial capabilities were enhanced. As stated earlier, product development consists of almost identical stages with the new venture creation especially in the early phases of the process. The students often described that the course was their first practical project work experience that required various team work related soft skills in order for them to succeed. Since this kind of practical project work experience of the early phases of product development is also vital in the new venture creation, the PDP –course can be seen as an enhancing experience for entrepreneurial capability.

Furthermore, the research suggests that high-level of self-efficacy does not always lead to success within the new product development teams. The results state that the team members often felt uncertain of their concepts, which drove them to seek

for approval and confirmation from project stakeholders. Obviously, these experiences concern creativity and are often related to concept generation and user testing, which are central elements for user-centered design as well as design-thinking methodology. However, if low self-efficacy beliefs lead development teams to question their concepts and interact more with the stakeholders, uncertainty and ambiguity can also be seen beneficial for the development process. Therefore, it can be claimed that the high-level of self-efficacy is crucial for the willingness to start a new venture, but tolerance of ambiguity, resilience and growth mindset also increase the entrepreneurs' capabilities to succeed.

Aalto Design Factory was seen as a platform that supported project related activities through openness and without judgment. The students were describing personnel as supportive and easy to approach in professional and technical matters. However, problem-based learning philosophy was new for the students and therefore, it often took relatively long period of time to adapt to this kind of teaching approach. Interviews showed that growth mindset was established when the students realized that the project activities such as the course deliverables were not done to satisfy the teaching staff but rather to help the team with their process. This realization seemed to increase the motivation, leading to growth mindset and resilience. As stated by Boyd & Vozikis (1994), entrepreneurial self-efficacy builds on one's capability to turn failures into positive learning experiences. Regarding to this, PDP –course can be seen as a potential platform for students to develop entrepreneurial self-efficacy.

**Implications for future research**

The project managers of the interviewed teams described their self-efficacy beliefs being strongly influenced over the product development project. In comparison to the team members, project managers were feeling especially strong emotional

responses to situations in which their confidence towards the project was impacted either in positive or negative ways. For instance, all the managers described negative experiences within project management being related to high levels of stress, frustration and even anger. On the other hand, proactive and committed team was clearly sensed as a relief and as motivation-boosting factor that consolidated managers' confidence towards their projects. According to Bandura's original theory (1977) of self-efficacy, these kinds of experiences may have long-term influences that become visible years after the actual experience. Therefore, it would be interesting to interview the same students again two years after completing the PDP and ask them to reflect the most influential experiences they had described in this study. Consequently, longitudinal study might reveal other significant events that had strong influence on individual's perceived self-efficacy in a long-term perspective. Therefore, natural implication for further research would be to map out the experiences during the product development project that had a long-term effect on perceived self-efficacy.

Longitudinal research on perceived self-efficacy would also enable further discovery of professional development of the interviewed individuals. As claimed by Bird (1989), the self-efficacy beliefs play an important role on individual's career selection. Since this research suggests PDP –course as a platform for self-development in terms of entrepreneurial behavior and entrepreneurial self-efficacy, it would be interesting to see how the PDP –experience affects the career selection of the interviewed students. As mentioned earlier, this study cannot show that PDP –course enhances individuals willingness to pursue own ventures but instead the course, including it's learning goals, promotes the adaptation of entrepreneurial behavior in terms of creativity.

Finally, the results indicate that the individual self-efficacy beliefs are rooted in the project team itself. In other words, team members' behavior and attitude contributed to the collectively experienced success and failure. Since the team communication and team dynamics are the core factors affecting team members'

individually perceived self-efficacy, the research could be extended to explore sources and construction of collective-efficacy. The discussion of collective-efficacy is relatively new in academic research, which means that the study would contribute to the development of collective-efficacy theory in terms of interdisciplinary teamwork, product development and entrepreneurship. Especially, the interdisciplinary aspect of product development teams requires careful examination in terms of the project management in order to utilize all capabilities in a most effective way. Related to that the product developers coming from diverse backgrounds and personalities have to learn to "speak the same language" in order to establish a fluent communication. As a result, it can be stated that further examination of collective-efficacy could significantly help to develop existing theories and course activities to better support team learning.

## 7. CONCLUSIONS

The aim of this research was to study situations that affect team member's self-efficacy beliefs during product development process and to examine what is the role of emotions and interactions in those situations. Three team members from three product development teams were interviewed in order to provide answers to this matter. The study can be claimed to be valid since the carried out analysis was able to provide answers for proposed research questions.

The multidisciplinary Product Development Project -course provides a safe platform for the students' self-development especially in the terms of soft skills. The students described how the course provided an environment, in which it was safe to fail and face setbacks during the project work. From the beginning, students were highly motivated towards the projects since the problems given by the sponsoring companies were real and an actual budget for the development work was provided. Such a practical approach was described as an exciting though a new kind of study experience. Aalto Design Factory was seen as a supportive, safe environment to learn from set backs rather than to give up the work. Therefore, the course has great potential to support and develop the growth mindset and resilience of the students.

The results indicate that the team itself is the core of both individual and collective self-efficacy. Since the feelings and attitudes are contagious among team members, the project teams need to take care of the team dynamics as well as promote open communication and feedback to enhance team performance. For instance, if half of the team members appear to be uncommitted to the project work, the rest of the team easily starts lacking the commitment as well. On the other hand, collectively experienced moments of success can result as enhanced self-efficacy in an individual level.

When compared to entrepreneurship, the new product development closely resembles new venture creation. The results of this study revealed that the PDP – course has great potential to simulate entrepreneurial project work, which enhances individuals entrepreneurial self-efficacy. The different project phases as well as the course objectives promote the importance of entrepreneurial behavior in terms of creativity and innovation. This study cannot directly claim that PDP – course would increase student's entrepreneurial intentions. Instead the course enhances one's self-efficacy beliefs towards entrepreneurial capabilities in multiple ways.

Overall, the course provides a platform for self-development as well as for adaptation and development of growth mindset and resilience during the project since the course lasts for whole academic year. Individual and collective reflection of project work is a key to such a change in mindset and confidence especially when feeling uncertain about the project performance. In addition, uncertainty drives students to interact more with fellow students and other project stakeholders. The study indicates that the more interaction there is the more changes in perceived self-efficacy will take place. Interaction is also the main source for strong emotions. However, the strength of related emotion has a secondary influence on self-efficacy beliefs when compared to the experience itself.

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# 9. Appendix

## Appendix I

**Interview questions for marvelous Master's thesis by Martti Jerkku**

Lets think about the PDP experience so far. Try to remember how you were feeling what were you thinking in different stages of the project.

This interview is carried out to collect data for my master's thesis. The research is carried out to observe similarities critical events in between PDP –course and entrepreneurial opportunity identification.

You will be asked to draw different kind of graphs indicating changes of certain values/feelings during the project. Afterwards you will be asked to point the most remarkable events during the project so far

1. Draw roughly the different phases of your PDP experience

2. Draw a graph indicating your level of excitement towards the project
   a. What was the event during the peak?
   b. What made you this exited?
   c. What happened during the downs?
   d. What made the excitement to decrease?
   e. Were these events critical to your project and if so, how?
   f. How would you define your role in a team during these times?

3. Draw a graph indicating the level of your commitment throughout the project.
   a. What made you more committed to the project at peak points?
   b. What was the reason making you less committed during the downs?
   c. Were these events critical to your project and if so, how?
   d. How would you define your role in a team during these times?

4. Point out max. 5 the most critical events for the project in your graph. In this context critical can mean the most exciting, depressing, memorable, fun, sad, etc.…)
   a. What were these events?
   b. Why were they critical?
   c. How did they affect the project?
   d. How did they affect you as a part of the team or otherwise?

5. Point out where did the concept ideas occur
   a. What was the idea?
   b. How was it founded?
   c. What made the idea spark?
   d. How did it affect the project or you?

6. Point out the biggest decisions made in the project
   a. What was decided?
   b. How would you reflect on decision?
   c. How did it affect you?
   d. How did it affect the team?
   e. How did it affect the project?

**Appendix II**

Name:

September  October  November  December  January  February  March  April  May

## Appendix III

**PDP Course syllabus**

If granted rights

| | |
|---|---|
| **Credits** | 10   cr |
| **Teaching Period** | I - V (Autumn - Spring) |
| **Workload** | Lectures 18 h<br>Teamwork in supervised groups 200 h<br>Demos (4 + 10 h) 14 h<br>Individual studies 32 h<br>Project mid-term evaluations (3 á 1 h) 3 h |
| **Learning Outcomes** | After the completion of the course the student:<br>- understands the quality of his or her own design, engineering, or marketing skills<br>- understands the potential and the challenges of interdisciplinary teamwork<br>- is able to carry out PD tasks by using both traditional and modern methods and tools<br>- understands PD costs and economy<br>- is able to deliver high quality oral and written reports<br>- is prepared for negotiation situations, and to deal with agreements, NDA's and IPR's |
| **Content** | Project work in team settings of roughly 10 students. The development projects are mostly offered and sponsored by industrial companies. The projects include all phases from planning to introducing of a fully functional prototype or demontrator. |
| **Assessment Methods and Criteria** | The course starts (period I) with introductory lessons and workshops, and by working out the project plans. The course text book is used as support material. The development project continues (periods II-V) for the whole winter and the final results are introduced in the middle of May. The grade is composed of practical results, project management, applying of proper methods and tools, and of mastering communication and documentation during the project. There is no final exam. |
| **Study Material** | Ulrich, Eppinger: Product Design and Development, selected chapters (4th edition 2008 recommended, but other editions are valid at this course, too). |
| **Substitutes for Courses** | The course replaces the old version Kon-41.002. |
| **Prerequisites** | The course is aimed at students of technology, economics, or industrial design who are interested in product development of investment or consumer products. Also, students from other disciplines are welcomed to the appropriate extent. The course is intended for the final stage of studies. For practical reasons, the number of students must be limited to roughly 140. Candidate (B.Sc) exam required as prerequisite in the new Aalto study structure. |
| **Language of Instruction** | EN.<br>English |
| **Course Staff and Contact Information** | Professor Kalevi Ekman, assistant Martti Jerkku and tutoring team from Design Factory |
| **Further Information** | English will be used in all course elements. |