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Juho Heikkinen

Conceptualizing the Role of Multidisciplinarity and Student Perceptions of University-Industry Collaboration in Project-based Learning

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ABSTRACT

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Project-based learning has a long history, especially in the disciplines of computer science and engineering. This approach is used to offer students a realistic view of their discipline, and this experience can be enhanced with industrial involvement as companies bring their real world problems to projects. One recent trend in project-based learning is utilizing multidisciplinary teams, enabling students to contrast their skills and experience with students from other disciplines.

This thesis focuses on a project course involving multidisciplinary teams and real customers that has been organized at the University of Jyväskylä since 2011 focused on developing students' general working life skills. The research presented here originated from the need to understand what happens in such collaborative projects. The research approach was exploratory, with grounded theory and thematic analysis used to analyze students' learning reports and data from a qualitative survey. This thesis comprises four articles that examine students' perceptions of the role of multidisciplinarity in their learning and students' perception of two features of university-industry collaboration: students' valuation of work that benefits their customers and the relationship between students and customers.

The emergent grounded theories demonstrate (1) how multidisciplinarity affects learning through team compositions and project topics, making learning experiences seemingly contingent, and (2) how students' valuation of work emerges as a complex calcution starting from a reference point that shows how students' equate project-based learning to work, internships, or coursework and related compensation. Analysis further reveals similarities with unpaid internships. Finally, the relationship between students and their customers is summarized through two main themes: students' perceived status with the customers, and the perceived value of their work. The results are presented as unified theoretical pictures and thematic networks, offering a comprehensive perspective views on the research.

Keywords: project-based learning, multidisciplinarity, university-industry collaboration, financial compensation

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1 INTRODUCTION

Project-based learning has a long history in higher education, and it is now used especially in computer science and engineering education. It has been a steady part of software engineering education; the first curriculum in software engineering already included a "true-to-life" programming project (Tomayko, 1998). The history of project-based learning can be tracked even further in the past, to 17th-century Italy, and later to the works of William H. Kilpatrick who is known worldwide as "Mr. Project Method" (Knoll, 2012). More recently, project-based learning has been implemented using several different course models and arrangements (Clear et al., 2001; Fincher et al., 2001). Project-based learning has been used as a vehicle for effective learning; in disciplines with a practical application students can demonstrate that they master the skills needed in working life by doing projects during their studies (Fincher et al., 2001).

Project-based learning can be used by universities to further close the gap between working life and education when collaboration with industry is added to the mix, with companies, non-profit organizations, and others acting as customers for whom the students implement their projects. These real customers also bring their realistic real-world problems to students, and in these "project with a client" (Fincher et al., 2001, pp. 47-52) type of projects students gain more realistic experiences of their discipline. Further, these real-world problems are often open-ended in nature, meaning that the goals of the project and how to reach them are unclear and unspecified (Hauer and Daniels, 2008).

One emerging trend in project-based learning is multidisciplinarity, meaning that students from different disciplines are put together to work in the same project team. In this thesis, the term multidisciplinarity is used when the collaboration between people from different disciplines is discussed. Depending on how the work is actually organized, the terms interdisciplinarity and cross-disciplinarity are also used in the literature, as these terms are not usually distinguished clearly from one another (Morse et al., 2007); it is not uncommon to select one of these terms and use it systematically (see, e.g., Borrego and Newswander, 2008). Another recent trend is multicultural teams, where students in the same project can be working in different countries or even continents (Jensen et

al., 2017; Pears and Daniels, 2010). Both of these trends correspond with trends in contemporary working life, where work is increasingly done in multicultural (Last et al., 2000) and multidisciplinary (Kruck and Teer, 2009) environments.

In this thesis, the focus is on a project course entitled *Multidisciplinary working life project*. During the course, multidisciplinary student teams implement a project for a real customer outside the university based on an open-ended project topic. The course is open to students from every faculty of the university, and the learning goals focus on so-called general working life skills (Bennett et al., 1999), such as project work, team work, and working with a customer. Two course coordinators from the university are responsible for all course arrangements, and customers pay a nominal administrative fee to the university. Students are responsible for implementing the project, and are rewarded with credits and a project certificate. Customers support the students project work by providing assistance on the substance of the project, and obtain the results and related intellectual property rights. For students the focus is on the learning process, whereas the university implements its societal interaction through the projects and customers receive help in developing their business or activities. This basic structure is illustrated in Figure 1.

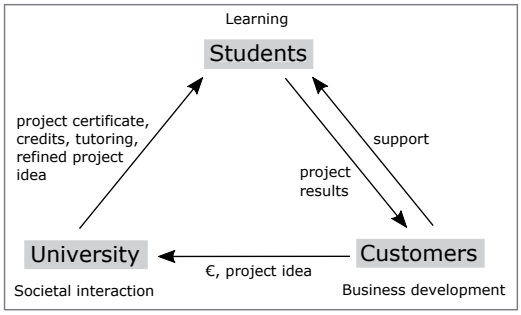

FIGURE 1 Basic course structure

The course under study has two distinctive features: multidisciplinarity and real customers. Utilizing real customers in a project course is not uncommon, but the way multidisciplinarity is involved in this course is more rare, as the course is open to students from all faculties. One example of similar course is Experts-in-team (Sortland, 2004) where students from all faculties are involved, however the collaboration with external customer is not necessary. There is no single discipline around which the course is centered, and this approach enables a wide selection of project topics and varied composition of student teams. This is in contrast to typical examples from research literature, where project courses are often centered around one or two core disciplines (see, e.g., Mosiman and Hiemcke, 2000; Hirsch et al., 2001; Burnell et al., 2003; Kruck and Teer, 2009).

This thesis discusses how students perceive these two distinctive features and their consequences: working with and for a real customer with real project topics and multidisciplinarity. More precisely, the focus is on the role of multidisciplinarity in students' learning process, and how they perceive collaboration

with their customers. Utilizing real customers also means real life project topics, and this aspect is discussed by analyzing how students see the value of their work and the compensation they gain. This is a topical issue, as students are essentially working for free for their customers, a setting similar to unpaid internships that have gained publicity and research interest in recent years, especially in the USA, but also in Finland.

Project-based learning is often studied by presenting course descriptions (Helle et al., 2006), and the research methods are often simple quantitative descriptions or else the qualitative method followed is not described at all (Malmi et al., 2016), often resulting in anecdotal reporting on certain aspects of project courses. Meanwhile, the literature reviews (Dutson et al., 1997) and other valuable holistic analyses (Clear et al., 2001; Fincher et al., 2001; Hoffman, 2014) have focused on classifying project courses and creating taxonomies. Thus, while project-based learning has a long history and has been studied for a long time, there is still room and a requirement for systematic research, using clearly stated research methods — a key motivation for this thesis. Research for this thesis started in 2012 after the course under study had been organized three times. The research interest started as a need to understand what happens within student teams during these projects, and this interest shifted to focus on the aspect of multidisciplinarity. The research interests developed as the course instances were organized and the issue of unpaid work emerged, followed by an emerging interest in forms of collaboration between students and customers.

This thesis presents exploratory research. Instead of testing preexisting hypotheses, the focus is on trying to analyze what happens in the projects from the students' viewpoint. This goal is supported by the selection of research methods used in the four papers: grounded theory and thematic analysis. This thesis presents an original theory on how students' learning experiences are affected by the insertion of multidisciplinary teams and project topics into the project-based learning setting. A second theory presented describes how students place value on their work contribution in a real-life setting with industrial customers. Finally, students' collaboration and relationship with their customers is presented using thematic networks.

1.1 Summary of the included articles and the author's contribution

This thesis consists of two journal papers, one conference paper, and one manuscript, focusing on three related research topics. Figure 2 demonstrates how the included articles PI-PIV are positioned with respect to the course structure. PI, the first paper titled "Learning mechanisms in multidisciplinary teamwork with real customers and open-ended problems," analyzes students' learning experiences using grounded theory method and students' self-reflective learning reports. Its results show how multidisciplinarity plays a role through the composition of teams and project topics, both of which are multidisciplinary. Further, it

is noted that the learning experiences relating to multidisciplinarity are not fixed as transformations from negative to positive can happen during the project work. Finally the resultant theorization of the different learning experiences is discussed with respect to existing research literature.

PII, the conference paper titled "Students' Opinions on Financial Compensation from Project Work" and PIII, the manuscript titled "Calculating the Value of Work in Experiential Learning with Industry Involvement through a Reference Point: A Grounded Theory," both discuss the same theme: possible financial compensation to students from project work. More precisely, as students are not paid for the projects, the focus of research is on whether students see a need for financial compensation, and how students value their work. The conference paper uses a qualitative survey sent to students, and aims to discover and classify how students view the need for financial compensation and how they see the value of their work. The results show that students value learning more than financial compensation; the latter is seen as potentially beneficial but at the same time problematic under certain circumstances. In conclusions, the findings are discussed and reflected on the topical issue of unpaid internships.

The manuscript continues the same topic, using additional data obtained from the same questionnaire, and employing a grounded theory method to reveal the complex processes that students engage in, as they calculate the value of their work. Their calculations are based around the core category labelled as the *reference point*, that summarizes students' previous experiences of academic work, experiential learning, and working life, and the compensation they have received. The reference point acts as a basis for their calculation of the value of their work: suitable compensation for work stems directly from the experiences summarized by the reference point. Students also use different types of justifications to support their calculations. The emergent grounded theory is then discussed again in comparison to the existing literature on unpaid internships.

PIV, the journal paper titled "Perceived status and value: the student-customer relationship inflected by the inherent challenges of university-industry collaboration," uses students' learning reports that are analyzed using a thematic network analysis. This analysis resulted in two thematic networks with the highest level themes of *Perceived status* and *Perceived value*. The first network shows the different ways students positions themselves with respect to their customers, while the second network shows how students see the value of their work. The results are discussed and related to the literature on students' similar experiences in project-based learning, and university-industry collaboration at a generic level. Finally, based on these results and existing literature, a comparison is made on how work differs between academia and industry.

The research process for each of the papers was similar. The author of this thesis was the researcher responsible for all parts of the paper. The initial research topics were discussed with the second author, after which the first author started collecting and analyzing data, as well as reading related literature. After the initial data analysis, the results were discussed between the authors, often in several rounds of iteration, exchanging ideas and improving the analysis. This mode of

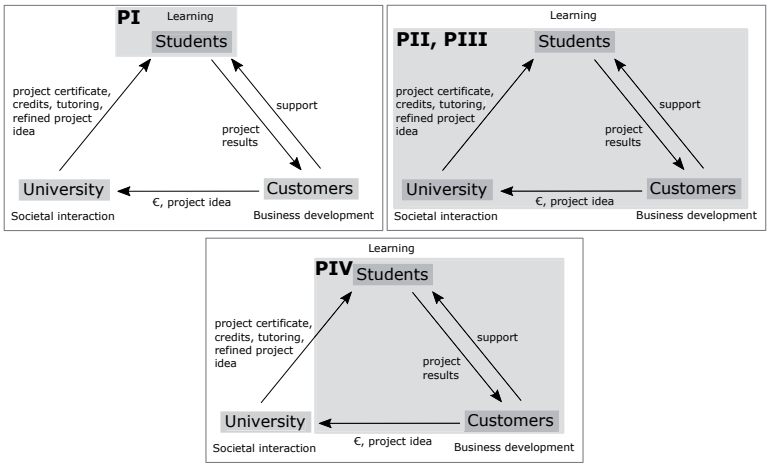

FIGURE 2 Included articles in basic course structure

work enabled rich and detailed results. The first author then started drafting the paper, with writing tips and assistance, as well as recommended related literature, from the second author. Finally, the final versions of each paper were read through by both authors to give the text its final form. The role of the second author gradually reduced as the first author gained more experience, with the second author's contribution being largest in the first paper and smallest in the last paper.

The remaining chapters of the thesis is structured as follows: the second chapter looks at the literature addressing on project-based learning, and the related topics of open-ended problems, multidisciplinarity, and real customers and university-industry collaboration. Third chapter describes the history, learning goals, and general arrangements of the project course under study. The fourth chapter discusses the data and methods, and in the fifth chapter, the results of research topics are summarized. The sixth and final chapter offers an overall discussion, followed by the original research papers.

2 RELATED LITERATURE

The course that is the subject of this study has two distinctive features: multi-disciplinarity and real customers. Connected to these features is the open-ended nature of the project topics. Utilizing real customer in a project-based learning course can also be seen as a part of university-industry collaboration. Also, students working in a project where the results benefit the customer resemble unpaid internships when looked at from the compensation viewpoint. This chapter explores at the research literature on these four issues.

2.1 Project-based learning

Problem-based learning originated in the 1960s in the field of medical education, from where is has spread to other disciplines such as engineering (Perrenet et al., 2000). The backbone of problem-based learning is a set of problems, supported by lectures and skills training (Perrenet et al., 2000). Project-based learning is a specific case of problem-based learning, and all project-based learning is essentially problem-based (De Graaff and Kolmos, 2003). The focus of problem-based learning is in acquiring new knowledge, while project-based learning emphasizes application of knowledge (Perrenet et al., 2000).

Project-based learning can also be seen as being more realistic and authentic, with more concrete deliverables that are implemented into practical use (Helle et al., 2006), which means they take longer to finish (Perrenet et al., 2000). Two aspects can be seen as crucial to project-based learning: there is a solution defined by students, and projects produce an end result, such as a report (Helle et al., 2006).

2.2 Multidisciplinary project-based learning

While the project courses in engineering and computer science, for example, often seem to be monodisciplinary courses (Dutson et al., 1997; Fincher et al., 2001), there are examples of multidisciplinary or interdisciplinary project courses as well. Here, the terms multidisciplinary and interdisciplinary are used interchangeably to describe situations where students from different disciplines collaborate, an approach used, for example, by Borrego and Newswander (2008).

Several examples of multidisciplinary project courses can be found in the literature. Often the collaboration happens within one university, where a new project course is created for this purpose (see e.g. Sharma et al., 2017; Corno and De Russis, 2017). Multidisciplinary collaboration can also be implemented by using existing courses (Burnell et al., 2003) to make the best possible use of limited resources; these courses can originate from different universities (Ivins, 1997). Using students from the same discipline allows multidisciplinarity by making students work with projects where multidisciplinarity appears through the real world application areas of the core discipline (Daniels and Cajander, 2010) or students are given multidisciplinary project topics (Brownell and Jameson, 2004).

Experts-in-team (Jaccheri and Sindre, 2007; Sortland, 2004) is a large-scale project-course where up to 1500 students are divided into "villages," with each village having a theme that combines two disciplines. An example of a multidisciplinary engineering course is provided by Daniels and Asplund (2000): 90 students from three different engineering disciplines work on a same project, with the aim of building a team of robots for the robot soccer world championships.

Most of these courses are capstone courses targeted at final year Master's students. A different approach is described by Hirsch et al. (2001), where first-year students from engineering and communication work in the same project teams. Furthermore, multidisciplinary project-based courses can combine students with different levels of experience, such as to combine experienced adult students with undergraduate students (Kruck and Teer, 2009).

We can see that multidisciplinarity is applied to project-based learning in various ways. Further, it appears that these multidisciplinary courses can be divided into two categories:

- Students from different disciplines work together on a project (Jaccheri and Sindre, 2007; Molina-Besch and Olsson, 2016).
- Students from one discipline work within a project that is focused on real-life problems and areas outside their pure discipline (Hauer and Daniels, 2008; Sharma et al., 2017).

Interestingly, it seems that a multidisciplinary approach is rarely combined with the use of real customers, with some exceptions described by Daniels and Cajander (2010) and Molina-Besch and Olsson (2016).

Multidisciplinary approach to project-based learning offers several benefits. Working with people from different disciplines is seen as a positive and meaning-

ful experience (Mosiman and Hiemcke, 2000; Kruck and Teer, 2009), even though it may cause an uneven distribution of workload (Kruck and Teer, 2009; Molina-Besch and Olsson, 2016). Students might also experience multidisciplinary teams as a challenge at the start of the projects, but by the end their experiences have transformed into positive ones, including improvements to their self-confidence and their problem solving and decision making skills (Ivins, 1997; Molina-Besch and Olsson, 2016).

Students compare multidisciplinary projects to monodisciplinary ones and comment that they learn different things, giving positive feedback in general (Jaccheri and Sindre, 2007), a similar phenomenon as to what happens when students compare monodisciplinary project courses to lecture courses (Isomöttönen, 2011). Participating in a multidisciplinary project has an important effect on students employability, as it improves students job placements and results better project evaluations compared to students in monodisciplinary projects (Hotaling et al., 2012).

2.3 Real customers

Students' experiences in project-based learning can be enhanced by adding real customers for whom the students implement the project, naturally bringing real world project topics with them. Overall, the value that real customers bring to the courses is known in the literature: students gain a better understanding of their skills and the requirements of working life (James, 2005; Helle et al., 2007; Isomöttönen and Kärkkäinen, 2008). Another reason to utilize real customers is the increase in students' motivation, especially through authentic projects and customers involvement (Brown, 2000; Helle et al., 2007; Bothe, 2001). Students also appreciate the opportunity to do in-depth work for a real customer (Bourner et al., 2001).

While in most cases the customers are from private industry that is not a necessary condition. Students working in projects where the customers are from the non-profit sector or where the project topics are socially relevant have been reported having similar experiences to those students with corporate customers (Buckley et al., 2004; Leidig et al., 2006).

Project-based learning is often studied in the form of course descriptions (Helle et al., 2006; Isomöttönen, 2011), resulting in anecdotal evidence to support or oppose different course arrangements. For example, Magleby et al. (2001) state that having an industrial sponsor and thus a real customer on a project course is a positive factor, without analyzing the situation more thoroughly. On the other hand, Rover (2000) briefly mentions the negative effect that real customers had on students, resulting in a reduced number of real customers used. Again, there is no explanation for how or why these negative experiences occurred.

In addition to bringing authentic project topics to the project courses, real customers can provide other resources, such as funding and expertise to the uni-

versity. The financial arrangements between the university and customers are however not frequently discussed. One example of these financial arrangements is provided by Warnick and Todd (2011): an educational grant of $20,000 is allocated to the university, part of which is allocated to cover student teams' expenses. A survey of 165 programs by the same authors revealed that less than 10% of customers pay more than $5,000 for the projects addressing their requirements. Student projects can however end up being hugely beneficial to customers, with Mann and Smith (2006) reporting examples of savings up to $50,000 as the customers did not need to use professional consulting services. Also, employers get to evaluate their potential future employees during the project courses (Todd and Magleby, 2005). From a financial point of view, project courses seem profitable for customers, offering low costs and potentially high benefits.

The relationship between students and customers can be a sensitive one, and the university must take several aspects into account, including financial arrangements, when planning a project course (Clear et al., 2001). There seems to be little research on financial arrangements between students and customers. Clear et al. (2001) for example do not take a stance one way or other, simply stating that payment to students can be permitted, disallowed, or permitted under certain circumstances. Cooperative education offers some of the same benefits as project-based learning, as students gain work experience in a realistic setting while companies benefit from the student workforce and can evaluate whether these students have potential to be their future employees (Reichlmay, 2006). Similarly, cooperative education can be paid or non-paid, with payment to students acting as a bonus and increasing customers' expectations toward students (Huggins, 2010).

Another example is described by Neagle et al. (2010): one reason to organize student companies was to provide earnings for students. Payment to students meant that a challenge arose in needing to assure customers of the quality of work.

Students learning can be enhanced through the use of open-ended problems that can follow from the needs of real customers and their real-world problems. Open-ended problems can be defined as problems without clear goals or previously identified means to achieve these goals (Hauer and Daniels, 2008), allowing many possible solutions (Kwon et al., 2006). This setting forces students to focus on solving the problem instead of trying to find the "correct answer" (Daniels et al., 2002, p. 133), with the emphasis on the negotiations between students and customers to define the customer needs (Daniels et al., 2002). Utilizing open-ended problems has a positive effect on students' motivation, as well as decreasing dropout rates (Daniels et al., 2002).

2.4 University-industry collaboration

Project-based learning involving real customers can be seen as a one way to implement University-industry collaboration. This collaboration has been studied since the 1980s, to better understand and regulate it (Geuna et al., 2003). This body of research has included same topics as project-based learning, such as different modes of collaboration (Perkmann and Walsh, 2009) and factors affecting motivation (Dooley and Kirk, 2007).

Both forms of collaboration have similar features; for example, Cyert and Goodman (1997) describe a situation where a university research team was pressed by the industrial partner to continue collaboration. James (2005) provides a similar example from a project-based course: faculty decided to finalize a collaborative effort that started as a student project, putting emphasis on the customers' needs at their own expense. Research on project-based learning however does not often seem to emphasize these comparisons to University-industry collaboration.

2.5 Unpaid internships

The use of internships has been increasing in recent years, as university students and unemployed professionals hope to improve their employability (McHugh, 2016; Willer, 2016; Steffen, 2010). For university students, internships can be a mandatory or voluntary part of the curriculum, and in some cases an internship period occurs immediately after graduation, often as an element in professional accreditation. One reason why internships have gained more research interest in recent years is the issue of intern compensation, or more precisely the lack thereof. Unpaid internships have been analyzed from several viewpoints, for example, from the perspectives of students and employers, to support or oppose unpaid internships in general, and to examine whether they are legal or ethical (see, e.g., McHugh, 2016; Rickhuss, 2016; Steffen, 2010; Westerberg and Wickersham, 2011; Durack, 2013; Burke and Carton, 2013).

Thiel and Hartley (1997) argue that internships originated as an option for students' to finance their studies. In this light, the increasing number of unpaid internships can be seen problematic, and Steffen (2010) links this increase to a trend of replacing permanent employment with permanent temporary ("permatemp") employment. The educational benefits of internships can vary greatly, with internships including menial tasks that do not correspond with the expertise and professional aspirations of a university student (Burke and Carton, 2013), and the term internship itself can mean any of several job-like activities performed for an employer (Durack, 2013). Furthermore, universities often do not discuss compensation in their internship guidelines (Durack, 2013).

One reason for the recent interest in unpaid internships, especially in the United States, is probably the widely publicized *Glatt vs. Fox Searchlight* case,

where a court ruled that two interns were essentially employees and ordered Fox Searchlight to pay them the minimum wage to compensate them for their time as interns. This court ruling was based on United States labor legislation and guidelines, which have since been discussed and interpreted in several papers, and it has been the basis for several other court cases as well (see, e.g., Durack, 2013; Burke and Carton, 2013; Willer, 2016).

Using the same criteria as Durack (2013) did when comparing cooperative education and internships, project-based learning and internships have similar features, especially when considering the issue of compensation to students. In both cases the work done by students benefits the customer or employer. Interestingly, Durack (2013) suggests that, in order to avoid difficulties that paid internships could cause to non-profit organizations lacking financial resources, project-based learning could be utilized instead.

This chapter has summarized some features of multidisciplinary project-based learning, including course arrangements, benefits, and challenges arising from such courses. There are examples of multidisciplinary teams and project topics referred to in the literature, however, these are not often combined with real customers. Furthermore, when project-based learning utilizes industrial collaboration, the benefits that real customers and real-life project topics bring are often taken for granted, and there seems to be little to no research on the interaction between students and customers. Also, the relationship between university and customers seems to be under-examined, and is not often discussed even in course descriptions. The following chapter describes these features of the course under study.

3 COURSE DESCRIPTION

Multidisciplinary working life project, the course under study in this thesis, originated at the Agora Center research institute of the University of Jyväskylä. In 2008, a three year project began, funded by the European Social Fund (ESF) with a broad aim of improving the collaboration between institutes of higher education and local small and medium sized enterprises (SME's) in the Central Finland region. For the first two years, the project team met and interviewed local companies in order to see how faculty members and students could help them to improve their businesses, and organized collaborative research and development projects to assist these companies. Quite early on, it was noticed that the scope of the challenges that these SME's faced was most suitable to be solved by using the skills of university students, and the work focused on organizing collaborative activities around students' bachelor and Master's theses and coursework. Also, during the last year of the project, the project team created and piloted the multidisciplinary project-based learning course in collaboration with the Faculty of Information Technology during the summer term of 2011. Due to the nature of the Agora Center as a multidisciplinary research institute, it was natural that the project course aimed to include all students at the university, and that the resulting teams were multidisciplinary by design. As such, there were no single core discipline that the course or learning process revolved around. This approach also enabled a wide range of project topics and customers, not focusing on a single area of business or type of project.

The pilot course was a success, and both students and customers gave positive feedback on the course concept. Following this experience, the university rector granted a two year fund to Agora Center to continue organizing and further improving the course throughout 2013 and 2014, in collaboration with the Career Services of the University of Jyväskylä. Following successful work, another two-year grant was awarded by the rector. In May 2015 the course was made a permanent fixture of the university's summer term courses by the rector's decision. There are several reasons why the university has seen the project course as an essential part of its educational services. It offers students a realistic view of working life and project work in a multidisciplinary team environment,

and helps bridge the gap between education and working life. Collaboration with local industry, and societal interaction in general, are among the main tasks of Finnish universities, and this project course is seen as one way to achieve that goal. The course also improves the summer course offerings of the university: it has been organized every summer, and has been primary known as a summer course. The course was also organized once during the winter, spreading over autumn and spring terms, and twice during the spring term. Student feedback and course application numbers, however, showed that the workload of the course was too much to complete the course at the same time as other coursework. After this the course was transformed purely into a summer course.

This project course model could be classified as a "Project with a client" project, using the taxonomy proposed by Fincher et al. (2001), however this does not account for the multidisciplinary nature of the course. A similar but more suitable description could be: "Multidisciplinary one-semester course with real customers and open-ended problems." While there are no extensive lectures on the topics that projects involve and students are expected to utilize their existing skills, the course cannot be considered a "capstone" course. Another classification for the course could be an "Open-ended Group Project" (Daniels and Cajander, 2010).

Between 2011 and 2016 the course was organized nine times by the Agora Center and the Career Services. During this time period, almost 250 students implemented over 50 projects for their customers. In 2017 after the university board decided to shut down Agora Center as a part of university's structural reorganization, the responsibility to organize the course was shifted to the Career Services office.

The author of this thesis has been involved with the project course since the beginning, first working as a project manager in the ESF funded project where the project course model was developed and piloted, and then continuing to work as a researcher in Agora Center until the end of 2016, with the responsibility to organize the course and act as a course coordinator, along with another course coordinator from Career Services. The data used in this thesis was collected from the students participating on the course between 2011 and 2016.

3.1 Learning goals and grading

The course sets four learning goals be met by students (Heikkinen and Isomöttönen, 2015). After completing the course, students should:

- Be able to recognize their own expertise and strengths in both project and team work;
- Be able to apply the theoretical knowledge of their discipline and other competencies in a real-world case;
- Be able to work as a responsible member of a project team and work with the customer;

– Know the basic concepts of project work, which include the ability to set goals for a project, write a project plan, implement the project in a multidisciplinary team, and present the results to the peer group.

Course coordinators do not measure directly whether students achieve these learning goals, but rather focus on enhancing their learning through a dialogic process and feedback. The grading of the course is pass/fail, with each student graded individually based on whether the team finishes the project and the student completes the individual learning assignments. More precisely, this includes at least 120 hours of work on the project for each student, with teams having the responsibility of keeping track of the hours and ensuring that the workload is distributed evenly. In addition to implementing the project, the team needs to provide a project plan approved by the customer, mid-term report that describes the progress of the project to the course coordinators, a final project report to the course coordinators and the customers, and finally the deliverables of the project described in the project plan. Student teams also have to give a final presentation of the project to the customers and course coordinators. Student then have to write an individual learning report where they are asked to reflect on the project, team work, and their experiences in relation to the learning goals.

All these requirements are easily graded as pass/fail, making it simple to see whether a student has passed the course. So far each student that did not drop out has passed the course. Students however do not consider the course to be easy to pass, on the contrary they consider it to have a heavy workload.

3.2 Before the course

The course has been run by two course coordinators, who are responsible for planning the course schedule, negotiation with potential customers, and dealing with students' applications to the course before the course starts.

Course coordinators meet all potential customers to discuss their needs regarding the project and the general arrangements and schedule of the course. Those customers that are interested in joining the course sign a tentative agreement about participation. At this point, the project topics are not fixed but the outline of the project is agreed, as it works as a basis for assigning students to each specific project.

After the student application period has ended, all applications are summarized and student teams are created to match customers' tentative project topics. This matching has three equally important aspects that need to be satisfied (Heikkinen and Isomöttönen, 2015):

– Each student should be in a team where he or she can be a useful member of the group;
– Each team should be multidisciplinary, with members from at least three different disciplines;

– Each team should have a combination of skills enabling them to implement the project.

This matching process dictates the final selection of customers and students for the course. Individual students or customers do not have any fixed criteria for selection, as the goal is to select the best possible team for each customer and vice versa. This means that in every course instance, some students and customers are unfortunately left out. However, as this is an optional course not required by any degree program for graduation, while this is unfortunate it is not too serious a problem for students. Interested students are advised to reapply for the next course instance. The course is aimed at Finnish speaking degree students, and with the exception of one foreign student on the pilot course, all students have been Finnish.

3.3 One course instance

The course starts with introductory lectures given by course coordinators on topics such as project planning and management, teamwork, working with customer, project communication, and project management tools. These lectures are organized as an intensive workshop taking place over two or three days, and are the only mandatory lectures included in the course. During the first day, students meet the other team members for the first time. The team building phase starts, and students are told to select a project manager from among them, as well as other possible roles, such as a secretary and a person responsible for communicating with the customer. Introductory lectures are followed by a two-hour meeting organized individually for each team, where they learn who their customer is and what their needs and hopes for the project are. In line with the learning goals of the course, and to promote authentic working life experience, course coordinators do not participate in any meetings between the team and the customer, and it is the team's responsibility to negotiate and define the final project topic with their customers.

Course coordinators have defined four mandatory checkpoints for the teams. First, each team gets face-to-face feedback of their first version of the project plan. Then, shortly after the deadline for project plans has passed and teams have started working on their projects, course coordinators meet with all the project managers to discuss and reflect on the starting phase of the projects. Around the half-way point in the projects, each student participates in an afternoon seminar, where they are mixed into new groups for some group exercises and to discuss and reflect on their learning and teamwork experiences so far. A couple of weeks after this meeting, teams write a project mid-term report, on which they are given written feedback.

Most of the time, student teams work independently. The course coordinators are responsible for assisting teams with respect to project work and team work in general, and customers are responsible for assistance when it comes to

the substance of the project. These features aim to promote an authentic working-life experience and accord with the "thrown in the deep end" approach: students work with other students from different disciplines, whom they do not know beforehand, their customer is unknown to them, the project topic might be outside their core skills, and they have to take responsibility of their work and work independently. This approach was in fact even more extreme the first time the course was run, but was then moderated somewhat following student feedback: introductory lectures were added and the possibility of tutelage on request was emphasized even more.

After the project has ended, the team presents their work to their customer and course coordinators. This is followed by a reflective discussion among all three parties, and course coordinators collect feedback by taking notes on the discussion. More feedback is collected from customers using a simple questionnaire of nine questions using a 5-point Likert scale, along with open-ended questions about the performance of the team and individual students. This is followed by a final seminar, which marks the conclusion of the course. Each team presents their project and results to other teams, and again teams are mixed for the following group work and discussions, in a similar manner to that used in the mid-point meeting. Students are given instructions for their learning reports: students are asked to reflect on the project, team work, customer, their own learning experience, and what they consider to be the positive and negative aspects to the whole project. After the course is finished, each student receives an individual project certificate that can be used, for example, as a reference when applying for a job. During the last two years, the part of the final seminar where teams present their projects was made a public event, in order for university to gain more publicity from the projects. Table 1 (Heikkinen and Isomöttönen, 2015) summarizes a single course instance as described above. One course instance lasts around 15 weeks.

3.4 Project contract

The students, the customer, and the university representative sign a project contract at the start of the course. The contract stipulates the rights and responsibilities of each party. For students it means they have to work between 120 and 180 hours on the project, and they do not need to work more than 180 hours even if the project is not finished by then. Students do not receive a salary from the projects, but all their ongoing expenses are covered by the customer if authorized by the customer in advance. Students receive 5-7 credits for the course based on their working hours (where each 30 hours means one credit) and an additional credit for participating in the introductory lectures. Originally each team member had to work the same number of hours, but this requirement was slowly loosened and then removed altogether. In addition to credits, students receive an individual "project certificate" that they can use as a reference. The intellectual property

TABLE 1 Overview of the course structure (Heikkinen and Isomöttönen, 2015)

When	Who	What
Week 1	Coordinators, Students	Introductory lectures about project work
Week 2	Coordinators, Students	Presentation of Customer and tentative project topic
Week 2	Students, Customers	Negotiations about project topic
Week 2	Students	Start working on project plan
Week 3	Coordinators, Students	Feedback about project plan
Week 4	Customer, Students	Signing the final project plan
Week 5	Students	Project work begins
Week 7	Coordinators, Students	Meeting with project managers
Week 8	Coordinators, Students	Meeting with all teams
Week 9	Students	Project mid-term report
Week 14-15	Coordinators, Students, Customers	Final presentation
Week 15	Coordinators, Students	Final seminar
After the project	Students	Project report, individual learning reports

rights for the students' work is transferred to their customers, but students obtain the right to use their work, such as collected data, in their studies, and have the right to use the project as a reference. In case of "significant economic benefit," the students and customers are required to negotiate additional compensation for the students.

Customers are obligated to provide a project topic for the students, and to support them during the project in project-related issues. Customers pay a organizing fee to the university after the projects. This fee has varied between 500 and 1200 euros (+ 24% VAT), and in some rare cases the fee has been waived for certain customers such as non-profit organizations. The university has to offer tutoring and mentoring to students, and provide them with facilities and equipment they need to implement the project.

4 DATA AND METHODS

Two different data sources were used in this thesis. All data used is qualitative, obtained in the form of students' learning reports and from a qualitative survey. Two different research methods were used: grounded theory (Glaser and Strauss, 1967) and qualitative content analysis, more precisely thematic analysis (Attride-Stirling, 2001) and first-level analysis of a qualitative survey (Jansen, 2010). Grounded theory was used exclusively with reference on qualitative data, it is however important to notice that, in itself grounded theory is neither a qualitative nor a quantitative research method; it can use both types of data as "all is data" in grounded theory (Glaser and Strauss, 1967). Sections 4.1 and 4.2 describe the two sources of data used, while Sections 4.3 and 4.4 describe the research methods.

4.1 Students' learning reports

This thesis uses data collected from students in two different ways. First are the learning reports that students write at the end of their projects. These learning reports are meant to be reflective, and no explicit questions that need to be answered are included in the instructions. The report assignment is first given during the introductory lectures so that the students are able to prepare for it early on. More detailed instructions for the assignment are given during the final seminar, where the students are shown some previously collected student feedback. The aim is to encourage students to reflect on their experiences instead of writing a list of the tasks they did during the project. Students are advised to reflect on the project, team work, customer, their own learning experience, and what they consider to be the positive and negative aspects of the whole project. Thus a diary type of report is not encouraged, but rather is explicitly forbidden, and there is no length requirement. The learning report is a part of the requirements to pass the course, but does not affect grading: a "bad" learning report does not mean that the student will not pass the course. These instructions mean that the con-

tent and length of the reports vary greatly, from half a page up to six pages, and from a few notes about project work to long analyses and self-reflection about everything that happened during the project.

Further, students are reminded that learning reports do not affect grading, in hopes that they would not hold back possible critique directed at the course and its organization. The learning reports are primarily intended to benefit students in their course reflections, but also offer course coordinators a way to assess each course instance and consider improvements and modifications to the course.

The learning reports are also a rich source of qualitative data. After the research on this thesis started in late 2012, at which point the course had been organized three times, all students were sent a request by email, stating that the author wanted to use their learning reports for his PhD research. Altogether, 66 out of 88 students replied and granted permission. A second request was sent to a new set of students in late 2014, at which point the course had been organized another three times, and on that occasion 27 out of 65 students granted permission. In both cases, not one student specifically refused permission to use their report; lack of replies from students can be attributed to their disinterest in course matters after they had completed it. After this occasion, the research permission request was included in the project contract, with each student given the opportunity to deny the use of their learning reports in this thesis research. The contract and the research underway were explained to students during introductory lectures, and again no student denied the use of their learning reports. This resulted another 73 learning reports, totaling 166 learning reports used in the research for this thesis.

4.2 Qualitative survey on financial compensation

The term survey refers here more to the method of collecting data through a questionnaire and does not refer to a typical survey research with an aim to test a specific hypothesis. Instead, the aim was to obtain data that could be used in understanding phenomena related to financial compensation. This second data source consisted of replies to an anonymous questionnaire sent to students by email. The focus of the questionnaire was on financial compensation, and it was created with the following four research questions in mind (Heikkinen and Isomöttönen, 2015):

- RQ1: What is the general opinion of the students regarding the course model and the arrangements?
- RQ2: Are students satisfied with the number of credits they get for the course and the model on which the credits are based?
- RQ3: What are the students' opinions regarding financial compensation in coursework with external customers?
- RQ4: Does the issue of financial compensation emerge when students are not specifically led to this topic?

While being presented fourth on the list, RQ4 it was actually the starting point for the questionnaire. The research questions and the questionnaire were initiated by discussions between the author of this thesis and his supervisor. There had been some commentary from non-participating students about the exploitative and work-for-free nature of the project course. If this was the case, why had the students on the course not commented on the issue directly to the course coordinators? The topic was seen as potentially sensitive for students, and thus the questionnaire was made anonymous.

The questionnaire consisted of an introductory text that described the purpose of the study and the basic course arrangements essential to remember when answering the questionnaire (Heikkinen and Isomöttönen, 2015):

- In this project course, multidisciplinary teams planned and implemented a project for a real-life customer.
- The course yields value and benefits for students, customers, and the university.
- There was a project contract stipulating the work hours, administrative fee, and intellectual property rights.
- Students were granted credits based on work hours, but were not paid.

The questionnaire consisted of three background questions: faculty, sex, and whether the respondent had been employed during the past 12 months, along with three open-ended questions that directly followed from research questions RQ1-RQ3, with RQ4 implied through the structure of the questionnaire (Heikkinen and Isomöttönen, 2015):

- "Q1: How do you see the basic arrangements of the project course, from a student perspective?"
- "Q2: Is the model used in granting credits good? Is the number of credits reasonable?"
- "Q3: Should students be compensated financially in addition to credits, for the coursework that has external customer that benefits from the work?"
- "Q4: Has completing the project course helped you obtain employment?"

The questionnaire was structured so that the first page included the foreword, quantitative background questions, and the first question. The second page included the second question, and the third page questions three and four, with each question having a short reminder of the aspects of course arrangements related to the question.

A link to the questionnaire, with a foreword explaining the study, was sent to students after the course that took place in the summer of 2013. At that point, 114 students had passed the course, and 111 of those were reached by the email, with some email bouncing back due to out-of-date addresses. Altogether, 38 students replied to the questionnaire at that point. This was repeated in late 2014, when a similar email was sent to students that had passed the two previous

course instances, resulting in answers from an additional 17 students. The questionnaire was repeated again in late 2015 and 2016, resulting in 8 and 5 answers respectively, bringing the total number of answers to 68.

4.3 Grounded Theory

Grounded theory, as formulated by Glaser and Strauss (1967), was used in two papers, PI and PIII, working with students' learning reports in the former paper and data collected using questionnaire on financial compensation in the latter. In both of these papers, the goal was to understand the phenomenon at hand, namely learning and multidisciplinarity in PI, and financial compensation from project work in PIII, instead of trying to test a hypothesis derived from existing literature. Grounded theory suits this purpose well, and it was selected because it is a data-driven method. Furthermore, grounded theory emphasizes theory emerging from the data without the use of related literature or a theoretical framework. Grounded theory has been used successfully in higher education research, for example in works by Gregory and Jones (2009), and its use in engineering fields is both increasing (van Niekerk and Roode, 2009) and recommended (Kinnunen and Simon, 2010). It is also suggested that using grounded theory could revitalize the engineering education research (Case and Light, 2011).

The analysis procedure in grounded theory is called the constant comparative method, consisting of four stages described by Glaser and Strauss (1967) as follows: comparing incidents applicable to each category, integrating categories and their properties, delimiting the theory, and writing the theory.

These stages overlap and are performed simultaneously, not in a linear order. This enables the continuous development of the theory emerging from the data, and the inclusion of new data as the research advances. Grounded theory is iterative by nature, and once a relevant core category, the "main concern or problem for the people in the setting" (Glaser, 1978), or framework begins to emerge, the analyst focuses on the theory development around this core.

Grounded theory emphasizes the use of naturally emergent data (Glaser and Strauss, 1967); students' learning reports feature this property. In analyzing financial compensation, the selection of the research method was partly influenced by a desire to experiment with how qualitative data collected from a questionnaire would work with grounded theory. The qualitative data from the first set of answers to the questionnaire turned out to be rich and in-depth, which encouraged the researcher to send the questionnaire to a new set of students.

In this analysis, the core category which was named *reference point*, emerged early in the process, which reasserted the premise supporting the use of the questionnaire data and encouraged to continue with the analysis. This is attributed to the fact that the questionnaire focused on the research topic at hand, and that the data from questionnaire was surprisingly rich in detail. It is assumed that the topic of the questionnaire, compensation from experiential learning, was a top-

ical issue for students, and that the questionnaire stimulated students to reflect the situation in sufficient detail. This rich data played a role in finding the core category of the theory and contributed to the depth of the analysis. The richness of the data means that students were analytical in their answers, and instead of a simple "yes" or "no," they made clear arguments to support their opinion.

4.4 Qualitative content analysis

Two different types of qualitative content analysis were used in PII and PIV: thematic analysis utilizing thematic networks, and unidimensional analysis. Thematic networks were used in PIV to analyze how students' view collaboration with their customer. Thematic networks can be seen as an extension of the thematic analysis, a "widely used qualitative analytic method" (Braun and Clarke, 2006, p. 77). Thematic analysis is a flexible method and by using it, it is possible to obtain a complex, rich, and detailed description of the data (Braun and Clarke, 2006). Attride-Stirling (2001) suggested that thematic networks could be used to present thematic analyses. She linked her view of thematic analysis to the argumentation theory proposed by Toulmin (1958), and argued that thematic analysis can discover implicit meanings from explicit statements.

This research method was selected after the research focus and the data to be used had been fixed, and the above mentioned features of the thematic analysis and thematic networks support the exploratory nature of the research. Previous findings on student-customer interaction have often been anecdotal; therefore, qualitative research using a well-defined method and a clear and holistic way of presenting results was seen as a welcome addition.

The analysis was done inductively, in a data-driven manner, which can provide a richer overall account of the data (Braun and Clarke, 2006). First, the learning reports were read through to familiarize the researcher with the data. This was followed by dissecting the learning reports into smaller text segments. These actions were based on the initial research interest concerning students' view of collaboration with their customers. Subsequently, initial codes were derived from the text extracts and grouped into basic themes which were then named. These basic themes were then arranged into organizing themes, which in turn were grouped to form the highest-level global themes. The three levels of themes were finally organized and presented as two thematic networks, each representing one global theme.

All the stages of the analysis after initial coding were iterative. Basic themes were constantly refined and reviewed against the text extracts, and organizing themes were refined as basic themes developed. Several versions of the thematic networks were created before the final one. Finally, the thematic networks and the patterns in the networks were interpreted and presented.

The analysis procedure followed the guidelines set out by Attride-Stirling (2001): three-level thematic networks were created, consisting of basic themes de-

rived from data, organizing themes that group basic themes into larger entities, and, finally, global themes that are deduced from organizing themes and are the highest level of abstraction. Attride-Stirling (2001) argued that thematic networks are useful especially in illustrating different levels of abstraction. An example of the structure of a thematic network consisting of one global theme, two organizing themes, and six basic themes is illustrated in Figure 3.

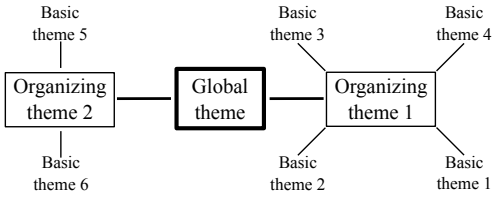

FIGURE 3 Structure of a thematic network (Heikkinen and Isomöttönen, 2017), adapted from Attride-Stirling (2001)

In PII, data from the qualitative survey was analyzed using the approach presented by Jansen (2010). The aim of this paper was to gain an overview of the students' perspectives on financial compensation. As the project-based learning literature rarely touches this issue, it was deemed necessary to first conduct a preliminary analysis of the topic. This first-level analysis of the qualitative survey was thus seen more appropriate than a more exploratory method, such as pattern coding (Miles and Huberman, 1994).

The data used came from the questionnaire about financial compensation, more precisely the three open-ended questions about course arrangements, credits, and financial compensation. The analysis was done as suggested by Jansen (2010) using first-level analysis, which is the most basic level of analysis described by the author. The analysis produces a three-level structure that has objects, their dimensions, and categories for dimensions, each at different levels. The coding activity can either be downward coding, starting from the objects, or upwards coding, starting from the categories. Here, the coding was done downwards, resulting in each object corresponding with a theme from a related open-ended question.

The coding procedure started from the objects, and each student answer was coded into dimensions. Following this, the coding continued within dimensions and categories were identified. Coding was an iterative process, and data segments were moved from one dimension to another, as well as from one category to another, when it was deemed appropriate. This means that, in practice, the analysis included some upward coding as well. Finally, the resulting structures were described and explained by writing them out. An example of this structure is presented in Figure 4 (Heikkinen and Isomöttönen, 2015), where the object "Financial Compensation," two of its dimensions and some of the categories of the dimensions are depicted.

Both of these applications of qualitative content analysis are similar in their basic ideas, and each produces a three-level description of the data. To obtain pre-

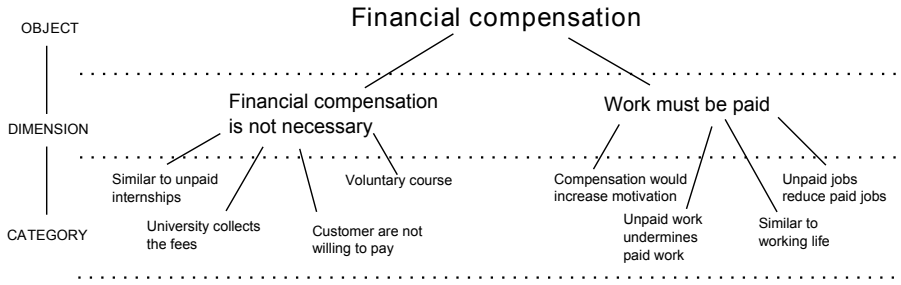

FIGURE 4 Example of the outcome of analysis procedure adapted from Jansen (2010)

liminary results on financial compensation, first-level analysis with downward coding was seen as a suitable method. Using thematic networks to describe the results of thematic analysis undertaken in a data-driven manner enabled a more abstract description of the collaboration between students and customers.

5 RESULTS

5.1 Multidisciplinarity and students' learning

Multidisciplinarity affects students' learning experiences through two different aspects: multidisciplinary teams and multidisciplinary project topics. These learning experiences can be either positive or negative, and they are not fixed, as transformations can happen in the learning during the projects. The students' learning mechanisms are depicted in a four-fold field in Figure 5.

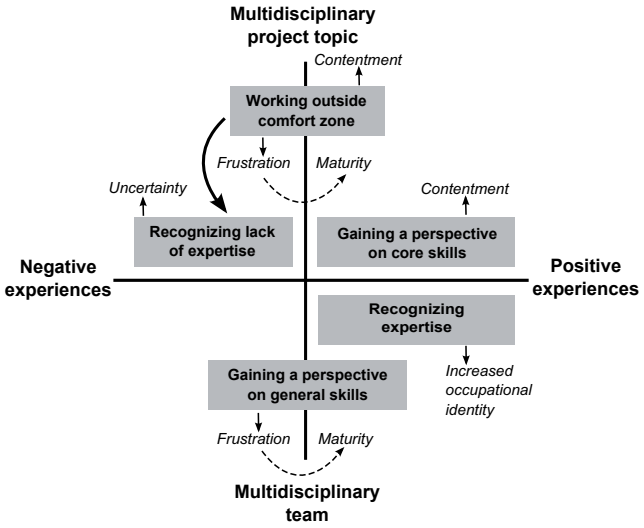

FIGURE 5 Students' learning mechanisms (Heikkinen and Isomöttönen, 2015)

The core category of the emergent grounded theory is in this case kind of a contingency, emphasizing the fact that the learning experiences are fixed, and that the learning can happen in several ways and there is no one right way to learn.

Multidisciplinary team is related to two categories of learning, *Recognizing expertise* and *Gaining perspective on general skills*. Multidisciplinary project topic is related to three categories, *Recognizing lack of expertise*, *Working outside comfort zone*, and *Gaining perspective of core skills*.

Multidisciplinary team and learning

Recognizing expertise occurs when students are put to work in a team where other people come from other disciplines and possess different set of skills. As the work progresses, students compare their own work contribution to that of others, and notice how they have learned skills during their studies that others do not have. Students understand their own discipline more deeply, as well as realizing how they can utilize these skills, leading to positive feelings, increased self-confidence, and increased occupational identity. This "who I am" kind of self-discovery may have been the most important learning experience that emerged from the data.

Students have general skills they have used before, in monodisciplinary teamwork or some other setting. Multidisciplinary teams enable them to utilize these same skills in a new and different setting, leading to both positive and negative learning experiences. Other team members' working styles differ from what each student is used to, leading students to evaluate and better understand their own skills. The same situation can, however, cause them to be frustrated with the situation. Further, this frustration can turn into a positive experience labeled here as maturity, as students learn to cope the different working styles of other team members.

Multidisciplinary project topic and learning

As the project topics are from the real world and stem from the needs of the customer, there inevitably are situations where students are not able to fully utilize their core skills, forcing them to work outside their comfort zone to be able to contribute to the project. They have to start learning new skills, either alone or by working together with another team member.

This implies a situation where students first become frustrated by the situation and hinder the teamwork dynamics when they make their frustration heard. Students can consciously improve their attitude if they recognize the situation, and the progress of their work and a supportive team spirit can also help them to overcome their frustration. In these cases, this original frustration turns into maturity, as students understand how they can contribute to the project. From another point of view, students who possess the needed core skills can see the students working outside their comfort zone as a burden. They feel frustrated and disappointed, as they think others are not sufficiently motivated or skilled to do these tasks. Further, one team had decided at the early stages of their project to keep everyone working within their comfort zones. While this might provide better results and more efficient teamwork, it prevents these possibly valuable

learning experiences from occurring.

Working outside their comfort zone enables students to learn and practice new skills, and to learn other disciplines' basic concepts and terminology, leading to contentment. This learning mechanisms occurs when students have a positive attitude toward learning, and they consider learning as an opportunity rather than a challenge.

Students may start to question their own skills and competencies when they work outside their comfort zone. Students compare their skills with the project's requirements, leading them to recognize lack of their expertize. This causes students to feel uncertain about their role and contribution to the project. This can be contrasted with Recognizing expertise that occurred through working in a multidisciplinary team; there were no indications that working with people from other disciplines had caused similar feelings of uncertainty and lack of necessary skills.

Finally, in some cases, students are able to use and combine several of their core skills, enabling them to gain a new perspective toward them. This again leads to contentment, similar to that which could result when students were working outside their core skills.

5.2 Students' views on financial compensation and the valuation of work

The issue of financial compensation from project work done for real customer was analyzed in two parts. First, the survey answers were analyzed to obtain an overview of the situation and to see how students view financial compensation in general. In second part, grounded theory method was used to analyze an expanded data set to see how students place value on their work.

Overview of financial compensation

While the focus of the survey was on the financial compensation, students were also asked about course arrangements and whether the course had helped them obtain employment. The answers to the survey question related to the course arrangements did not include any comments about financial compensation, so this question was excluded from the analysis. The question about employment was meant to be used to improve and evaluate the course, and it was excluded as well.

Students' comments regarding credits focused on three main themes (or dimensions): the number of credits, the model used to calculate the credits, and the amount of work in relation to the credits awarded. In addition, two other themes were identified: tracking of working hours and an emphasis on learning instead of focusing on the credits.

Students' comments about financial compensation were grouped into five themes. While only one student commented on this issue in previous questions,

directly asking the students about it made them comment in great detail. First, financial compensation was deemed not to be necessary, as the course was voluntary and not required by any degree program and the lack of financial compensation was known to interested students before the course began.

Learning and credits were given more value than money. While the customers obtained useful tools and results from the teams, students felt that things such as learning, credits, references, networking, and the possibility of future employment were seen to be more useful for them. In this sense, students saw the project as an "investment for the future."

However, students felt that there should be a possibility to negotiate with the customer in case the project resulted in significant financial value. In the students' opinion, this possibility would increase their motivation to work better and would also increase the fairness of the collaboration.

Comparing the course with "real working life", students argued that there should be some salary just like there is employment. They saw unpaid jobs reducing the availability of paid jobs, as companies could utilize similar project courses instead of hiring employees or using consulting companies.

Students argued that payment could also cause some problems. There might be difficulties in sharing the payment within the team given that individual students' contributions to the project vary. Similar situations might occur between different teams, with different customers being more or less willing to compensate students. Compensation could also disrupt teamwork, as students might start competing with each other.

Finally, financial compensation is not an issue that students comment on, unless they are asked directly. Only one student mentioned the possibility of a salary when asked about credits. This can be caused by two things. Students might consider financial issues to be sensitive, and are timid in raising them into discussion. They might also be more interested and focused on other aspects of the course, such as learning.

Valuation of work

Students' calculations of the value of their work follow in each case a complex process that can realize in many ways. The emergent core category discovered using grounded theory method was named *reference point*. It consists of students' previous experiences with academic work, experiential learning such as internships, and working life. These three types of work are associated with some compensation, such as salary from work and credits from academic courses.

In the simplest case, this reference point leads directly to some reward in students' calculations. In more deeper analysis, students use various justifications to support their reference point, or to change the value of their calculations. Further, students compare rewards in different situations and give them a certain order in a process named *reward chain*. Finally, in the most complex calculation, the reference point is accompanied by a justification that affects both the reward deemed suitable, while the reward chain is included in the calculations as well.

This whole process is depicted in Figure 6.

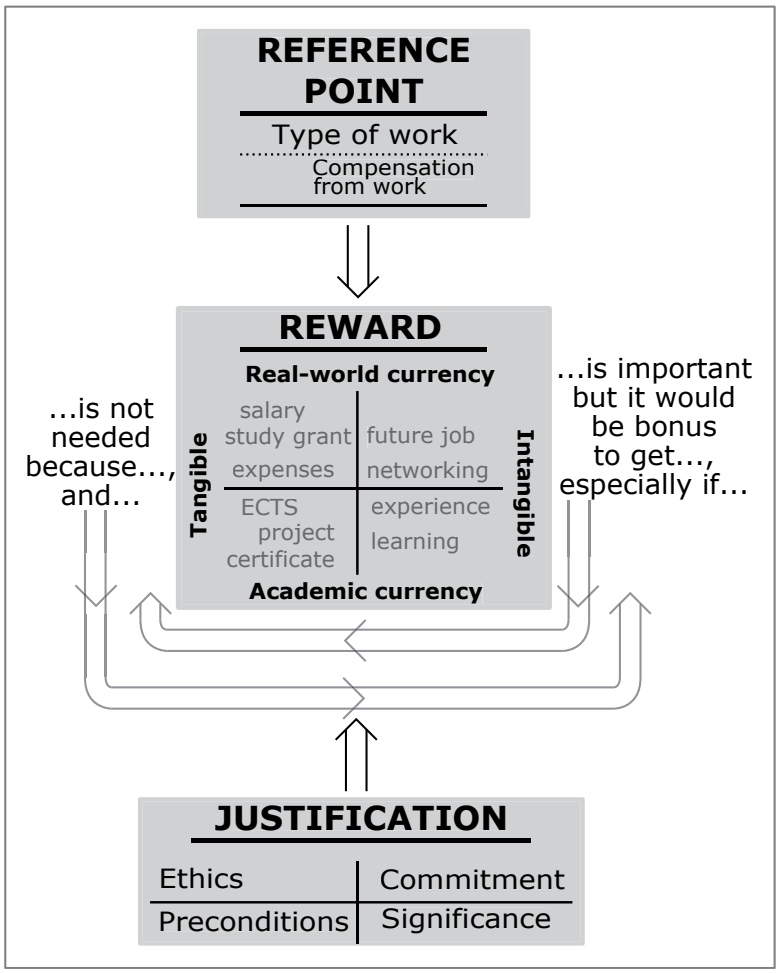

FIGURE 6 Students' calculation of the value of the work

The rewards that students deemed suitable were categorized into those that have value in the real world, and those that have value in the academic world. These rewards are either tangible or intangible, resulting in a four-fold table of rewards, as seen in Figure 6. Tangible real-world rewards include salary, study grant, and expenses that their customers covered. Intangible real-world rewards include possible future jobs and networking. Experience and learning are intangible academic rewards, and credits and project certificates represent tangible academic rewards.

The category *Justification* employed in students calculations has four properties, depicted in Figure 6: Ethics, Preconditions, Commitment, and Significance. Concerning ethics, students argued that being paid would represent a potential advantage, but it could cause ethical problems. These include how to share the salary within and between the teams, and could contribute to inequality as indi-

vidual students' contributions to project vary. Additional compensation from the customer would also increase the requirements of the work, and together with the distorted motivations that money could cause, might shift the focus from learning to something else. Ethical considerations also support financial compensation. It would increase the motivation to perform, and would ensure the students' livelihood during the project, because the credits are not enough to receive a full study grant.

Students recognize the preconditions of the course arrangements and take them into consideration in their calculations opposing financial compensation. There is a "harsh reality" evident in students comments, as they understand how increased financial commitment could decrease customers' interest in the course, devaluing the learning experiences that real customers bring: "no salary is better than no course", as one student commented. Other preconditions include the voluntary nature of the course and the fact that no compensation is promised at any point.

Students' understand that their work can have a significant value to their customer. In support of financial compensation, students argue that some of the profits or savings should be given to them, if the project has produced something significant. Savings can emerge as customers do not need to hire consulting companies to do the project, and they profit from the work by gaining a competitive advantage. Another aspect of significance relates to customers' own evaluation of the project: if they deemed the results to be useful and the work well done, some sort of bonus would be in place.

Students use their own commitment to the projects as an argument to support financial compensation. The number of hours spent on the project makes them feel compensation would be needed. They compare the workload to other courses where credits are the compensation, and argue that project work requires more work and therefore a financial bonus should be given.

The reward chain is depicted in Figure 7. Each student's reference point leads him or her to deem some rewards suitable, while taking some other reward into consideration as well. For example, some tangible, real-world reward it may not be needed because of a reward later in the chain; for example, a student argues that "there's no need [for salary], because the course is very useful to students as it is, and the number of credits is sufficient."

Students' calculations use the reward chain in both directions, as they argue for some reward being the most important, but at the same time see some other reward as a bonus or useful addition: "In practice it would be great to be paid for the work, but I see the course worthwhile the way it is, because it may lead to employment later on, or at least it enables students to network with companies."

In addition, the reward chain is also affected by preconditions, making it complex. The complexity of the calculation of the value of work is demonstrated by the following student quote:

> Financial compensation could increase motivation and of course would be a satisfying bonus after work well done. On the other hand it could cause some problems as well, because the compensation would have to be based on the working hours and the

contribution to the project, which would be really difficult to evaluate at an individual level. How should the compensation be divided within the team and between different teams? Thus I feel that credits are sufficient compensation to students.

FIGURE 7 Reward chain

5.3 Collaborating with customer

Thematic analysis of students' learning reports resulted in two global themes, *Perceived status* and *Perceived value*, including three and two organizing themes, respectively. Perceived status reveals the different ways in which the students perceived their status with respect to their customers, while Perceived value discusses how students perceived the value of their work for themselves and for their customers. Finally, based on the analysis and the existing literature, differences in work between academia and industry were identified.

Perceived status

Three modes of interaction were identified between the students and the customers. First, in *Parity*, students experienced the customers as supportive, and themselves as being in an equal position with customer, contributing to fluent collaboration. Four basic themes were linked with Parity: Freedom, Trust, Collaboration, and Support. This thematic network is illustrated in Figure 8.

Students were given freedom to work within the project, but at the same time they received support from their customers. Students understood and appreciated this freedom and showed gratitude toward their customer, as it made their work easier. While the freedom meant that some students experienced challenges in defining the projects' scope, the overall experience was positive.

Freedom was closely associated with the trust that the customers demonstrated toward students. This trust contributed to the success of the projects, as project topics and new related ideas were discussed openly. Customers treated students as professionals of their disciplines, allowing students to fully utilize their expertise, and increasing their motivation.

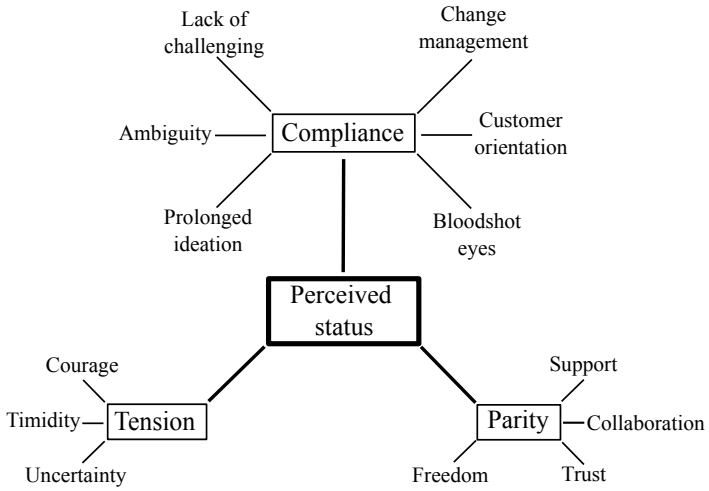

FIGURE 8 Thematic network for global theme "Perceived status" (Heikkinen and Isomöttönen, 2017)

Collaboration emerged through informality, enabling quick communication and letting students focus on the tasks at hand. An open atmosphere encouraged students to contribute and increased their confidence and motivation. Students acknowledged this good communication and customers' active participation as major factors in their projects' success.

The support students received from their customers contributed to their projects' success as well. Getting just the right amount of feedback and support was emphasized by students, affecting the students' motivation and self-confidence in a positive way.

In summary, it seems that *Parity* was initiated by the customers' personalities and actions. Therefore, it might be difficult for students to affect the situation significantly. Also, while the four basic themes have been presented here as separate issues, in reality many of them were linked together in students' comments (e.g., trust and freedom) and affected students in similar ways (e.g., trust and collaboration improved motivation).

The organizing theme *Compliance* describes the conflicting interests that students and customers can have, and how students complied with customers' requests even when doing so was against their own interests. Six basic themes were linked with Compliance: Prolonged ideation, Ambiguity, Lack of challenging, Change management, Bloodshot eyes, and Customer orientation.

Customers' need to plan and ideate the projects for too long caused challenges for the students, because the goals of these projects remained unclear. This, in turn, stalled these projects and caused anxiety to students. Student compliance toward their customer meant that they did not push back to their customers with their own opinions, even though they recognized the challenges of this situation.

In some cases the customer was not sure what they wanted from the project.

This ambiguity forced students to remind the customer about previously agreed issues, and their compliance toward their customer meant they did not challenge them. Instead, students acknowledged that "even customers themselves do not always know what they want." This ambiguity also emerged when customer had a lot of ideas, but no concrete expectations. In general, ambiguity decreased the quality of the project, and even though students acknowledged the situation, they were unable to react accordingly.

Related to this, students acknowledged that they should have challenged their customer more with respect to their project topics. They felt too scared to argue face-to-face with their customers about certain aspects of their projects, and therefore submitted to customers' requests. The decision to avoid challenging their customer weakened the quality of the work in students' opinion.

Students found situations where customers wanted to make changes to the project plan frustrating, because the tasks and deadlines kept changing. Teams' approach to change management was to stay silent and accept customers' changes when they were proposed, and to vent their frustration later, making it seem from customers viewpoint that everything was under control. Interestingly, students commented that these challenges improved team spirit and made their teams more coherent.

The term "Bloodshot eyes", adapted from Brown (2000), describes situations where changes caused problems for students. These changes caused delays and missed deadlines, creating situations where students worked more hours than required by the university. Bloodshot eyes was also caused by dropping already agreed parts of the project and adding new parts. Again, students did not protest but simply accepted the situation and chose to work harder.

The last basic theme, Customer orientation, can be seen as a summarizing theme for Compliance. Even with all the challenges, students considered focusing on customers requirements as the most important thing. Students emphasized the need to listen to and understand these even when they conflicted with the students' own interests, understanding that these situations helped them to develop their skills and competencies.

Compliance appears to be a conflicting phenomenon. It involves both challenges and learning opportunities for students, and resembles a real world business-to-business relationship, where a certain amount of compliance toward customer might be needed.

The two previous organizing themes were similar, in the sense that they represented stable relationship between students and customers. In *Tension*, the relationship is unstable, as it varies from students' timidity towards the customer to taking control of the project. The related three basic themes are Uncertainty, Timidity, and Courage.

According to the course structure, students can not select their team members or customers. They are given the contact info of their customer, and expected to start planning the project with them. This situation caused uncertainty for students, making them question the usefulness of the projects and their own contribution, before the project is even started. This uncertainty continued after

students learned their project topics, even though the team spirit was good and supportive.

Before the first meeting with their customer, students were nervous and timid about the whole situation. They were nervous when making the first phone call, acted formally in customer meetings, and planned their actions carefully. This timidity, however, disappeared quickly as students came to understand that their customers were "just" normal people like themselves. Customers' informality likely played a role here, but at the same time, students acknowledged their own false preconceptions. Another reason might result from the course structure: course coordinators do not participate in these meetings, forcing students to take responsibility and starting to communicate with their customers. In a different course setting where coordinators participate in these meetings, timidity has been a more difficult problem, as students can shift communication responsibilities to coordinators (Isomöttönen and Kärkkäinen, 2009).

Finally, in another scenario the tension between students developed to the point were students took control of the project and started challenging their customer. They understood that "the customer is not always right", and wanted to make sure that their project would be a success by taking control of the project. This resulted in challenging but rewarding situations, as students were able to identify the weaknesses in the customer's business plans, and sell their own solutions to the customer with the help of a supportive team and tips from course coordinators.

Perceived value

This global theme describes how students perceive the value of their work. *Project evaluation* focuses on the students' reactions after they hear feedback from their customers, and *Authentic project* discussed how students perceive the value of the project work for themselves. This thematic network is illustrated in Figure 9.

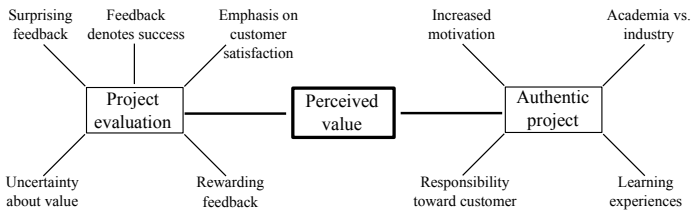

FIGURE 9 Thematic network for global theme "Perceived value" (Heikkinen and Isomöttönen, 2017)

.

Five basic themes were linked with project evaluation: Uncertainty about value, Surprising feedback, Feedback denotes success, Emphasis on customer satisfaction, and Rewarding feedback. While students felt satisfied with their work,

they were uncertain how the customer would react upon seeing the final results. Lack of communication and feedback during the project was seen as one reason for this uncertainty.

However, after receiving positive feedback from customers, students felt that their projects were successful. Good team spirit and meeting deadlines while finishing every deliverable also demonstrated the project's success. Students also emphasized customer satisfaction, and even when some parts of the project could have been better, customer satisfaction was the most important aspect. This experience was intensified as students' inexperience caused them to underestimate their skills during their projects. Finally, students put a high value on genuine positive feedback from customers, demonstrating that their own contribution to the project was worth it.

Students' perspective concerning their project results evolved as they reflected on customers' feedback. Students perception follow a pattern, where their original uncertainty evolves step by step into feeling rewarded by customers' feedback. This pattern is illustrated in Figure 10.

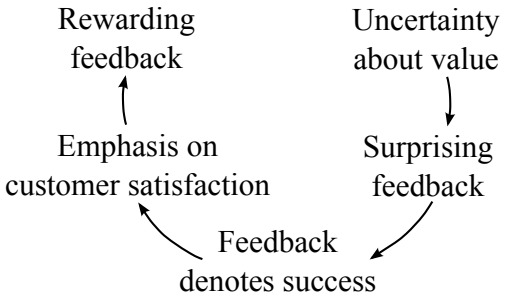

FIGURE 10 Pattern showing students' evaluation of the project's results (Heikkinen and Isomöttönen, 2017)

Authentic project was linked with four basic themes that show how students experienced the existence of a real customer: Increased motivation, Academia versus industry, Learning experiences, and Responsibility toward customer. Students' motivation was increased because they were working for a real customer that had a real need for the project. Working with a real-world project topic demonstrated to students the differences between academia and industry as they got to know what the life of an entrepreneur is like. They recognized differences in working styles, as their customer was typically more interested in results than the methods used to get them.

Real customers enabled several learning experiences for students. They got the experience of working with a real customer, and improved their so-called general working-life skills (Bennett et al., 1999). In some cases, they were able to get to know a new business domain, and in general working with a real customer was considered to be the best part of the project course.

Students also faced a pressure to perform and finish the work, as the work was done for a real customer. Responsibility toward their customer kept students

working in spite of difficulties with the project or with team members' attitudes. Difficulties were kept to the background, and successful completion of the project was seen as a matter of personal pride.

Finally, based on this analysis and existing literature on university-industry collaboration, four different scenarios were identified showing how work differs between academia and industry. These scenarios are summarized in Table 2.

TABLE 2 Classification of differences in work between academia and industry (Heikkinen and Isomöttönen, 2017)

Scenario	This Analysis	Existing literature
Clarity of the work - fixed goals versus openness	Students are forced to work and deal with ambiguity; situation is reinforced by students' compliance	"Inherent conflicts" in U-I collaboration due to different goals (Cyert and Goodman, 1997, p. 47), Customers do not know what they want (Bond, 1995), Courses are properly planned (Collin and Tynjälä, 2003)
Emphasis of the Work - theory versus practice	Emphasis on concrete results demonstrates to students' the differences between academia and working life	Applied research is shaped by the industry, researchers see it as an investment for the future (Perkmann and Walsh, 2009), Difference in products is acknowledged (Cyert and Goodman, 1997)
Evaluation of the Results - scientific procedure versus value to customer	Students understand the value of their work through customer feedback	Nonexistent in literature review - it is assumed that experienced researchers understand the differences in value
Two audiences - course requirements versus project work	Nonexistent in this analysis - course emphasizes focusing on the project	Students experience working with different requirement challenging (Collin and Tynjälä, 2003)

6 DISCUSSION

The aim of this thesis was to analyze what happens during the students' projects, and the research interests developed toward multidisciplinarity and student-customer interaction as the work progressed. The exploratory nature of this research was supported by the methods used: grounded theory and two types of qualitative content analysis. The results provide emergent grounded theories on the effects of multidisciplinarity on students' learning and their evaluation of their work, as well as systematic analysis of how students perceive their collaboration with their customers. Some of the individual findings in this thesis are likely to be familiar to teachers and researchers involved with project-based learning, and the main contribution of this thesis is the integrated analysis and presentation of the results.

Students' learning experiences are affected by both multidisciplinary team compositions and multidisciplinary project topics, and the core category of the grounded theory is contingency. This core category emphasizes the transformations that can happen in the learning process, and the fact that there is no right or wrong way to learn in multidisciplinary setting, similar to what Gregory and Jones (2009) have asserted with respect to teaching practices. Working in a multidisciplinary environment can lead students to recognize their expertise and increase their own occupational identity, which may be the most interesting learning mechanism in the present grounded theory. Working outside their comfort zone can lead students to negative experiences and frustration, or to positive experiences like maturity and contentment, and positive team spirit can play an important role in these transformations.

Students were generally positive about the course and multidisciplinarity, similar to views reported previously (Ivins, 1997; Burnell et al., 2003; Jaccheri and Sindre, 2007). Analyzing students' views on course arrangements using the qualitative survey also strengthened this image, as students generally commented on the course being a positive experience, taking into account the number of credits received. The source of students' positive and negative comments was their previous experiences with traditional academic courses, especially when they compared the heavy workload of the course to other courses. Concerning potential

financial compensation to students, two main points were identified. Students value the learning experiences, and the financial compensation was seen not as necessary but as a pleasing bonus that would improve the fairness of the course structure. Drawing comparisons to working life, students' felt the need for compensations, especially if the project produces significant value to customer.

Interestingly, students did not comment on the lack of financial compensation unless explicitly asked. When asked, however, their comments were thorough and insightful. This implies two things. First, the financial compensation or the lack of it is not a prevalent issue for students, as they consider the project as an academic course and focus on learning. Second, they might consider it a sensitive issue, and do not want to bring it in discussion themselves. As noted by Clear et al. (2001), the relationship between students and customers is a sensitive one.

Another interesting finding is the students' comparison of project-based learning with real customers and unpaid internships. While analyzing unpaid internships, Burke and Carton (2013) compared them with cooperative learning, and using their criteria, project-based learning resembles internships, partly justifying the comparisons made by students. This comparison is interesting, as unpaid internships have been researched greatly in the recent years (McHugh, 2016; Rickhuss, 2016; Steffen, 2010; Westerberg and Wickersham, 2011; Durack, 2013; Burke and Carton, 2013), providing a framework for analysis of financial compensation from project work.

One motivation for this analysis was to address the not-so-direct comments about the unfair, exploitive, and work-like nature of the project course, and the need to survey the students on this issue. This concern was erased for the most part, but the results show that teachers need to openly discuss the financial issues with students, and inform them about the financial relationship between the university and customer as well, as students might be timid to raise the issues into discussion themselves. Further, this analysis showed that the financial issues in project-based learning are an interesting research topic that has not however gained much attention. Thus, the analysis was continued and grounded theory was seen as the most suitable research method, as the additional data collected demonstrated thorough analysis from students' part as seen through their replies to the questionnaire. The goal of the research was not to answer the question whether students should be paid, but rather to analyze the whole situation more thoroughly.

The emergent grounded theory describes the complexity of students' calculations as they attempt to determine the value of their work. The core category of this theory is the reference point, consisting of students' previous experiences with work, academia, and internships, and the compensation they have received previously. When students are asked about the value of their work, they start with this reference point, and compare the current situation with their experiences, and based on them assign a value to their work. This calculation can be affected by other factors as well. The calculation may be justified by using ethical considerations, preconditions such as course arrangements, perceived signifi-

cance of their work, and their own commitment. Students perceptions of different rewards and their value, presented in the emergent grounded theory as a reward chain, can also play a role in their calculations.

Interestingly, this reference point type perspective is implied in several research papers about unpaid internships (Burke and Carton, 2013; Durack, 2013; Bacon, 2011; Steffen, 2010) and may represent one reason for the lack of research on financial compensation to students. In the aforementioned papers, the focus is on arguing for or against unpaid internships, often equating them with employment which is paid, or academic coursework which is unpaid. For researchers in project-based learning the reference point appears to be "unpaid coursework," meaning that financial compensation to students is not on their agenda. Durack (2013) reports that in recent years some employers have started requiring their interns to obtain college credit for their internships, which interpreted though the theory presented here can be seen as employers unconscious attempt to move interns reference point toward unpaid learning.

Much of the discussion about the ethical and legal issues of unpaid internships revolves around Fact Sheet #71 of the United States Department of Labor, that describes the conditions which determine whether a person is an intern (and therefore does not require a minimum salary) or an employee. While these criteria have been interpreted in different ways, when using the totality of circumstances test where not all criteria need to be fulfilled for a person to be deemed an intern (Collidge, 2015), it resembles the students justification of the present grounded theory. There is a learning component involved and the project course benefits the student, there is a mutual understanding that there will be no salary, and no promise of employment after the project, all of which students used to argue against financial compensation. Students also analyzed their commitment and the significance of their work, resembling the Fact Sheet #71s notion that internship should not provide immediate benefit to the customer. Students' justifications also made reference to ethical issues like student equality and financial issues like livelihood during the project course, both of which were seen as factors opposing the use of unpaid interns, similar to the argument previously made by Steffen (2010).

The interaction between students and their customers is summarized by two global themes, Perceived status and Perceived value, each with its related thematic networks. Both of these themes have similarities with the findings of previous research in university-industry collaboration. Perhaps the most important finding concerns the students' compliance toward their customer, one of three organizing themes regarding students' perception of their status with their customers. In general, students let the customer take control of the project, and even if they recognize that changes are needed, they comply with the customers' needs and requests. Similar behavior in project-based courses has been reported by Clear et al. (2001) and James (2005). In the latter case, the compliance characterized faculty as well, as they finished the work started as a student project. Similar examples of university researchers complying with the needs of industrial partners are presented by Cyert and Goodman (1997).

Based on the thematic analysis and existing literature, four different scenarios were identified concerning how work differs between academia and industry. For students, this has an impact on how they have to work and deal with ambiguity, how they understand that the focus of work in industry is in the results and not on methodologies, and how they learn the value of their work through customers' feedback.

There is a certain built-in tension in the relationship between universities and industry, and this tension encompasses the student-customer relationships as well. The role of university in this setting may hinder the realistic experience of working with a customer, as in the project courses it may differ from the authentic business-to-business relationship.

6.1 Implications for teaching practice

The emergent grounded theory describing students' learning experiences can be used to plan multidisciplinary project courses and their learning outcomes. This is in line with the general benefits and uses of substantive grounded theory: teachers can "work with familiar occasions purposefully" (Glaser, 1978, p.14). Emphasizing either multidisciplinary teams or multidisciplinary project topics allows certain learning experiences to be expected among students, such as increased occupational identity and gaining perspective on general skills. Further, the role of team spirit in transforming the negative experiences to positive implies the importance of team selection and coaching, especially when it comes to the team building phase in the early stages of project work. When the students in a project team are from different disciplines, it can be assumed that they are not familiar with each other. This supports the idea that the team compositions should not be random or determined by students, but instead carefully determined by the teacher based on the best information available about the students. This approach has been used in the course under study, where teams are formed based on students' applications.

Similarly, students' might prefer to work within their own comfort zone to make sure the work progress more fluently, as was implied by some students' comments. This can be a preferred option if the emphasis is on the final product to customer, however it inhibits some valuable learning experiences for students. In this sense, demonstrating the different learning possibilities by using Figure 5 might encourage students to work outside their comfort zone.

The grounded theory describing the students' calculation of value of their work can be used in similar fashion in course planning. If the reward for project course performance is already fixed, the theory works as a checklist, enabling teachers to go through different aspects (categories of the theory) to see if the course arrangements support the predetermined reward. The checklist can be used in different direction as well, starting from course arrangements and determining a suitable reward. It is good to remember that this theory does not offer

clear and unanimous answers to what a suitable reward is, rather providing a general framework for analysis.

The theory offers a tool for teachers to explicitly raise the issue for discussion with students. Students' selection of reference point appears to be unconscious, and teachers need to provide a lens for students to understand the learning that happens in experiential learning (Westerberg and Wickersham, 2011) and make sure the learning component is explicit (Isomöttönen, 2014). If not, it is possible that students reference point unfortunately remains as "paid work" and has negative effect on their performance. Further, as suggested by Durack (2013) the teachers can critically examine their own courses to see if the focus is on learning or exploiting the students.

The thematic analysis revealed some challenges that students might face in their interaction with the customers. From the teachers point of view, it might not be beneficial to remove these challenges, as they can provide valuable learning experiences given that students are coached to deal with challenging customers. However, teachers should make sure that the project topics and customers' expectations are reasonable (Clear et al., 2001). The course under study utilizes a project contract to define the responsibilities of each party, further making sure students are given a safe learning environment. While the challenges in university-industry collaboration can diminish over time as both parties gain more experience in collaboration (Bruneel et al., 2010), this cannot occur in project courses as each course instance brings new students. Thus it remains the teachers responsibility to provide the students with necessary skills to enable successful collaboration.

6.2 Methodological considerations

Qualitative research has long been evaluated using concepts originally used to evaluate quantitative research; however, qualitative research typically does not meet these standards (Oktay, 2012). Lincoln and Guba (1985) devised four criteria for qualitative research: credibility, transferability, dependability, and confirmability. When evaluating the credibility of the results obtained using qualitative content analysis as employed in PII and PIV, we examine whether the results seem believable and represent the "truth" of the situation. In both PII and PIV, the data analyzed was collected over several course instances using the same data collection methods, resulting in persistent observation and providing depth for the research. Scope, another term related to credibility, follows from the author's role as a teacher and researcher, meaning that the research setting was familiar to the researcher.

For both PII and PIV, the transferability of the results was obtained through describing the research setting, data collection, and course setting, thus helping other researchers to apply and interpret these results in other contexts. The same issues hold for dependability, as the arrangements of the research setting are ex-

plained and how they might have affected the study. Also, student quotations are included to support the research results presented. It is, however, good to remember that in PIV the data came from the students' learning reports, where no explicit questions about the role of customer were included, meaning that students might have left out some comments about their customers. Confirmability of the research assesses whether other researchers could confirm the results, and how objective the researcher was. Here, the data analysis was done in collaboration between the two authors of the research papers, reducing the possibility that either author's individual biases could have affected the results.

The suitability of these criteria to evaluate grounded theory can be questioned (Oktay, 2012; Piantanida et al., 2004). In grounded theory, used in PI and PIII, the emphasis is on development of the theory and on the researcher's ability to conceptualize from the data. The quality of the data is not a concern in grounded theory, and the emergent is not ever considered to be finished. Thus, using grounded theory in another course setting could produce a different theory that is not conflicting with the one presented here, instead offering new insights.

6.3 Future research

The research process and the results of this thesis give rise to several topics for future research. First, the emergent grounded theories and the thematic networks identified do not establish the significance of different categories or themes with respect to each other. This motivates additional qualitative studies using surveys constructed on the basis of these grounded theories and thematic networks. The grounded theory emphasizes the constant development of theory produced, because they are never finished, and both of these theories could be developed further. For learning mechanisms stemming from multidisciplinarity, this can be done with the help of additional data and investigating such quantitative factors as hours spent on the project and team composition. Another specific issue to examine could be the transformation from negative to positive experiences and the role of team spirit in these transformations.

Students' compliance toward their customer emerged as an interesting theme that calls for more analysis. Using grounded theory method this could be seen as a core category for further analysis on student-customer interaction. A recent master's thesis (Malinen, 2016), using students' and customers' interviews from this same course, implied that customers might act with similar compliance toward the course coordinators: in these interviews customers gave more critical feedback toward the course arrangements compared to the feedback collected by the course coordinators. Undermining this attitude of compliance can be seen from the viewpoint of course development as requiring honest feedback.

There are challenges that stem from the key course features of multidisciplinarity and real customers. These challenges could be removed or significantly ameliorated by changes to course arrangements, lectures to students, and

coaching of customers. Removing all these challenges could also remove valuable learning experiences, so additional analysis to find the correct balance could be worthwhile.

The research and analysis has also revealed additional interesting research topics and directions, such as financial compensation and the possible relevance of the university-industry literature in project-based learning research. The non-systematic literature review on multidisciplinary project-courses could be expanded into a systematic one, resulting in a taxonomy similar to Fincher et al. (2001).

YHTEENVETO (FINNISH SUMMARY)

Monitieteisyyden vaikutuksesta oppimiseen ja opiskelijoiden näkemyksiä yritysyhteistyöstä projektioppimisessa

Projektioppimisella on pitkä historia korkeakouluissa, erityisesti tietoteknisillä aloilla. Projektioppimisen kautta opiskelijat saavat realistisen kuvan omasta oppiaineestaan ja sen vaatimuksista, ja tätä oppimiskokemusta voidaan laajentaa yritysyhteistyön kautta: opiskelijaprojektien asiakkaina toimivat yritykset ja muut vastaavat toimijat mahdollistavat oikeiden projektiaiheiden käyttämisen. Viime aikoina projektioppimisessa on myös lisääntynyt monitieteisten tiimien hyödyntäminen, mikä mahdollistaa monipuolisemmat projektiaiheet ja tarjoaa opiskelijoille uusia ja erilaisia oppimistilanteita.

Tässä väitöstyössä keskitytään Monitieteinen työelämäprojekti -kurssiin joka tähtää opiskelijoiden yleisten työelämätaitojen kehittämiseen. Vuodesta 2011 asti Jyväskylän yliopistossa järjestetyllä kurssilla monitieteiset opiskelijatiimit toteuttavat asiakasprojektin yliopiston ulkopuoliselle asiakkaalle. Väitöstyön lähtökohta oli eksploratiivinen: halu lisätä ymmärrystä siitä mitä projekteissa tapahtuu. Käytännössä tutkimuksessa käytettiin grounded theory -menetelmää ja erilaisia laadullisia sisältöanalyysimenetelmiä, ja aineistona käytettiin opiskelijoiden oppimisraportteja ja laadullisen kyselytutkimuksen kautta saatua aineistoa. Väitöstyö koostuu neljästä erillisestä tutkimusartikkelista, joissa tarkastellaan kuinka opiskelijat kokevat monitieteisyyden oppimisen näkökulmasta, sekä kuinka opiskelijat kokevat yritysyhteistyön kahdesta eri näkökulmasta: kuinka he arvioivat projekteissa tehdyn työn arvoa, ja kuinka he kokevat yhteistyön asiakkaan kanssa.

Grounded theory -menetelmän tuottamien teorioiden avulla nähdään (1) kuinka monitieteisyys vaikuttaa oppimiseen sekä tiimikokoonpanojen että projektiaiheen kautta, ja kuinka nämä oppimiskokemukset ovat opiskelijakohtaisia, ja (2) opiskelijoiden omista kokemuksista lähtevä monitahoinen prosessi jonka avulla opiskelijat arvioivat työnsä arvoa ja vertaavat sitä työelämään, harjoitteluun tai perinteisiin kurssitöihin. Tulokset myös osoittavat mielenkiintoisen linkin projektikurssien ja palkattomien harjoitteluiden välillä. Lisäksi temaattisen analyysin kautta nähdään kuinka kaksi pääteemaa, koettu status ja koettu arvo, vetävät yhteen opiskelijoiden ja asiakkaiden välisen yhteistyön opiskelijoiden näkökulmasta. Väitöstyön tulokset esitetään myös yhtenäisinä teoreettisina kuvina ja temaattisina verkkoina jotka tarjoavat kokonaisvaltaisen kuvan tutkimuksen tuloksista.

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ORIGINAL PAPERS

PI

LEARNING MECHANISMS IN MULTIDISCIPLINARY TEAMWORK WITH REAL CUSTOMERS AND OPEN-ENDED PROBLEMS

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Learning Mechanisms in Multidisciplinary Teamwork with Real Customers and Open-ended Problems

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Recently, there has been a trend towards adding a multidisciplinary or multicultural element to traditional monodisciplinary project courses in computing and engineering. In this article, we examine the implications of multidisciplinarity for students' learning experiences during a one-semester project course for real customers. We use a qualitative research approach and base our analysis on students' learning reports on three instances of a project course titled *Multidisciplinary working life project*. The main contribution of this article is the unified theoretical picture of the learning mechanisms stemming from multidisciplinarity. Our main conclusions are that (1) students generally have a positive view of multidisciplinarity; (2) multidisciplinary teams enable students to better identify their own expertise, which leads to increased occupational identity; and (3) learning experiences are not fixed, as team spirit and student attitude play an important role in how students react to challenging situations arising from introduction of the multidisciplinarity.

Keywords: project-based learning, multidisciplinary education

1. Introduction

Computing and engineering education has a long history of using projects as a teaching method. In fact, even the first curriculum in software engineering included a "true-to-life" programming project, and since then project courses have constituted a fixed part of software engineering education (Tomayko 1998). In the present day, project-based learning is implemented in these disciplines through a range of course models and arrangements (Fincher, Petre, and Clark 2001; Clear et al. 2001). One of the recent trends is adding a multicultural or international element to the traditional project courses (e.g. Pears and Daniels 2010). Another trend is that courses are organized in collaboration between two or three departments or faculties, thus bringing a multidisciplinary element to the project work (e.g. Burnell, Priest, and Durrett 2003). Both of these trends correspond with the fact that in today's working life one often has to work in multicultural (Last et al. 2000) or multidisciplinary environments (Kruck and Teer 2009).

This article reports on a multidisciplinary working life course offered at the University of Jyväskylä, Finland. Our research interest is in the implications that the multidisciplinary character of the course has for students' course work. This research interest emerged through commencing an inductive grounded theory analysis (Glaser and Strauss 1967; Glaser 1978) on the learning reports that students are required to prepare at the

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end of their projects. We find this theory development-oriented research approach welcome, as the project education field is often studied in the form of course descriptions (Helle, Tynjälä, and Olkinuora 2006). Another unique feature of the present research is that the course under study is targeted at students in all faculties of the University, whereas the multidisciplinary project courses discussed in the literature are often centered on a couple of core disciplines (e.g. Mosiman and Hiemcke 2000; Hirsch et al. 2001; Burnell, Priest, and Durrett 2003; Kruck and Teer 2009). This aforementioned approach used in our project course enables a broader scope of project topics and student team compositions. We base our study on qualitative data collected during three instances of the course where a total of 88 students have worked in 20 different projects with a total of 28 customers.

While our research focuses on the learning experiences caused by the multidisciplinary aspect in general, we believe that our research findings are beneficial and interesting to computer science and engineering education researchers in particular. This is because computer science is a discipline that nowadays penetrates all the sectors of business and everyday life. This presence of the computing discipline can also be seen in the project topics of the multidisciplinary course under study. Thus, students in computing disciplines can benefit greatly from the experience gained from working in multidisciplinary teams.

2. Related work

2.1. *Project-based learning*

The pedagogical approach utilized in this multidisciplinary project is project-based learning. Helle, Tynjälä, and Vesterinen (2006) consider two aspects to be crucial to project-based learning: projects involve a student-defined solution to a problem, and projects commonly produce some kind of end result, such as a report or design plan. They also emphasize problem orientation as the most distinctive feature of project-based learning. While all project-based learning is essentially problem-based (De Graaff and Kolmos 2003), project-based learning is more authentic, and the deliverables are more concrete and implemented into use (Helle, Tynjälä, and Vesterinen 2006).

2.2. *Multidisciplinarity in project courses*

Computer science and engineering project courses are often monodisciplinary capstone projects, as is evident from a cursory glance at the different literature reviews and other published research analyzing engineering design (Dutson et al. 1997) and computer science projects (Fincher, Petre, and Clark 2001), for example. However, there is also an increasing number of multidisciplinary and interdisciplinary projects. As Morse et al. (2007) point out, interdisciplinary or multidisciplinary are terms that are often used when more than one discipline is involved in teaching or research, but these terms are usually not well-defined. For the sake of simplicity, we will not go into detailed analysis of the usage of these terms, but rather consider them to mean situations in which different disciplines interact. A similar approach is used by Borrego and Newswander (2008), who use the general term cross-disciplinary to refer to both interdisciplinary and multidisciplinary collaboration.

Experts-in-team (Jaccheri and Sindre 2007; Sortland 2004) is a large-scale framework for organizing university-level project courses. Up to 1,500 students are divided into "villages" of 30 students, with each village being assigned its own theme for projects. Students are then divided into 6 teams of 5 students, with the aim that each student in

the team comes from a different discipline. The theme assigned to each village combines two disciplines, such as Art and IT. Daniels and Asplund (2000) describe a course where students from computer science, electrical engineering, and mechanical engineering work together to build a team of robots for robot soccer world championships. All 90 students work within the same project, and with a clearly defined contribution from each discipline. Ivins (1997) reports on a project course where courses from two different schools are combined to create a multidisciplinary project course with students from the engineering and design disciplines. Kruck and Teer (2009) describe a project course where experienced adult students from business administration and degree students from accounting are brought together for a multidisciplinary course. A combination of existing courses is used in a project course reported by Burnell, Priest, and Durrett (2003), where three different disciplines and universities work together to make the best possible use of the limited resources available and offer product development exercises in multidisciplinary project teams.

Brownell and Jameson (2004) describe a project course where all the students in the project teams are drawn from the same master's program but with different backgrounds, and work on interdisciplinary problems. In a course titled IT in Society (Daniels and Cajander 2010), the students are all from computer science, but the project topics are real-world cases, and multidisciplinarity appears in the areas of application of IT, such as the hospital environment. While most of the above courses are capstone courses aimed at final-year master's students, Hirsch et al. (2001) describe a freshman course where students from both engineering and communication are brought together.

On the basis of our non-systematic review, multidisciplinary or interdisciplinary projects appear to divide into two categories:

- Students from different disciplines work together on a project (cf. Experts-in-team),
- Students from one discipline work within a project that is focused on real-life problems and areas outside their pure discipline (cf. IT in society).

In the present study, multidisciplinarity is present through both of these categories: students work as members of multidisciplinary teams and on real-life open-ended project topics. The specific feature of this course is that we have had students from each of the seven Faculties, and within those from 18 out of 19 departments. This is illustrated in Appendix A, which shows the team compositions by department of the three course instances under study. All teams have had students from at least three different departments when they have started their project work (team number 19 is the exception here due to student drop-outs during the course). The multidisciplinary nature of project topics is illustrated in the following section through project examples.

2.3. *Benefits of multidisciplinarity*

Several examples of the benefits for students working in multidisciplinary teams compared to monodisciplinary teams can be found in the literature. Quantitative analysis conducted by Hotaling et al. (2012) supports their hypothesis that students on a multidisciplinary capstone course have both better job placement and better evaluation of project results compared to students who work in monodisciplinary teams. Students also prefer working in multidisciplinary teams: they consider the project worthwhile, despite unequal distribution of the workload (Mosiman and Hiemcke 2000). Students consider multidisciplinary projects to be more challenging but also more rewarding than monodisciplinary projects, and the importance of the teaming phase can be seen in student feedback (Burnell, Priest, and Durrett 2003). Students see working with people from varying backgrounds as a positive aspect (Kruck and Teer 2009). Ivins (1997) reports

that despite students' early reactions of fear and anxiety originating from difficulty of the project brief and working with students from different schools, their post-course reflection was mostly on positive outcomes: increased self-confidence and improved problem-solving and decision-making skills. Working in multidisciplinary teams also transformed students' negative and dismissive stereotypes into more positive and realistic views of other disciplines' students. In addition, multidisciplinarity and communication were seen as important parts of the learning process. Students often feel that they learn different things in multidisciplinary project courses compared to normal lecture courses and give positive feedback about these learning experiences (Jaccheri and Sindre 2007), while such positiveness also constantly emerges when students compare monodisciplinary projects with lectures (e.g. Isomöttönen 2011).

3. Course description

In this section, we describe the history and motivation behind the project course. We also describe the main features of the course and the preparations needed to organize one instance of the course.

3.1. *Background and history*

The present multidisciplinary working life project was created within a development project funded by the European Social Fund (ESF) and administered by the Agora Center research unit of the University of Jyväskylä. The main goal of the development project was to improve collaboration and knowledge transfer between local small and medium-sized enterprises (SMEs) and the university, an area which was seen as in need of improvement. The resources of SMEs participating in the development project were often rather limited and the scale of their problems were suitable for student course exercises and as thesis topics, and thus it was natural that collaboration focused on utilizing these student resources.

Based on the experiences of the collaboration between SMEs and students gained in the development project, a multidisciplinary project course with real-life customers was piloted during the summer term of 2011. As the course was run without content-oriented input from the faculties no single discipline was the focus and thus a multidisciplinary approach to the course was natural. This meant that the project topics were by and large not limited in any way and hence collaboration became possible with a wide range of customers in different business sectors. Accordingly, the focus of the learning was on general working life skills rather than on enhancing the students' substance skills.

3.2. *Learning goals and grading*

The course sets four learning goals to students. After completing the course, students should:

- Be able to recognize their own expertise and strengths in both project and team work;
- Be able to apply the theoretical knowledge of their discipline and other competencies in a real-world case;
- Be able to work as a responsible member of a project team and work with the customer;
- Know the basic concepts of project work, which include the ability to set goals for a project, write a project plan, realize the project in a multidisciplinary team, and present the results to the peer group.

All students are individually graded as pass/fail. Pears et al. (2001) have demonstrated that using pass/fail when assessing students is sufficient and does not affect student motivation in a negative way compared to more detailed grading systems. In order to pass the course, students need to actively participate in the project, which means that they have to work at least 120 hours on the project and keep track of their working hours. The documents required by the course are project plan, mid-term report, project report, and personal learning report. At the end of the projects, teams present their results to the customer and to the course coordinators. In the project reports, student teams summarize and analyze project deliverables and how they managed the project, and provide feedback on the course. These requirements can be easily graded as pass/fail, while the working hours tracking enables monitoring of student participation throughout the project. Students have to monitor themselves how the workload is distributed within the team, and thus it is also the teams' internal responsibility to prevent free-riding. Customers give feedback on the projects, which affects how the course is developed and supports student learning, while it does not directly affect whether an individual student will pass the course. Instead of "measuring" whether the students achieve the predetermined learning goals, the focus is in enhancing their learning during the course with a dialogic process in which the course coordinators give feedback on the students' deliverables.

So far all the students who have finished their project work have passed the course. Altogether, 103 students were accepted to the course. Of these, 6 canceled their participation, 5 dropped out during the introductory lectures, and 4 students dropped out during different phases of the project work. Thus 88 of 92 students who started the project also passed the course, which equals to 96%. While a great majority of the students pass the course, they do not consider it to be an easy course. Instead, they have commented the course having extremely heavy workload. Similarly, Brown (2000) reports that students enjoy project work and often spent more hours than required to complete the projects.

From the research point of view, we are not interested in how well students reach the learning goals, nor are we trying to evaluate the course. Instead, we are interested in the conceptual mechanisms that explain the students' learning experiences, as derived from their personal learning reports.

3.3. *Preparations*

Thus far, during the three instances the course has been organized, there have been two course coordinators. Before the course starts, their responsibility is to plan the course schedule, screen prospective customers, and deal with students' applications for admission to the course.

All prospective customers are met face to face to discuss their needs and potential project topics. Customers are informed about the nature of the projects in these discussions. That is, they act strictly as customers, not partners, and participate in project work only by advising and giving feedback and information needed by the students. Eligible customers sign a preliminary agreement to participate. Final project topics are not decided at this stage, but tentative project topics and guidelines are agreed upon. Once the student application deadline has passed, all applications are evaluated and summarized, and student profiles are created on the basis of their free-form applications. Prospective customers and student applicants are then matched to form student teams. This matching has three equally important aspects that need to be satisfied:

- Each student should be in a team where he or she can be a useful member of the group.

- Each team should be multidisciplinary, with members from at least three different disciplines.
- Each team should have a combination of skills that can enable them to realize the project.

The final selection of customers and students for the course depends on this matching process. There are no fixed criteria for the selection of students or customers, and due to resources there is a limited number of seats for students, which means that some of the prospective customers and students are inevitably left out. As this project course is optional and not a required course in any degree, this does not cause any delays or problems for students regarding their graduation. Interested students are advised to reapply for the next course instance.

3.4. *During the course*

At the beginning of the project, students receive introductory lectures on project work, working with customers, communication, and multidisciplinary teamwork. These lectures are scheduled for the first two or three days of the course, and no other mandatory lectures follow. During the lectures, students meet other team members for the first time, and their teaming phase starts.

Promotion of an authentic working life experience, which is the course target, is mainly implemented by using real customers and open-ended project topics. While the course coordinators have negotiated with customers about the project topics, it is the responsibility of each team to finalize and agree upon the project topic with the customer and write a corresponding project plan. At no point do the course coordinators participate in the meetings between the team and the customer or get involved in fixing the project topic.

There are only four mandatory checkpoints for all teams. First, the course coordinators check and comment on the first version of their project plans with the teams around three weeks after the course has started. A meeting with the project managers takes place around the mid-point of the project, along with a similar meeting for all the students on the course. Teams have to write a project mid-term report after these two meetings. Otherwise, the student teams work independently.

The above-mentioned features that aim to promote an authentic working life experience accords with the "thrown in the deep end" approach: students have to work with previously unknown people for a customer on a project topic that may be outside their core skills, and they have to learn to work independently and take responsibility of their work without constant supervision. This approach of light tutelage and independent work was in fact even more extreme the first time the course was run, but was then moderated somewhat following student feedback: introductory lectures were added and the possibility of tutelage on request was emphasized.

Once the projects are finished, the teams prepare a final presentation for their customer and the course coordinators. In discussions following this presentation, feedback is collected from both customers and students. Customers are also given a feedback form to fill in later on. So far, the project customers have shown a high level of satisfaction with the course arrangements, student teams, and project deliverables.

There is also a final seminar where the teams present their project to the other teams, and the course coordinators sum up the course. Student feedback is collected along with each teams' project report and the individual student learning reports. In their personal learning reports, students are asked to reflect on the project, team work, customer, their own learning experience, and what they consider to be the positive and negative sides

of the whole project. After the course is finished, each student receives an individual project certificate that can be used, for example, as a reference when applying for a job.

Table 2 summarizes a single course instance described above. One course instance lasts around 15 weeks. A project contract that is signed by the university, customer, and students stipulates that students do not need to spend more than 180 hours on the project. An important part of learning is planning the project so that the goals can be achieved. Students take advantage of computer labs and meeting rooms, while they also work off-campus. In the project plan, they are expected to plan the practice of their collaboration including the timetable.

In the classification of computer science project courses by Fincher, Petre, and Clark (2001), this course best corresponds to the "Project with a client" type of course. However, this definition excludes the multidisciplinary aspect of our course. A brief description that would include all the main aspects of our course could be "Multidisciplinary one-semester course with real customers and open-ended problems." While there are no extensive lectures on the topics that projects involve and students are expected to utilize their existing skills, we do not consider our course to be a "capstone" course. Our course might also be classified as an "Open-ended Group Project" (Daniels and Cajander 2010).

3.5. *Examples of project topics and deliverables*

Examples of the projects realized by multidisciplinary teams during the first three course instances are given below:

- Example 1: Customer was a micro-sized company in tourism and travel business who wanted to increase the number of visitors during their off-season. The student team produced a report on the current state of company's web-based marketing and coverage. They redesigned the company's website, created new content for the website, and created new self-directed activities for tourists.
- Example 2: Customer was a small-sized IT company that was launching a new product and wanted help in their marketing efforts. The students designed a logo, slogan, and visual look, as well as a brochure and website for the product. They also created a prototype version of the product and conducted a customer survey and competitor analysis.
- Example 3: Customer was a micro-sized company that was creating a new web-based service. They wanted to strengthen the brand of the company and receive help on the development of the service. The students designed and created a promotional video of the service, conducted a competitor analysis, and devised a questionnaire for the current and potential users of the service.

These examples illustrate the wide range of projects realized in the course. We have observed that IT is the element often included regardless of the main business domain of the customer. However, the projects of the course are not intended to be system-development projects or requested as such. Student teams are involved in defining the project goals together with their customers, meaning that the students from several disciplines are sharing ideas and innovating solutions together with customers for given open-ended problems. Here, different disciplines such as business and marketing, computer science, and arts and humanities meet. Depending on the project topic, some students in the teams provide technical perspective, while others bring understanding of the customer's business domain or add a human-centered perspective, for example. After the period covered by our research data the spectrum of customers has broadened to cover areas such as culture, sports, learning disabilities, entrepreneurship, and environment.

4. Method

Our research interest was in general to develop an understanding of multidisciplinary student project work. The results of the study bring to the foreground conceptual mechanisms, generally related to multidisciplinarity, which emerged from and explain the students' experiential data. The research method of the study is the grounded theory method originally formulated by Glaser and Strauss (1967). This method was selected due to our interest in the phenomenon of multidisciplinary project work instead of validating the course through hypothesis testing or verifying existing theory. Our main reference to the grounded theory method is the classic form of it (Glaser and Strauss 1967; Glaser 1978, 1992, 2004), which by its definition was deemed suitable for our research interest.

The use of grounded theory method is increasing (van Niekerk and Roode 2009) and has been encouraged (Kinnunen and Simon 2010) within engineering fields. The article by Case and Light (2011) suggests that the use of grounded theory and other "emerging methodologies" can expand the research in engineering education. The classic grounded theory method has been used in ICT-related dissertations by van Niekerk (2009) and Isomöttönen (2011). The study by Gregory and Jones (2009) provides an example of the classic grounded theory study in higher education.

At the beginning of our results, we provide a general description about how multidisciplinarity showed up in our data (cf. content analysis), while the main focus of the paper is in the grounded theory analysis provided thereafter.

4.1. *Grounded theory*

The general idea of the grounded theory is that the process which generates the theory should not be separated from the theory itself. It considers theory a process emphasizing the "generation" of the theory instead of fixed conceptualizations. Accordingly, the grounded theory method is characterized by the tenets such as "ever-developing" and "theory as a process" (Glaser and Strauss 1967, 32). The value of it is in the relevance of theory generated from the data (cf. deductive theories).

The analysis procedure in grounded theory is called the constant comparative method consisting of four stages (Glaser and Strauss 1967):

- Comparing incidents applicable to each category.
- Integrating categories and their properties.
- Delimiting the theory.
- Writing the theory.

These stages are overlapping and done simultaneously as opposed to a linear order. This enables the continuous development of the theory emerging from the data, and the inclusion of new data as the research advances. Grounded theory is iterative by nature, and once a relevant core category or framework begins to emerge, the analyst focuses on the theory development around this core.

In grounded theory "all is data," and instead of worries about data accuracy, the emphasis is placed on the researcher's ability to conceptualize from the data. Theory development is bounded by the current data, and the resultant theories are open to modification. The grounded theory presented in this paper should thus not be seen as a fixed conceptualization.

Section 4.3 shows through examples how the constant comparative method was utilized in this research. A more detailed description of the grounded theory analysis and constant comparative method is provided by Glaser and Strauss (1967, 101-115).

4.2. *Data*

The data analyzed in this study are the learning reports produced by students at the end of their projects. After the course was held for the third time in summer 2012, all the students who had passed the course were sent a research permit request by email by a course coordinator who is also an author of this research. Altogether, 66 students out of 88 gave permission for their learning reports to be used for the research purposes. We did not receive responses denying the use of answers for research. Regarding those who did not respond, we believe that the email retrospectively requesting the research permit was out of students' interests. It is worth noting that almost 1.5 years had passed from the first course instance, and some students had already graduated.

As we requested the research permission retrospectively, the research did not affect the data used. The data thus realistically reflect students' experiences collected as a natural part of the course close-up activities. It is also worth noting that no direct questions were set for the students to answer in the reports, and that the questions accompanying the assignment were intended to structure their analysis and process of self-reflection. Moreover, we consider data applicable to research in the sense that students seem to express their frustration and problems in the data. It should be noted here that the course is graded only with pass/fail, meaning that students do not have to restrict their criticism of the course in the fear that this would affect their grade. These aspects are in line with the idea that the role of a grounded theorist is essentially a passive one (Glaser 2002).

The report assignment is given during the start-up lectures so that the students are able to prepare for them early on. More detailed instructions on the assignment are given during the final seminar, where the students are shown some previously collected student feedback. The aim is to encourage students to reflect on their experiences instead of writing a list of the tasks they did during the project. Thus a diary type of report is not encouraged, but explicitly forbidden. Students are advised to write the reports so that they too can benefit from them. There is no length requirement, and the report has no effect on the students' grading. These instructions mean that the content and length of the reports vary widely, from half a page up to six pages, and from a few notes about project work to long analyses and self-reflection about everything that happened during the project.

4.3. *Analysis procedure*

We began by open-coding (Glaser 1978, 56) the data with ATLAS.ti software. The first author did the initial open coding by first reading through all the learning reports to obtain a general view of the data, and then by coding all the key points that emerged as interesting. In the data, multidisciplinarity emerged as one of the most meaningful aspects for the students. Following this stage, the second author reviewed the codings related to multidisciplinarity in a shared session, and some re-codings were made. Initial emergent theoretical ideas were written down from the very beginning.

Through sorting out the resultant codes, the analysis continued with attempts to integrate the results into conceptual hypotheses and a coherent theoretical view (see Glaser 1978). Finally, the research process became selective, focusing on the theme of multidisciplinarity, and evolved into an iterative process where after several integrative stages, re-perusal of the data, and writing sessions, the final theoretical framework emerged.

Glaser (1978, 72-82) has proposed several coding families that can facilitate the integration of theory. In our case, we find the resultant theory to resemble a 'typology' (Glaser 1978, 65–68) within which several 'causalities' (Glaser 1978, 74) can be identified. We refer to these causalities as mechanisms.

In grounded theory, "categories and properties are concepts indicated by the data": a category is a conceptual element of the theory, and a property is a conceptual aspect or element of a category (Glaser and Strauss 1967, 36). A key feature of a grounded theory is the emergent core category, which ties the theory together and is meaningful for those involved. The core category of the present grounded theory is seen as a kind of contingency, signifying what happens when students encounter multidisciplinary project work. Thus there is no single mechanism in play when the students, with their various motives and attitudes, arrive to start the course; instead, their learning experiences can vary, resulting in both positive and negative experiences, and possible transformations from negative to positive experiences. Within this framework, there are opportunities for valuable learning experiences, in particular through the identification of the peculiarities of one's own discipline and expertise—as will be explained in the Results section.

The key element of the grounded theory analysis is how conceptualizations emerge from comparison (Glaser and Strauss 1967, 101-115; Glaser 1978, 62). An example is given as follows: at certain point of coding, we had a category 'Working outside comfort zone,' which refers to situations where students face tasks outside their expertise. In our data, students reflected this situation as being frustrating, and thus Frustration became one property characterizing this category. Through comparing on-coming data incidents with this conceptual scheme, we observed that some students' response to this same situation was more mature and favorable. Thus, Maturity became another property of the same category. Further comparing these two conceptualizations, we noted that Maturity was always preceded by Frustration instead of being a direct consequence of working outside comfort zone, and noted that transformation from Frustration to Maturity occurred in some cases. Continuing the comparison, team spirit emerged as a factor in whether this transformation occurred, and transformation became a category with team spirit as its property.

5. Results

This section presents the results of our analysis. We begin by describing the general view that students had of the course and multidisciplinarity, and then continue by focusing on the mechanisms that reveal how multidisciplinarity played a role in learning.

5.1. *General experience of the course and multidisciplinarity*

In the 66 learning diaries, we found a total of 112 comments on multidisciplinarity. These were either direct comments or descriptions of situations that we interpreted as relating to multidisciplinarity. More specifically, these 112 comments were found in 48 different learning diaries, which means that 73% of the students commented on multidisciplinarity in some way. The richness of information in what we refer to as a single comment varied greatly. One code about multidisciplinarity could originate from several paragraphs across the report or be an explicit expression about multidisciplinarity.

While some negative and neutral comments were found, overall the course feedback was mostly positive:

> [student:] *It was a long journey, sometimes very stressful but really rewarding and it was worth it.*
>
> [student:] *If I had known how much work the course required I might not have applied. But I am happy I did, this was absolutely one of the best courses in my university studies.*

Comments of this kind are in agreement with the literature on student project courses,

where positive experiences are often found even if a lot of problems have been experienced during the course. This can be attributed to the fact that these projects are often students' first experiences of more practical coursework after their theoretical courses, boosting their positive experiences (Isomöttönen 2011). Most of the students commented on the multidisciplinarity of the course in either a positive or neutral way:

> [student:] *Multidisciplinarity was clearly a benefit in this project since the project required a lot of different skills.*

> [student:] *I think our group's strength was that our disciplines were so different and everybody brought their own expertise to the project.*

> [student:] *I felt that multidisciplinarity was neither a benefit nor a handicap.*

In fact, we found no directly negative comments, and most of those who saw multidisciplinary teams as a challenge commented that such a setting was rewarding:

> [student:] *Now I know how challenging it is to form a well-working project team, but I also know how rewarding it is to work in a project where different skills* [refers to different background of team members] *and personalities meet.*

On the basis of these generally positive responses, we are inclined to conclude that, from the student perspective, this practical and multidisciplinary course is a worthwhile addition to the curricula of many faculties.

5.2. *Overview of the effects of multidisciplinarity on learning*

Figure 1 summarizes the grounded theory that emerged on the effect of multidisciplinarity on learning experiences, as interpreted from the students' experiential reports. The main concepts that we were able to identify settled on the matrix with two orthogonal axes. The horizontal axis describes whether the learning experience was negative or positive, and the vertical axis whether it was caused by the multidisciplinary project topic or multidisciplinary team. Those student experiences that were identified as being caused by working with a project topic outside their expertise were grouped into the Multidisciplinary project topic, and experiences caused by working with people from different disciplines were grouped into the Multidisciplinary team.

We found the multidisciplinary project topic to be related to three main categories; 'Working outside comfort zone,' 'Gaining a perspective on core skills,' and 'Recognizing lack of expertise,' the last of which follows from the first mentioned (see Figure 1). Further, we identified four different concepts that relate to the main categories as their consequences: 'Contentment,' 'Maturity,' 'Frustration,' and 'Uncertainty.' Both positive and negative experiences followed from 'Working outside comfort zone,' while the two other main categories were linked with purely positive or negative experiences.

The multidisciplinary team was found to be related to two main categories, 'Recognizing expertise' and 'Gaining a perspective on general skills.' Three concepts, 'Frustration,' 'Maturity,' and 'Increased occupational identity,' were found to be linked to these categories as consequences.

We thus found that multidisciplinarity plays a role in student learning experiences in several ways: the theory in Figure 1 captures several different conceptual mechanisms. Further, we also identified transformation in the consequences of multidisciplinarity from negative to positive, meaning that the learning experiences arising from particular factors are not always fixed and thus that there is no right way to learn or teach on this course. In this sense, we associate the generated grounded theory in Figure 1 with the 'contingency theory,' along the same lines as Gregory and Jones (2009).

In the following sections, we review the mechanisms found in Figure 1. We begin with

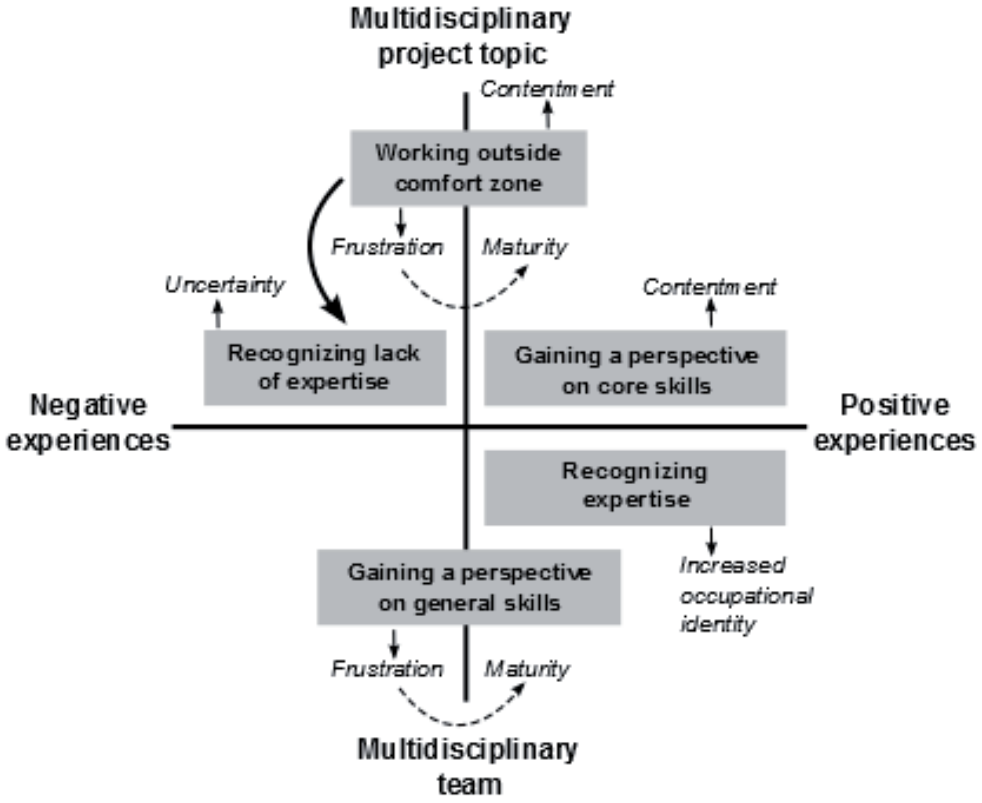

Figure 1. Learning mechanisms in Multidisciplinary project work

the mechanisms that relate to the multidisciplinary team and continue with those that relate to the multidisciplinary project topic.

5.3. *Multidisciplinary team and learning*

Mechanism: Recognizing expertise ⇒ Increased occupational identity

'Recognizing expertise' refers to the situation where students start to understand their own discipline, i.e., what they have actually learned during their university studies and what possibilities they have to utilize these skills. This occurs when students are put to work in a multidisciplinary team and start to compare themselves to the others in the team. This causes positive feelings and self-confidence and increases students' occupational identity, as illustrated by the following quote:

> [student:] *I have sometimes wondered what the gain from my own discipline to my subsequent working life could possibly be, but then I noticed that during the project that I often relied on my sociological imagination and the methods I had learned during my studies. It is a really great feeling to be able to utilize them in a real and meaningful way.*

The effect of being a part of multidisciplinary team was particularly emphasized when students made favorable comparisons to their previous experiences of monodisciplinary teamwork:

> [student:] *Because the team was multidisciplinary I realized that I actually know quite a lot about human behavior and the factors affecting it. When talking to other students with the same major this was not so evident but when I was working in this team I noticed that lots of the things that are obvious to me are new to others.*

In our opinion, this self-discovery of "*Who I am*" is the one of the most important learning experiences that emerged from data.

Mechanism: Gaining a perspective on general skills ⇒ Frustration ⇒ Maturity

'Gaining a perspective on general skills' occurs when students possess a set of general skills that they have used before in monodisciplinary teamwork or in some other setting. They have some understanding of these skills and how well they are able to use them. When put to work in a multidisciplinary team, they are faced with a new situation, and hence see their skills in a new way. They do not necessarily learn new skills but better understand their existing skills and how these skills can be utilized:

> [student:] *It was interesting from the viewpoint of teamwork skills to work with students from different disciplines because teamwork was different compared to working with students from my own discipline. With them the working style is quite similar but in the multidisciplinary working life project I learned how others work and also to modify my own working style to suit different situations.*

While students find 'Gaining a perspective on general skills' for the most part a positive thing, it can also be a source of negativity, in particular frustration, during project work. For some students, this frustration transforms into maturity as the project advances and the students begin to understand other students' characteristics and ways of working:

> [student:] *There were a lot of different kinds of personalities in the team. In teamwork in my own discipline the people are more homogeneous. Even though there are different personalities there as well the background is more or less the same... I learned to cope better with team members' whining and to sift the essential parts out from the daydreamers' great visions and in the future I will have at least a little bit more courage to give my own opinions.*

5.4. *The multidisciplinary project topic and learning*

Mechanism: Working outside comfort zone ⇒ Frustration ⇒ Maturity

Situations inevitably arise in this course where students are faced with real-world project topics that do not allow them to fully utilize their core skills. Because the students come from different disciplines, the project topics appear multidisciplinary, and hence may require them to operate outside their comfort zone to be able to contribute to the project. They then have to start learning requisite skills alone or with another team member; it is this situation that we refer to as 'Working outside comfort zone.'

Working outside comfort zone implies a learning mechanism that starts from feelings of frustration that gradually transform into maturity. This frustration can hinder teamwork, and, when it turns into maturity, may give rise on reflection to feelings of embarrassment:

> [student:] *It was from these situations outside my comfort zone* [a student of humanities was designing a web site] *that I learned the most about myself. I have a lot to improve in my teamwork. I have always considered myself a solidary team player but now I noticed myself whining to other team members just like a teenager. I am embarrassed by my behavior but I have decided to learn from this experience.*

A quote from another student in a similar situation shows that this transformation can happen when the students see the project advance and they can contribute to it in a meaningful way. Team spirit can also serve as an enabling element in this transformation:

> [student:] *When the project progressed and the results started to seem more concrete my own motivation also started to grow. I believe this was because the project tasks progressed*

and that I noticed I can manage them even though I was very uncertain in the beginning. Another even bigger factor was our team spirit which grew stronger during the project.

Viewing this situation from another angle, students who possess the requisite skills and are working within their comfort zone might feel disappointment and frustration. For them, the other students are a burden, and they feel that they have to do all the work themselves:

[student:] *I was slightly disappointed after the first few meetings when I realized that three of the team members did not possess the skills to contribute to it or were not interested in the business-related part.*

As a side note, this team finalized their project successfully, and the customer was satisfied with the results. However, the team spirit in this particular team turned out to be poor, and negativity and accusations directed at other team members appeared in their learning reports. It seems that team spirit can play an important role in students' learning processes, especially in whether the students can transform negative experiences into positive ones during the project.

It is also worth noting that one team decided early on in the project that nobody needed to work on tasks they were not familiar with. While this may be an efficient way of working, it eliminates the possibilities for the above-mentioned learning experiences caused by 'Working outside comfort zone'.

`Mechanism:` Working outside comfort zone ⇒ Contentment

Furthermore, students who worked outside their comfort zone reported learning new skills. The students in this situation were able to practice new skills and learn the terminology and basic concepts used in other disciplines. This leads to positive learning experiences, which we refer to as 'Contentment':

[student:] *Business process modeling was a completely new thing for me. Now I love it [...] and I am going to apply it in the future in several areas.*

In particular, Contentment emerges when students have a positive general attitude towards practicing and learning new skills. In other words, practicing new skills is seen as an opportunity rather than a challenge:

[student:] *My personal goal in joining the course was to learn something new and practical for working life. Making brochures, creating the website and meetings with the customers were in my opinion the most important parts of the project in regards to achieving that goal.*

`Mechanism:` Working outside comfort zone ⇒ Recognizing lack of expertise ⇒ Uncertainty

Working outside one's comfort zone can cause students to compare their skills with the project's requirements in a negative way. They start to question their own competence and role in the project and notice that they do not possess the skills required. We refer to this as 'Recognizing lack of expertise':

[student:] *I was concerned about my part in the project since I have no knowledge at all of marketing or sales.*

This comparison causes 'Uncertainty' among the students:

[student:] *I started to doubt my own competence with regard to the tasks I was assigned, and I was worried by the somewhat large amount of time that the entire course required.*

We can contrast this learning experience with 'Recognizing expertise' through working in a multidisciplinary team. We did not find any comments to the effect that working in a multidisciplinary team or with unknown people caused uncertainty of this kind.

Mechanism: Gaining a perspective on core skills ⇒ Contentment

Due to the presence of a real customer and a multidisciplinary project topic, some students were able to draw on and combine several of their core skills. We refer to this as 'Gaining a perspective on core skills.'

> [student:] *I was able to utilize my previous experience of creating websites as well as my expertise in environmental and ethical issues and combine all these things in a way I had not done before. This was a good experience that suited me well.*

Here, 'Contentment' is also a consequence of learning. Thus, the learning mechanisms in this case resemble that mentioned above, where 'Contentment' emerged from working outside one's comfort zone.

6. Conclusions and discussion

In this article, we analyzed the learning experiences of students enrolled in a multidisciplinary project course. The students' attitude towards the multidisciplinarity of the course, present in the multidisciplinary nature of the project topics and working with students from other disciplines, seems to be positive overall.

The main contribution of this study is a unified theoretical picture that captures the mechanisms that explain the student experiences of a multidisciplinary course setting; see Figure 1. We consider two mechanisms the most important ones. First, working in a multidisciplinary team enables students to recognize the peculiarities of their own discipline, and thus their own expertise, which increases their sense of occupational identity. Second, engagement in a multidisciplinary project topic directs students to work outside their comfort zone. Reactions to this situation differ among students. For some of them it is an experience that results in contentment. For others it can cause frustration, which again can transform into maturity as students come to realize that they can make progress. A supportive team spirit can contribute to this transformation.

Students' positive attitude towards multidisciplinary project courses has been reported by several authors (Burnell, Priest, and Durrett 2003; Ivins 1997; Jaccheri and Sindre 2007). Ivins (1997) noticed that working in multidisciplinary teams enabled students to break somewhat negative prejudice that they potentially have against other disciplines' students, which is complemented by our findings on the occupational identity. While researching computer science projects, Isomöttönen (2011) noticed that one and the same element in a realistic project course can engender both a positive and negative experience, and attributed this to the fact that several issues in project-based learning are of sensitive nature—this is likely to relate to our concerns about how the transformation from frustration to maturity can occur. Our findings also support the notion of Gregory and Jones (2009) "that there is no one best way of teaching" in a sense that both team composition and project topic have different and non-fixed effects on learning experiences.

We have not come across grounded theory studies on multidisciplinary student projects; one grounded grounded theory analysis has been applied to multidisciplinary research teams in academia (Younglove-Webb et al. 1999). In this connection, the emergent theoretical framework in Figure 1 can be utilized in planning a multidisciplinary project course, evaluating such a course, or informing research surveys about student learning in a multidisciplinary context. For instance, a teacher of a multidisciplinary project

course can be interested in promoting a certain learning experience, such as Recognizing expertise, and focus the course planning accordingly, in this case by emphasizing the multidisciplinarity of student teams. In general, the value is that using this substantive theory teachers can "work with familiar occasions purposefully" (Glaser 1978, 14).

The grounded theory method allows the constant development of theory. Thus we can continue our research and take into account such factors as hours spent on the project, students' major and other background information, project topic, and the team spirit. This can be done by analyzing further the data we have already obtained. This includes students' learning reports, projects' final reports, and the working hours students have reported. Utilizing this data would allow us to deepen the theoretical framework in Figure 1. For example, the hours spent by each student could provide interesting insights into learning experiences. We have also planned doing a full content analysis on the students' learning reports to develop a complete picture of the course and aspects other than multidisciplinarity.

Using projects in computer science education has a long history (Tomayko 1998), with a range of recognized project-based course models (Fincher, Petre, and Clark 2001; Clear et al. 2001). In our view, multidisciplinary project work can revitalize computer science projects with one prominent benefit being the emerging possibility of identifying the peculiarities of one's own discipline. From a more practical viewpoint, it would be necessary to investigate more profoundly how the transformation from frustration to maturity, as discussed above, occurs, and how this process could be enhanced—in order to emphasize positive learning experiences.

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Appendix A. Team compositions during the first three course instances

Table A1. Composition of student teams by Departments

Team	Students from Department of...
1	Chemistry; Computer Science and Information Systems; Mathematics and Statistics; Social Sciences and Philosophy
2	Biological and Environmental Science; Computer Science and Information Systems; Physics; Social Sciences and Philosophy
3	Computer Science and Information Systems; Health Sciences; Mathematical Information Technology; Social Sciences and Philosophy
4	Communication; Computer Science and Information Systems; Mathematics and Statistics
5	Computer Science and Information Systems; Social Sciences and Philosophy
6	Computer Science and Information Systems; Music, School of Business and Economics; Social Sciences and Philosophy
7	Computer Science and Information Systems; Languages; Physics
8	Computer Science and Information Systems; History and Ethnology; Languages; Physics; Social Sciences and Philosophy
9	Communication; Health Sciences; School of Business and Economics; Social Sciences and Philosophy
10	Education; Health Sciences; Languages; School of Business and Economics; Social Sciences and Philosophy
11	Art and Culture Studies; Biology of Physical Activity; Computer Science and Information Systems; School of Business and Economics
12	Communication; Education; Health Sciences; School of Business and Economics
13	Computer Science and Information Systems; Languages; School of Business and Economics; Social Sciences and Philosophy
14	Computer Science and Information Systems; Mathematics and Statistics; Psychology, Sport Sciences
15	Communication; Computer Science and Information Systems; Education; School of Business and Economics
16	Biology of Physical Activity; Computer Science and Information Systems; Languages; School of Business and Economics
17	Computer Science and Information Systems; History and Ethnology; Mathematical Information Technology; Physics; Social Sciences and Philosophy
18	Education; Languages; Mathematical Information Technology
19	Mathematical Information Technology; Social Sciences and Philosophy
20	Communication; Computer Science and Information Systems; Education; Social Sciences and Philosophy; Sport Sciences

Table 2. Overview of the course structure

When	Who	What
Week 1	Coordinators, Students	Introductory lectures about project work
Week 2	Coordinators, Students	Presentation of Customer and tentative project topic
Week 2	Students, Customers	Negotiations about project topic
Week 2	Students	Start working on project plan
Week 3	Coordinators, Students	Feedback about project plan
Week 4	Customer, Students	Signing the final project plan
Week 5	Students	Project work begins
Week 7	Coordinators, Students	Meeting with project managers
Week 8	Coordinators, Students	Meeting with all teams
Week 9	Students	Project mid-term report
Week 14-15	Coordinators, Students, Customers	Final presentation
Week 15	Coordinators, Students	Final seminar
After the project	Students	Project report, individual learning reports

PII

STUDENTS' OPINIONS ON FINANCIAL COMPENSATION FROM PROJECT WORK

by

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Students' Opinions on Financial Compensation from Project Work

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Abstract: Project-based learning with real customers arguably offer value for all stakeholders. This value has been discussed in literature both from the viewpoint of customers and the related economic value, and the enhanced learning of students. This paper presents the results from an empirical study on students who have completed a multidisciplinary project course with real customers. A qualitative survey was focused on how students see the value of project-based learning and whether there should be financial compensation to students. The students placed a higher value on learning than financial compensation, and while they argued that it would be fair and nice if some compensation was paid, they did not see it as a necessity. They also considered financial compensation problematic: how should it be distributed within the team, and could it affect students' and customers' motivation to participate in the project course. Students emphasized that the issues related to financial compensation should be discussed openly.

1 Introduction

Many problems can emerge during project courses, although student enthusiasm toward authentic project participation usually yields a positive overall learning experience no matter what problems occur (Isomöttönen, 2011). The starting point of this paper is that this overall positive experience can mean that students are not comfortable raising important but sensitive questions during the project course.

Project-based learning can be organized as a "Project with a client", where students realize a project for a real customer and are faced with real-world problems (Fincher *et al.*, 2001). In some cases, the economic value that customers gain from this type of projects is significant, while the value for students is in the learning (Mann and Smith, 2006).

One somewhat analogous situation in higher education is unpaid internships, which have received negative publicity in the mainstream media over the last few years[1]. In these cases, interns are essentially doing the same tasks as employees of the company, but without pay, and the learning aspect essential to internships is left out[2].

The present qualitative study originates from a project course where multidisciplinary student teams realize projects for real customers. In each project, a project contract is signed by the customer, each student, and the university. Customers are billed an administrative fee by the university, and the university grants credits to the students.

While the students are generally satisfied with the course, we have received (sometimes anonymous) feedback from students not participating on the project course, arguing that students should get some financial compensation since they are in one sense "working without pay" for their customer. Thus, the course has been labeled as "exploiting students for the benefit of customers" by some. With this in mind, we sent out a questionnaire to students who had completed our project course to find out how they see the value of project-based learning and the work they do in projects.

A total of 38 students answered a qualitative survey (Jansen, 2010) that explored students' opinions on the project course arrangements in general, the number of credits they are granted, and whether they should be paid. The research focused on the issue of financial compensation and the related fairness in project work.

[1]http://www.businessweek.com/articles/2013-06-27/unpaid-intern-lawsuits-explained

[2]http://www.forbes.com/sites/theyec/2013/04/19/6-legal-requirements-for-unpaid-internship-programs/

One can argue that the premise of this research is trivial and students are satisfied with conditions in project-based courses as they have been organized for decades, and are fixed part of curricula in many higher education institutes. However, there seems to be little to none empirical research on financial compensation to students.

2 Related work

Industry often participates in capstone courses as a sponsor, providing resources such as funding and expertise, and sometimes acting as customers offering "authentic involvement" (Dutson *et al.*, 1997). Warnick and Todd (2011) describe a project model in which customers allocate an educational grant worth $20,000 to the organizing school. A total of $1,500 of this is allocated to each team's internal budget to be used on realizing the project. The cost of projects to customers seems to be low in general: according to a survey of 165 programs, less than 10% of the respondents reported utilizing project model where customers pay more than $5,000 (Warnick and Todd, 2011).

Warnick and Todd (2011) describe the results from surveys conducted with current and potential customers of their school's project course. The researchers observed that granting IPR (Intellectual property rights) to customers was essential in ensuring meaningful projects for students as companies would not join as customers without being granted IPR. The authors also discuss how this IPR policy can be seen as exploiting the students. They argue that the value from learning enhanced by real-world problems compensates granting IPR to customers, since the focus of project courses should be on learning. Similar issues are discussed by Isomöttönen and Kärkkäinen (2008): the role of a real customer in the students' learning process is valuable, but at the same time, one has to pay attention to the students' rights and ethical issues that may arise from project work.

Mann and Smith (2006) propose a four-factor model for estimating the value of capstone projects and list several examples from the literature of significant financial benefits for the customers, including savings up to $50,000 in consulting services. Another example by the same authors demonstrates that customers can profit from the project deliverables, which support customers' everyday business, resulting in savings through more efficient use of resources, or directly through sales of the finished products. By participating in student projects customers also get to evaluate their potential new employees in a real-life setting (Todd and Magleby, 2005).

In summary, companies that participate in student projects as a customer seem to be in a profitable position: the price of student projects is relatively low (Warnick and Todd, 2011), especially when the cost is compared to professional consulting services, but the value for customers can be significant (Mann and Smith, 2006).

For students, the value of project-based learning is in the enhanced learning. Project work reinforces learning, enables the students to demonstrate that they have mastered their needed skills, and, when project work is done in teams, provides an authentic working environment (Fincher *et al.*, 2001). The educational benefits are also one reason universities organize student projects, since "many stakeholders in the discipline believe that an 'apprentice approach' is a key component of inculcating learners into the discipline" (Fincher *et al.*, 2001). Although student projects require more resources from the faculty, they offer "substantial and sustained learning" (Brownell and Jameson, 2004).

Multidisciplinary project work, which is the specific context of the course under study, is seen as necessary to prepare students for the working life after graduation (Burnell *et al.*, 2003) and this realistic setting has a positive influence on student motivation and work spirit (Daniels and Asplund, 2000). Students consider these experiences invaluable and the course as the most important during their studies (Brownell and Jameson, 2004). Multidisciplinary projects done in the first year with real customers and real projects are excellent preparation for later studies as students gain important skills (Hirsch *et al.*, 2001).

When designing a capstone course, the university and teaching staff must consider several aspects (Clear *et al.*, 2001): if the capstone course is organized as a project with a real customer, one important and sensitive issue is the financial relationship between the customer and the students. However, whether students should get financial compensation from the projects is not thoroughly discussed in the literature. Clear *et al.* (2001) discuss the policies regarding students being paid: it can be permitted, disallowed, or permitted under certain conditions.

Another approach to experimental learning is cooperative education. Reichlmay (2006) describes a cooperative education program, in which students get paid for the work they do during their studies. Students get work experience in a long-term realistic setting, and companies acting as customers get to know their potential future employees. Similarly, Huggins (2010) discusses cooperative education that in general can be paid or non-paid, but does not go deeper in an-

alyzing these two options. Including payment to students however increases the employers' expectations while students get some income which is a bonus for them (Huggins, 2010).

Neagle *et al.* (2010) discuss student companies: when organizing a student company in their university "a secondary, but not unimportant, driver was to provide students with earnings" as students often need to work part-time to support their living. One challenge was to assure the potential customers of the quality of work provided by the student company. The authors also discuss two other student company models in different universities. In both cases payment to students was later replaced with granting credits to students as compensation. Interestingly, granting credits instead of payment improved students' motivation and quality of work (Neagle *et al.*, 2010).

The value customers gain from the projects can be quantified through increased efficiency of business processes or sales of new or improved products (Mann and Smith, 2006). The value for students is in the learning, which is more difficult to measure and compare with the value customers gain. This raises the question about the fairness of the situation: does the students' enhanced learning balance the customers' economic benefits.

3 The project course

During the project course under study, multidisciplinary teams of 4-5 students realize a project for a real customer. Project topics are "open-ended" (Daniels and Cajander, 2010) and the course is open to students in all faculties, enabling, together with the multidisciplinary approach, a wide spectrum of project topics from local companies and non-profit organizations. The multidisciplinary approach also means that the focus is in the learning general working life skills rather than enhancing substance skills.

The course is organized in collaboration between a research unit and the university's administration. This further reasserts the multidisciplinary approach of the course since no single faculty is in charge. While the project topics are multidisciplinary, computer science is present in majority of the projects in one way or another.

The pedagogical approach used is project-based learning, to which two aspects are essential (Helle *et al.*, 2006): students produce a solution to a problem, and the projects produce an end result, such as a report or a product. Further, the project course emphasizes the "thrown in the deep end" approach, meaning that students have to take responsibility for their work without constant supervision. Tutoring, however, is available from the course coordinators when requested. Students are encouraged to work independently, but also instructed to ask for help if needed.

The projects are supervised with a similar "light" process, which focuses on giving students and teams feedback on their deliverables and teamwork throughout the project. The students write a mid-term report, and feedback is given in a meeting with the project managers and another meeting with all course participants.

The project contract signed by all three stakeholders (customer, students, university) stipulates that students must spend between 120 and 180 hours on the project and they receive 4-6 credits (European Credit Transfer and Accumulation System, ECTS) based on the hours spent (in the case of this course, 1 credit equals 30 hours of work), and an additional credit for participating introductory lectures before the actual project.

The possibility of variation in the credits and work hours within team members was added after the first course instance based on student feedback. Students have to plan the project according to the tentative assignment from the customer and decide how many hours they can and have to use to complete the project, and then keep track of their work hours. Granting credits according to the actual hours spent prevents situations where students might do non-essential tasks just to achieve planned hours, while the project is already completed. Similarly, it allows them to work up to 6 credits to achieve the project goals even though the project would have been planned to match 4 or 5 credits. Further, it offers an authentic working life experience, as the goal of any project should never be to spend all planned resources, and sometimes projects take more time than expected. In addition to credits, students receive an individual "project certificate" that they can use as a reference.

The university collects an administrative fee (750 euros + 24% VAT) from the customers after the course, and the customers pay for all the running costs the teams need to realize the project. The project contract stipulates that the customers are granted the IPR to the results, and in case of "significant economic benefit," the students and customers are obligated to negotiate additional compensation for the students. Students also maintain the right to use the results of the project in their own studies at the university, and have the right to use the project as a reference.

4 Qualitative survey

4.1 Research questions

The research was initiated by four research questions:

- RQ1: What is the general opinion of the students regarding the course model and the arrangements?
- RQ2: Are students satisfied with the number of credits they get for the course and the model on which the credits are based?
- RQ3: What are the students' opinions regarding financial compensation in coursework with external customers?
- RQ4: Does the issue of financial compensation emerge without specifically leading the students to this topic?

While being the fourth RQ on this list, RQ4 was actually the starting point for this research. The research was initiated by the discussions between the two authors of this paper on the issue of financial compensation: if the comments from non-participating students regarding the unfairness of the lack of payment were relevant, why the students attending the course had not commented on the issue. This whole research revolves around the issue of value of project-based learning to students, and thus more direct research questions RQ1, RQ2, and RQ3 were included. These three questions also enabled us to potentially answer RQ4, as explained in the section describing the questionnaire.

4.2 Questionnaire

After the summer 2013 course was completed, a link to an anonymous questionnaire accompanied by a foreword explaining the purpose of the study was sent by email to all 114 students who had completed the course in the four previous course instances, covering a time period of two years. The email reached 111 students with three emails bouncing back due to inactive email accounts. A total of 38 students answered at least some parts of the questionnaire.

The questionnaire consisted of an introductory text that described the purpose of the study and the basic course arrangements essential to remember when answering the survey:

- In this project course, multidisciplinary teams planned and realized a project for a real-life customer.
- The course yields value and benefits for students, customers, and the university.
- There was a project contract stipulating the work hours, administrative fee, and IPR.
- Students were granted credits based on work hours but were not paid.

The questionnaire was implemented using a web-based system offered by our university. The questionnaire consisted of three background questions: faculty, sex, and whether the respondent had been employed during the past 12 months, and four open-ended questions that directly followed from the research questions:

- "Q1: How do you see the basic arrangements of the project course from a student perspective?"
- "Q2: Is the model used in granting credits good? Is the number of credits reasonable?"
- "Q3: Should students be financially compensated in addition to credits for the coursework that has external customer that benefits from the work?"
- "Q4: Has completing the project course helped you get employed?"

The first page of the questionnaire consisted of the foreword, background questions, and the Q1. The Q2 was on the second page with a short foreword related to that question. The third page included Q3 and Q4, again with a short foreword related to Q3. Further, Q3 was formulated to avoid limiting the answers to the course under study; students could comment on the issue also generally. The Q4 was included to be used in evaluating the course from the management perspective, and thus the answers are not analyzed thoroughly in this paper.

RQ1, RQ2, and RQ3 correspond directly to the first three open-ended questions, and RQ4 was enabled through the structure of the questionnaire, as the issue of financial compensation was not emphasized in any way in the survey title, introduction, and the first two questions. We could thus review if the financial compensation in an unprompted manner emerges from the first two questions, and compare such observations with the answers to direct question on financial compensation.

4.3 Analysis procedure

The analysis followed the procedure presented by Jansen (2010). Our approach was first-level analysis (unidimensional description), where the data is coded and then organized "into objects, dimensions for each object and categories for each dimension" (Jansen, 2010). We utilized downward coding, where we specified "diversity within an object by distinguishing dimensions and diversity within dimensions by distinguishing categories" (Jansen, 2010), moving towards

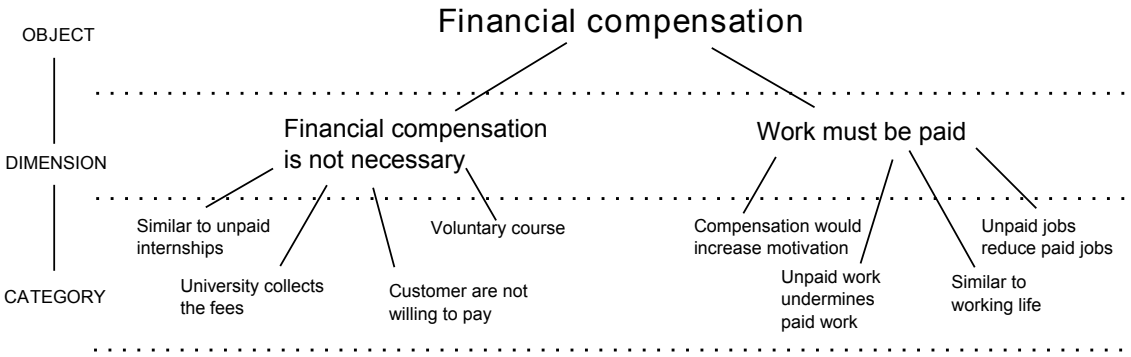

Figure 1: Example of the outcome of analysis procedure. Adapted from Jansen (2010).

lower level of abstraction. From our research setting and the use of downward coding, it follows that each object corresponds with the theme of a predetermined survey question. For each object, students' answers were first coded into dimensions. Then, coding continued within each dimension, and categories were identified as the level of abstraction lowered. During the iterative reviews of the coding some upward coding was also done. In these cases a data fragment representing a dimension or its category was moved to a dimension that was deemed to be better fitting. Example of this structure is presented in Figure 1, where the object "Financial Compensation", two of its dimensions and some their related categories are depicted. In Section 5, these objects are presented as subsections. Dimensions for each object are identified at the beginning of paragraphs in quotation marks, with paragraphs describing the categories related to that particular dimension.

Since the topic of students' opinions on financial compensation is not widely researched empirically, we wanted to perform this first-level analysis to achieve preliminary findings and thus give directions for future research that will utilize students' interviews, instead of using a more explanatory analysis such as pattern coding (Miles and Huberman, 1994). The quantitative background information was purposefully left out for future research. As the answers to the Q1 did not include themes related to the financial compensation, the analysis of students' answers to Q1 is not reported in this paper.

5 Results

The main interest in this paper is the students' opinions on financial compensation from project work. The answers to Q4 did not contribute to this theme; for what reason we only show the summary of students' answers here, in Table 1.

Table 1: Student answers to question "Has completing the project course helped you get employed?", where n = number of students and f = frequency.

Answer	**n**	**f**
Course has helped getting me employed	6	20,7%
Hopefully it will help	5	17,2%
Has not help but I gained useful skills	10	34,5%
Course has not helped getting me employed	3	10,3%
I do not know	5	17,2%
TOTAL	29	100%

5.1 RQ2: Are students satisfied with the number of credits they get for the course and the model on which the credits are based?

Students' comments regarding credits focused on three main themes: number of credits, the model used in granting credits, and the amount of work compared to credits. Another theme that emerged from this question was the tracking of work hours.

"Sufficient, suitable, and limited number of credits." Students found the number of credits suitable and reasonable for this type of course. It enabled them to focus on other tasks during the summer, because the amount of work and credits were limited to 180 hours and 7 credits. However, students noted that maximum number of the credits is not enough for the summer term to obtain the study grant for that period.

"Fitting and flexible model but prone to cause unfairness." The model used to grant credits was considered to be good and fitting. It enabled variation in workload between different teams as customers' needs and project topics varied. It was deemed flexible to individual students, because individual contri-

butions were reflected in their credits. Students commented, however, that the number of credits should be the same for each team member on each team, because the allowed variation in credits and workload caused disruptions in teamwork.

Students argued that the model is good in principle, but changes should be made. These proposed changes included the possibility of have variation in credits between team members and awarding extra credits if the project quality was good. The model was considered good if followed; one student said their team spent more than the required hours per credit, meaning that even though the hours and credits were limited, students felt motivated to complete the project.

"Suitable workload in a vacuum, but a heavy workload compared to other courses." Students compared the workload of the course to other lecture-based and project courses. In both cases, they felt this course had a heavier workload because they spent 30 hours for each credit, and the project was done during a 3.5 month period compared to a full semester in other project courses. The traditional model used in almost all lecture-based courses is one where the teacher estimates hours students have to spend studying and sets credits accordingly.

Another factor contributing to the workload was the existence of a real customer. Students felt this was an external motivating factor that increased the pressure to perform, and thus made the workload seem bigger. When students evaluated the course "in a vacuum", the workload was seen as suitable. One reason students mentioned to explain this was that the project was so enjoyable it did not feel like work.

The workload compared to credits gained divided students' opinions. Some considered them to correspond well with the workload, while others found the number of credits small compared to the workload. Because the course covers a time period of 3.5 months, the students felt committed to the project, which, again, made them feel the workload was bigger.

"Tracking work hours was important to learn to some but useless to others." Mandatory tracking of work hours was considered time-consuming and challenging by some students. This was related to their opinions regarding project management being in excess of their expectations and, how it detracted from actual project work. Some commented that tracking work hours was a waste of time, and it was more important to establish solid team work and realize a successful project.

Challenges were also related to personal differences between team members. Students commented that team members had different concepts about what types of tasks constituted work to be included in the project. They had different skills and competencies, which made distributing the workload difficult. Similarly, understanding other disciplines' tasks and the hours required to perform them was a challenge.

Conversely, tracking work hours was seen as an important learning experience. Most of the students' previous courses had not included a similar system, but they recognized that tracking work hours is not uncommon in the working life. Tracking work hours also helped with project management by keeping them on schedule. It increased motivation because progress, or lack thereof, could be monitored. Students suggested that more instructions should be included how to efficiently track work hours.

"Learning is more important than credits." Students felt the learning experiences gained from the course were more important than credits. Thus, they emphasized that the project course's focus should be in the learning and networking, not providing cheap labor for customers. Additionally, one student commented regarding financial compensation. The student argued that a salary or grant would help students during the summer, because they cannot have summer jobs due to the project's heavy workload.

5.2 RQ3: What are the students' opinions regarding financial compensation in coursework with external customers?

Although there was only one comment related to financial compensation in the previous answers, the students reflected on and analyzed - with great detail - possible financial compensation and the factors related to it when directly asked.

"Financial compensation is not necessary." Students analyzed this project course against their experiences in working life and internships. Because the project course is voluntary and additional to their studies, the terms are agreed upon before the course, and all parties involved are aware of the lack of financial compensation, students felt that financial compensation was not needed and the current situation is suitable. They compared the situation to prior unpaid internships, and argued that, similarly, no payment was necessary. Students argued that the university should be paid by the customer; they organize the project course, tutor students, and are responsible for the projects. Analyzing the situation from the viewpoint of customers, they felt customers would not be willing to pay students, therefore asking for additional

compensation would be pointless.

"Learning and credits are more important than money." Students placed great value on the learning experiences gained from the project course. Although they acknowledged that their customers had gained useful tools from the project, the students considered other factors more important than payment; learning experiences, credits, references, and networking with customers were seen as suitable and reasonable compensation. Possible future employment with the customer was also seen as a suitable reward for project work. In that sense, students saw the project as an "investment in the future."

"Fairness of the situation" Again, students acknowledged that customers might gain significant benefits from their projects. In this light, students felt that there should be the possibility of negotiating with the customer regarding additional compensation. The opportunity to be paid after significant results would, in their opinion, be fair, and it would increase motivation. Students' opinions here emphasized the significance of the results and benefit to the customers, as well as the fairness of the situation as an argument supporting compensation. Students felt that financial compensation would help them during the summer, and while not necessary, it would be a nice bonus for the work.

One comment raised an important issue: whatever the model regarding the financial compensation and fees collected by the university, it should be transparent and visible to all stakeholders; they should know who pays for what and how the money is used.

"Work must be paid." Students made an argument that project work does not differ from "real working life". In that sense, they commented quite strictly that there should be a payment of services, just as in normal working life. They argued that unpaid jobs can reduce paid jobs, as customers opt to participate in a project course instead of using other commercial services, such as consulting companies. Related to this, one strong statement in favor of financial compensation was that "unpaid work undermines paid work". Since the project course is organized during the summer term and it takes a lot of work and time, students commented that some students might be unable to take a summer job at the same time, and thus, compensation would be in place. In students' opinion financial compensation would also increase their motivation to perform. Students also commented that the running expenses should be covered by the customer.

"Payment might cause problems." Some students argued that compensation might cause unfairness within the team due to the unequal distribution of work: some team members' contribution to the results could be more significant, making it difficult to distribute the compensation fairly. Students speculated that similar situation might occur between different teams who have different customers, some more willing to compensate for good results, thus putting different teams within the same course in unequal positions. In students' opinion, compensation might affect the students' motivation to participate in the course and even dilute the teamwork as team members might start competing against each other instead of working together as a team.

Students analyzed financial compensation from customers' point of view as well: students understood that customers sometimes participate in the project course in order to test ideas outside their normal business or product development. Students realized that customers might not be eager to participate if the costs of this type of experimental R&D were increased through financial compensation to students. Students acknowledged that increase in payment from customers would also mean increase in requirements and deliverables of the projects.

5.3 RQ4: Does the issue of financial compensation emerge without specifically leading the students to this topic?

The results regarding RQ4 seem quite clear. Additional financial compensation did not emerge in the students' answers (except in a single comment) when they evaluated the course model (Q1) or the credits (Q2). However, the students analyzed this issue deeply when specifically asked (Q3). We assume that this can be caused by two things. First, students can be cautious when sensitive issues need to be discussed (Isomöttönen, 2011). Second, students simply are more interested in learning experiences and do not consider financial compensation an essential part of the project work, as our analysis of RQ3 seems to point out. While financial compensation would be fair and a nice bonus for the work, students consider project work as an investment in the future, and they highly value learning experiences.

6 Conclusions and discussion

In this paper, we analyzed how students see the value of project-based learning, focusing on students' opinions of whether or not they should get financial compensation for their work. Based on the qualitative survey, students were satisfied with the course

and its arrangements, including the number of credits granted. While additional financial compensation would be a nice bonus, the lack of it does not constitute a severe flaw. Students' positive or negative attitudes towards the course arrangements stems from comparison to other traditional courses and students' expectations. This is apparent when they compare general experiences and the workload of projects to other courses, similar to what has been reported before (Isomöttönen, 2011).

The main results of this paper concern financial compensation for students. Financial compensation had no dominant role when students generally assessed the project course, even when slightly led towards the topic. When asked directly, however, they analyzed the situation more thoroughly.

Two opposing viewpoints regarding financial compensation were identified: first, students valued learning experiences higher than financial compensation and felt that financial compensation was not necessary. However, compensation would be a nice bonus and improve the fairness of project course arrangements. Similarly, providing earnings to students was one reason to establish student companies as reported by Neagle *et al.* (2010).

Second, some students drew a parallel between doing projects and being employed by the customer, and thus they felt they should be paid. Students argued that there should be compensation if the project produces significant profit for the customer, as stipulated by the project contract. We must acknowledge that defining whether or not a project has "significant value" can be problematic; it can take years for the value of deliverables to be identified.

As previously mentioned, there are some similarities between project courses and unpaid internships, and from the pedagogical point of view both of them fall in the same category of experiential learning (Burke and Carton, 2013). United States Department of Labor has listed six criteria [3] to determine whether a person is employed, or considered to be in an internship, which can be unpaid under the Fair Labor Standards Act. Five of these criteria apply to project-based learning in most cases, but one criterion defines that there should be "no immediate advantage" to employers. Project courses with real customers do not generally satisfy this criterion, as the universities at least claim the projects to be beneficial to customers (Mann and Smith, 2006). This dilemma corresponds to the students' opinions that there should be possibility to negotiate with the customer in case they gain financial benefit from the project. One could argue that based on this criterion, project courses transform from "learning experience to students" to "work that should be paid" if customers gain immediate benefit from projects; more research on contract models used on project courses is likely to be needed.

Students were satisfied with credits as the compensation for the project course, and, when again drawing a parallel with unpaid internships, this can be seen acceptable as the project course is voluntary (Burke and Carton, 2013). In unpaid internships the university does not have to provide instruction or classroom, for example, and thus granting credits for internship can be problematic: students have to pay tuition fees to the university fees for the work they do for their employers (Burke and Carton, 2013). The Finnish university system does not have tuition fees, and this can be one reason why our students felt that the university should collect the payment from customers, as they understood that organizing project courses requires more resources than standard lecture courses. Further research could focus on financial compensation from the viewpoint of educational-cultural differences, especially free higher education (Nordic countries[4]) versus one subject to tuition fees (USA).

Burke and Carton (2013) in fact argue that unpaid internships should undoubtedly be voluntary. This viewpoint showed up on our survey as well, as students acknowledged that they were participating on an optional course, where conditions (no payment) where known beforehand. In computer science curricula, however, it is not uncommon to have mandatory project course, leaving students with no options other than participate on the course if they want to graduate. From this premise, it would be interesting to target this same questionnaire to students on mandatory, real customer project courses.

Students reflected on other problematic issues related to financial compensation as well, such as division of compensation within the team and possible distraction. They argued that the negatives might outweigh the positives if financial compensation was provided for students. They also acknowledged that customers' expectations of the quality of project deliverables would increase, similar to what was reported by Neagle *et al.* (2010).

Differences of opinion were present when students analyzed financial compensation from the customers' viewpoint. Some argued that students should be paid, as they are essentially employed by the customer. This implies that in students' opinion the customer would realize the project, even if student

[3] http://www.dol.gov/whd/regs/compliance/whdfs71.htm

[4] https://theconversation.com/why-finland-and-norway-still-shun-university-tuition-fees-even-for-international-students-36922

projects were not available, by utilizing commercial services. Other students argued against financial compensation on the grounds that these projects are more experimental in nature, and they could not be realized without students' participation as the price of student projects is low.

As one student noted, no matter how the financial issues are arranged between customers, students, and the university, they should be discussed openly. Based on our experiences with project courses, we propose a similar approach; financial arrangements should be discussed and explained thoroughly to all stakeholders and clearly included in contracts. Keeping financial issues, especially compensation to students, open and visible for each stakeholder is suggested by Clear *et al.* (2001) as well. If sensitive issues are constructively discussed by teachers, students might become more willing to bring up flaws regarding course arrangements, thus enabling the development and improvement of project course models.

This research was motivated by comments received concerning the claimed unfairness of the situation ("Students are not paid for the project work"). Based on these results, we can conclude that these comments are not concerning for the most part. However, since the students highly value the learning from the projects, focus must be on continued development of the educational areas of projects. Discussion regarding the financial and other sensitive issues should remain open as well. The comments show that financial compensation for students is a complicated issue that can be viewed and analyzed from several perspectives. This issue is not thoroughly discussed in literature, and in our view, needs further research.

Our data set includes background variables useful for further analysis, and we plan to reproduce the survey presented here to new student cohorts. We also plan to use semi-structured interviews based on our preliminary insights into students' opinions and use additional material, such as students' learning diaries, in further research. Types of projects and customers need to be analyzed as far as if the project is product development for a company with ready-to-use deliverables or basic research for a non-profit organization. These compositions can make a difference in student opinion on financial compensation. For future research, it is necessary to investigate different concepts, such as student companies, cooperative education, and students' experiences in them.

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PIII

CALCULATING THE VALUE OF WORK IN EXPERIENTIAL LEARNING WITH INDUSTRY INVOLVEMENT THROUGH A REFERENCE POINT: A GROUNDED THEORY

by

Juho Heikkinen and Ville Isomöttönen 2017

Manuscript

PIV

PERCEIVED STATUS AND VALUE: THE STUDENT-CUSTOMER RELATIONSHIP INFLECTED BY THE INHERENT CHALLENGES OF UNIVERSITY-INDUSTRY COLLABORATION

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Perceived status and value: The student–customer relationship inflected by the inherent challenges of university–industry collaboration

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Abstract
This article examines how students in a multidisciplinary project-based learning course involving real customers perceive their interactions with their customers. The authors conducted a qualitative study and analysed students' learning reports by means of a thematic network analysis. The analysis shows how students perceive their status in relation to their customers and how their perceptions of their work affect how they see the value of the projects. The authors consider their empirical findings in the context of the existing literature on university–industry collaboration and thereby summarize different scenarios of the contrasting working practices and priorities in academia and industry. Based on the observed similarities between their own analysis and results reported in the literature, the authors recommend that project-based learning researchers should pay greater attention to research done on university–industry collaboration.

Keywords
open-ended problems, project-based learning, student–customer relationship

Project-based learning is used in higher education to offer students an authentic experience of the discipline they are studying. This experience can be enhanced by adding real customers and real-world problems to course projects. In these 'project with a client' type courses, students are granted an opportunity to work with real people in industry and act as a kind of a consulting firm, realizing a project for their customers (Fincher et al., 2001). The value of using real customers in the context of project-based learning is well known in the literature: through interaction with real customers and real-world problems, students gain better understanding of their skills and what is expected of them in the working life (Helle et al., 2007; Isomöttönen and Kärkkäinen, 2008; James, 2005).

Project-based learning with real customers is one option for implementing university–industry collaborations. The relationship between universities and companies has been studied since the 1980s, and many studies have been conducted to better understand and regulate the collaboration process (Geuna et al., 2003). The use of different research methods and data sets has been diverse and extensive, including case studies of a single university or company, different qualitative methods and statistical analysis utilizing large, cross-country data sets (Geuna et al., 2003). Research has focused on, among other things, barriers to collaboration, the methods and effectiveness of collaboration, motivational factors and learning and knowledge dissemination (Bruneel et al., 2010; Dooley and Kirk, 2007; Perkmann and Walsh, 2009), and the different factors that affect university–industry collaboration, such as regional policies and firm size (Geuna et al., 2003; Van Looy et al., 2003).

Furthermore, Dalrymple et al. (2014) argue that work-based learning is a triadic learning endeavour in which the student, work-based facilitator and university lecturer are all equally important to the learning process. However, while equally important, the stakeholders can demonstrate different and conflicting interests – the setup of these three stakeholders can embody inherent challenges. For instance, research has shown that students may see projects with

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several stakeholders as being problematic, while the university and customers may have different objectives: although students are supposed to focus their efforts on producing something useful for their customers, they have concurrently to do what may be considered irrelevant work to fulfil course requirements (Collin and Tynjälä, 2003; Isomöttönen, 2011).

In summary, we observe that the use of real customers is an essential part of project-based courses. Project-based courses can be seen as part of larger university–industry collaborations when real customers are involved, and this setting signifies collaboration with several stakeholders. Further, student–customer collaboration may reveal inherent challenges. Thus it seems obvious that the interaction between students and customers is an important research topic. One example of the empirical analysis of student–customer interaction is provided by Isomöttönen and Kärkkäinen (2010) who examined this interaction from the perspective of communication and noted how students could fail to see the importance of communication. In this article, our aim is to advance this type of empirical research and to analyse systematically students' perceptions of their customers so that we can construct a framework to summarize how students see this interaction. The course under study focuses on developing students' working life skills and has three defining features: real customers, open-ended problems and multidisciplinary teams.

Real customers in project-based learning

Students' increased motivation can be seen as one reason for using real customers in project-based learning. For example, research by Isomöttönen and Kärkkäinen (2008) showed that challenging, real-world problems increased student motivation. The positive effect real customers have on student motivation has also been discussed by Helle et al. (2007) and Brown (2000). In the former study, students identified authenticity and the involvement of the client as factors that had increased their motivation (Helle et al., 2007).

Real-world problems are naturally linked to the use of real customers. A survey conducted by Bourner et al. (2001) of first-year students who had completed a project course showed that the best part of the course for almost half of the students had been the in-depth work done for a real organization. Further, Isomöttönen and Kärkkäinen (2008) found that using real customers on a software engineering course had allowed students to understand the complexity of real-world work.

Magleby et al. (2001) identified several positive features brought to project courses by the involvement of an industry sponsor, including improved student motivation; realistic, open-ended problems; and an industry-like environment. Interestingly, those authors identified real customers as a positive factor without describing the benefits in detail, implying that the use of real customers is valuable in its own right.

While in most cases the customers are from industry, it is not essential to engage a customer from the business world. According to Buckley et al. (2004), socially relevant projects had a positive effect on students because they regarded their work as important and potentially helpful to others. Similarly, students enjoyed working for real customers that were non-profit organizations because they felt they could contribute to the community (Leidig et al., 2006).

Interestingly, even though the existence of a real customer is generally seen as a positive feature, examples to the contrary do exist. Real customers can have a negative effect on students, and Rover (2000) indicates that the number of external customers in a design course had been reduced because of this: however, the author does not offer an explanation for the positive or negative reactions caused by the real customers.

To summarize, in most cases, real customers have a positive effect on students' performance and motivation. However, project courses are often studied in the form of course descriptions (Helle et al., 2006; Isomöttönen, 2011), and findings such as those described above are often not discussed and analysed specifically but rather are noted anecdotally in the course descriptions. Further, literature reviews (Dutson et al., 1997) and other valuable holistic analyses of project-based learning (Clear et al., 2001; Fincher et al., 2001; Hoffman, 2014) have focused on classifying project courses and hence on creating taxonomies. We notice that often a mere 'realistic experience' is considered to be a sufficient 'end product' of project-based learning, while more detailed analyses are not available.

Open-ended problems

Another feature that enhances learning is the use of open-ended problems. In the context of project-based learning, open-ended problems can be defined as projects of which the goals and the means to achieve those goals are unclear or unspecified (Hauer and Daniels, 2008). Using open-ended problems, students' skills and knowledge can be enhanced (Daniels et al., 2002). Daniels et al. (2002) suggest that open-ended problems offer an effective way to prepare software engineers for their future work as well as developing and enhancing their skills. They also reported increased student motivation and fewer dropouts or failures. Open-ended problems force students to focus on solving the problem instead of trying to find the 'correct answer' (Daniels et al., 2002: 133). Further, Daniels et al. note that negotiating with a customer and defining the customer's needs are an essential part of learning in open-ended projects.

Multidisciplinary project course

This research concerns a project-based course with real customers from local industry and multidisciplinary teams of students from each faculty of the University of Jyväskylä. The focus of the course is on learning the so-called general working life skills (Bennett et al., 1999), such as teamwork, negotiation skills and working with a customer. The project topics are open-ended (Daniels and Cajander, 2010) and multidisciplinary. The customers are primarily small and medium-sized enterprises from varying areas of business. Students have to apply to the course and cannot select their customer or project topic. The course work includes introductory lectures during which topics such as project planning and management, working with a customer and project communication, are discussed.

To offer authentic working life experience, the course emphasizes independent work and light supervision from the course coordinators. The coordinators have negotiated with potential customers before the course begins and have agreed on a tentative, open-ended assignment. However, students are responsible for defining the project topic and goals in collaboration with customers, because the course coordinators do not participate in any meetings between the customer and students.

A project contract is signed by the students, the customer and a university representative. The contract defines, for example, the maximum number of hours students are obliged to work on the project. It stipulates that the results do not have a warranty and that neither students nor the university is obligated to maintain or update the results after the course has ended.

The open-ended project topics in this course arise as follows. The customer has a certain problem, an area of business or a product that needs to be developed. Because they lack resources (time, skills, money, etc.), they want to use multidisciplinary student teams. At this point, the appropriate methods for and outcomes of the project are often unknown. Thus, it is the team's responsibility first to clarify its customers' needs and then to define the project goals and write the project plan for approval by the customer. Naturally, the types of results produced vary between each project. They may be concrete products, such as a website or product prototype, or more abstract, such as a research report. This corresponds to project-based learning in general, in which students produce a solution to a problem, and the projects produce an end result, such as a report or a product (Helle et al., 2006).

Students' individual learning reports

The data used in this research are the students' individual learning reports, which they write on completion of their project. They are asked to write the reports freely and reflectively, and the preparation instructions include no direct questions which students have to answer. Instead, they are given a few themes to be used as a backbone for the report. They are advised that they should analyse the failures and successes they faced during the project, how their general and core skills developed, how the team functioned and whether or not they had achieved all the learning goals of the course. There is no minimum requirement for length, and the learning report does not affect the student's grading. The reports used in this study are from seven different course examples. In total, we use 142 learning reports, with an average length of two pages each.

Thematic network analysis

Thematic analysis is a 'widely used qualitative analytic method' (Braun and Clarke, 2006: 77) used to identify and analyse patterns in data. It is a flexible research method that 'can potentially provide a rich and detailed, yet complex, account of data' (Braun and Clarke, 2006: 78). Attride-Stirling (2001) linked thematic analysis to the argumentation theory of Toulmin (1958), which aims to explore 'the connections between the explicit statements and the implicit meanings in people's discourse' (Attride-Stirling, 2001: 388). This ability to discover implicit meanings from explicit statements means that thematic analysis is a suitable method for this research. Because previous research findings on student–customer collaboration have often been anecdotal, this type of exploratory research with a qualitative method to gain a deeper understanding of the phenomenon and open up possibilities for quantitative studies is needed.

Our analysis specifically follows guidelines set by Attride-Stirling (2001), who proposed that using thematic networks in thematic analysis can be useful, in particular, for illustrating the different levels of abstraction. Thus, we created three-level thematic networks consisting of (a) basic themes derived from the data, (b) organizing themes that group basic themes into larger entities and (c) global themes which are deduced from the organizing themes and which are the highest level of abstraction. An example of the structure of a thematic network consisting of one global theme, two organizing themes and six basic themes is shown in Figure 1.

As many guidelines on qualitative analysis explain (Attride-Stirling, 2001; Braun and Clarke, 2006; Hsieh and Shannon, 2005), the analysis can be done inductively, deductively or by combining both approaches. In our case, the coding of the data was done inductively (in a data-driven manner), which tends to provide a richer overall description of the data (Braun and Clarke, 2006). First, we read the learning reports thoroughly to familiarize ourselves with the data. Then the data were dissected into segments and the initial coding was done. There were no specific research questions to be answered, so the initial

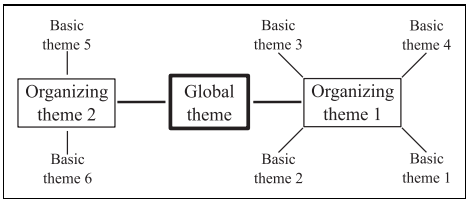

Figure 1. Structure of a thematic network. *Source:* Adapted from Attride-Stirling (2001).

coding and text extraction were based on the research interest – the students' view of customer collaboration.

The next step of the analysis was to advance to take the initial codes from the text extracts and collate them into larger groups (basic themes), which were then named. This was an iterative process in which the themes were constantly reviewed and refined so that they corresponded with the text extracts. The first author of this article conducted the text extraction, the coding and the generation of basic themes. Then, both authors critically reviewed and refined the groupings of the codes and the basic themes as a joint effort. The basic themes were then arranged into organizing themes, after which the highest-level global themes were identified through comparative thinking. All themes at the different levels were then organized into thematic networks. Again, the whole process was iterative and several versions of the thematic networks were created before the final version was determined. In the last phase, tensions and patterns across the thematic networks were interpreted and discussed for evocative analysis and presentation.

Limitations

The data and research method impose some limitations on the study. The data, students' learning reports, offer a snapshot of a certain point in time when students are reminiscing about their experiences after the project. As noted above, the instructions regarding the learning reports do not include any direct questions for students to answer, and it is possible that some features of the student–customer interaction are left out because the student did not happen to consider them. Because the course is graded with pass/fail, it is possible that some students write their learning report with fairly minimal effort. Moreover, each student has a unique role in his or her team and some have more interaction than others with their customer during the project. Thus, the thematic network analysis used in this article offers a conceptualized view of the student–customer interaction, and it is not feasible to draw conclusions about the relative significance of the themes.

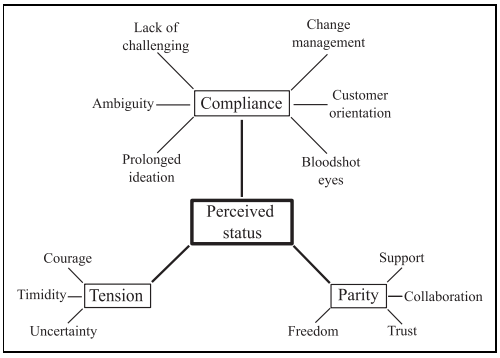

Figure 2. Thematic network for global theme 'Perceived status'.

Results

The thematic networks produced through the analysis consist of two global, five organizing and 22 basic themes. The two global themes were named 'Perceived status' and 'Perceived value'.

Perceived status

The first global theme, Perceived status, consists of one thematic network that is illustrated in Figure 2. This network reveals the different ways in which the students perceived their status with respect to their customers. We identified three modes of interaction between students and customers. First, students thought that the customers were supportive and participated in the project work equally. Somewhat to the contrary, students also felt that the customer was in control of the project, and they had given in to the customer's demands. While these two modes of interaction were relatively stable, the third was not. In this interaction, students were initially uncomfortable about working with the customer but started to take control of the situation as they became more comfortable with their work and then began to challenge the customer. We named these organizing themes 'Parity', 'Compliance' and 'Tension', respectively.

Parity. This organizing theme describes a situation in which the collaboration between students and customer was fluent, and the students perceived themselves to be equals with their customer. It consists of four basic themes: freedom, trust, collaboration and support. Students were given *carte blanche* to work with their projects but, at the same time, the customer offered them support, and neither party appeared to take control of the project over the other. Students' comments showed gratitude toward their customer, and they appreciated the freedom they were given because it had made their work easier. Some might have faced difficulties with this freedom, because it made defining the

project less easy, but they managed these challenges and the overall experience was positive.

Students associated this freedom with trust when they reflected on the customer's actions during the project. They acknowledged that the trust displayed by the customer had contributed to the project work in its entirety. Negotiations about the project topic were conducted in a good spirit, issues were discussed openly and new ideas for the project came from both parties. Students felt that it had been easy for them to use their expertise in the project because the customer had trusted them as professionals in their area. Further, the trust served as a motivational factor at both individual and project team levels. One student remarked:

> Our team had an easy to work with customer, who we have to thank for trusting the team. This mainly emerged in how we were given freedom with what things the project focused on and how those things were done.

Parity between the two parties also emerged as an informality. Students commented on how their customers were informal in collaboration settings. This further enabled quick communication and made it possible for them to focus on the project's tasks instead of bureaucracy. A good and open atmosphere also encouraged individual students to bring out their ideas and opinions and improved their confidence in their own skills. When the collaboration worked, students increasingly gained motivation from the meetings with their customer. Students understood that the customer's active participation and collaboration with them were a major defining factor in the project's success.

Fast-paced support and feedback were also credited with having a positive effect on the projects' outcomes. Students emphasized how important it was to get just the right amount of feedback and suggestions from their customer. Again, this improved their motivation to work. The customer's support and interest in each team member's skills further helped to increase the students' self-confidence. In summary, based on the students' comments, it seems that Parity was initiated by the customers' personalities and actions and was related to how they saw the collaborations with students. Thus, we assume it is difficult for the students to create a situation of parity by themselves. While the basic themes are presented as separate issues above, many were in fact linked together in students' reflections (e.g. trust and freedom) and many affected the students similarly (so trust and collaboration improved motivation).

Compliance. This organizing theme describes how students and customers can have conflicting interests in the project. Students complied with the customer's requests, even if they recognized that those requests were not the best option for them or the project. This compliance emerged through different situations, which we classified into six basic themes: 'Prolonged ideation', 'Ambiguity', 'Lack of challenging' 'Change management' 'Bloodshot eyes' and 'Customer orientation'.

Students found it problematic if the customer wanted to continue the planning and ideation stage for too long. This made it difficult for them to advance the project because the final goals remained unclear for too long and caused anxiety as days and weeks went by and nothing happened. Similar prolongation happened later during the project as well, when the customer remained undecided with regard to the final details of the concrete products. Students' compliant attitude towards their customer was apparent here, in that while the students had strong opinions about the details of the project and had the skills to finalize the product, they were reluctant to assert their opinions strongly to the customer. According to one student:

> The customer wanted to continue the planning for a long time and keep the project open for new ideas. Because of that we spent only a few hours in the early stage, because we could not do anything but plan and create new ideas. It felt frustrating when I wanted to learn something about my discipline and apply my knowledge. In early July [around the halfway mark of the project] when the project topic was still not agreed, I started to feel anxiety.

'Ambiguity' refers to a situation in which the customer was not sure what they wanted from the project or what the final goals should be. In such cases, students were forced to remind the customer what they had agreed on in their previous meeting, which caused frustration. Instead of challenging their customer to focus more on the project, they simply acknowledged the situation as being evidence of the fact that 'even customers themselves do not always know what they want'. Situations in which the customer had a lot of ideas but no concrete expectations also caused problems for the team. Students reflected that the ambiguity of the project decreased its quality and that they should have taken responsibility to discuss and clarify the project with the customer and course coordinators, but had failed to do so for some reason.

Another phenomenon relating to ambiguity was the acknowledgement of students that they should have challenged their customer more regarding the project topic. These students felt that the entirety of the project would have been better had they been able to argue their opinions to the customer. They commented that they were simply too scared to argue face-to-face about the importance of certain aspects of the project, and in some cases, they submitted to the customer's requests and let the customer take control. Overall, the decision to avoid challenging the customer weakened the quality of the work, and students recognized that they should have reacted earlier during the project. For example:

> Even though the limited results of marketing research were not my fault, afterwards I have been thinking whether we could

> have affected this issue. I think that already during the planning stage of marketing research we should have challenged the customer's viewpoint more.

In several projects, the customer wanted to make changes to the expected outcomes during the project. This was caused, for example, by a customer's peculiar working styles.

Students found these situations frustrating because the tasks and deadlines changed frequently. The team's approach to change management was simply to stay silent and accept the customer's changing needs and vent their frustration later when the customer was not present. We assume that, from the customer's perspective in such cases, the team had seemed able to handle the changes. On the other hand, students reflected that dealing with these difficult situations might have improved the team spirit and made the team more coherent. Again, students' compliance prevented them from raising these issues for discussion with their customer.

We use the term Bloodshot eyes, adapted from Brown (2000: 46), to describe situations in which changes caused different problems for students. First, these changes caused delays and missed deadlines. Students were disappointed when some parts of the project were dropped and additions to the tasks forced them to rush its completion. Changes to the project also caused extra work for the students and forced them to spend more hours on the project than required by the university. In these cases, they did not protest. Instead, they simply accepted the situation.

Finally, students' compliance is apparent in how they viewed the project in general. Even with all the difficulties, they considered focusing on the customer's needs to be the most important thing. They emphasized how important it was to listen to the customer and to try to understand their needs, even when those needs conflicted with the students' interests. Although these situations required the students to adapt, they understood how the situations had contributed to the development of their skills and competencies. One commented:

> I also learned that one cannot always agree with the customer, and while you can and have to express your opinion, you should still always follow the guidelines set by the customer. You cannot let that affect your work and collaboration with the customer.

We noticed that compliance appears to be a conflicting phenomenon because it involves both challenges and learning experiences for students. Their comments and experiences reflected real-world business-to-business collaboration, in which a certain amount of compliance towards the customer is needed. Furthermore, students may learn things that do not seem essential for the project but are still important (Isomöttönen, 2011).

Tension. The first two organizing themes describe how students and customers were in an equal position and worked together for a successful project. They also indicate that students felt that they were in an inferior position to their customers and so complied with customer requests even at their own and the project's expense. While these organizing themes are different and emerge from different student experiences, they are stable with regard to the style of interaction. The third organizing theme, Tension, is unstable in the sense that students' perceptions varied from timidity to taking control of the project. As per the course structure, students could not select their customer or project topic. Instead, they are given a tentative assignment by the course coordinators, including the customer's contact information. They were then expected to contact the customer and start negotiating the project topic without supervision from the course coordinators.

This approach caused uncertainty among the students. Some questioned the usefulness of the course and their contribution even before the course started. After learning of their project topic, they continued to feel uncertain about the course. The team spirit might have been strong and supportive, but individual students still had negative feelings towards the topic and were anxious about future tasks.

Before the first contact and meeting with their customer, students were timid and nervous about working with a real customer. They were afraid of the first phone call, acted very formally in first meetings and planned their actions and comments carefully beforehand. However, this initial timidity disappeared quite quickly after the project work had started, and students realized that the company representatives were 'just' normal people. The customers' actions and informality seemed to play a role here, but at the same time, students acknowledged their own initial misconceptions, and understood that they need not have worried. In the words of one student:

> It was exciting to go to the first meeting with the customers. We were nervous, since we did not know anything about the people we were going to meet. I had talked with them on the phone twice. [. . .] The first meeting always makes me nervous, and we had felt the customer to be just some faceless authority until we sat down for the first time face to face. We felt immediately relaxed, and the discussions about the project topic were equal.

Interestingly, we note that one reason for the rapid disappearance of students' timidity after they had met the customer might be related to the course structure. Because the course coordinators do not participate in any meetings, students are forced to start communicating with their customers. Isomöttönen and Kärkkäinen (2010) reported a different course setting in which

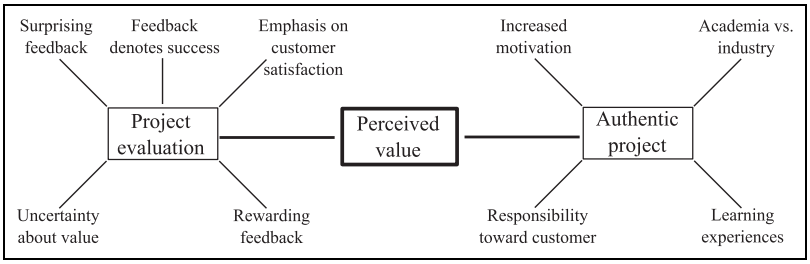

Figure 3. Thematic network for global theme 'Perceived value'.

timidity appeared to be a more difficult problem because all three stakeholders were present at meetings and students could shift the responsibility for communication to the course coordinators.

Furthermore, the tension between students and customers developed into a situation in which students were encouraged to take control of the project and start challenging their customer. They quickly understood that the customer was *not* always right and that if they had followed the customer's guidelines, the project would have never been completed. Students found it challenging and rewarding to sell their ideas to their customer. They identified weaknesses in customer's business operations and their need for the project and had the courage to interfere. Using solid arguments and supportive advice from their team and course coordinators, they were able to convince the customer to follow their ideas. One student commented:

> The conversation was long and challenging, but after a while we were able to argue our team's agenda to the customer, who finally understood our point of view. Based on this conversation we were able to direct our project in such way that it was meaningful for us and beneficial to the customer.

In summary, the global theme of Perceived status appeared in three different ways. First, students perceived themselves as being in an equal position with the customer.

This resulted in several positive outcomes, such as students' increased motivation. It appeared that the customer's attitude towards the students were an extremely important factor in this respect. Second, students viewed their position as lower than that of the customer; thus, they complied with the customer's requests, even though doing so caused them difficulties. Similarly, if the customers' requests and the course requirements collided, the students' priority seemed to be fulfil the customer's needs. Third, the types of interaction between students and customers were not always stable, because the students' early uncertainty and timidity in communication transformed into their taking control of the project's direction.

Perceived value

The second global theme concerns how students perceived the value of their work for themselves and for their customers. The thematic network is illustrated in Figure 3. Two organizing themes emerge from the students' attempts to evaluate the value of the projects. The first is 'Project evaluation', which focuses on students' reactions to the results and feedback given by the customer. The second concerns the significance of an 'Authentic project' and what kind of value students thought they had gained from the project work.

Project evaluation. After students had presented their results to the customer, they began the process of evaluating their work. They were in an expectant mood and curious to know how their customer would respond to the results. While they felt satisfied with themselves and, naturally, hoped that the customer could fully utilize their work, they were uncertain about how the customer would react. Students identified a lack of communication and feedback during the project as one of the reasons for this uncertainty. Based on the positive feedback from the customer following the final presentation of the project results, students concluded that the project had been successful. Customers' overall satisfaction, positive feedback and lack of negative feedback, combined with the team's strong spirit, keeping within deadlines and finalizing every deliverable promised in the project plan were substantially evident in students' comments as proof that the project had been a success.

Further, students strongly emphasized customer satisfaction. While they acknowledged that some parts of the project could have been better, they considered customer satisfaction to be the most important aspect and outcome. This feeling was boosted by the students' realization that they had initially underestimated their skills and accordingly were satisfied when the customer praised their work. According to one student:

> The customer was satisfied; I think the materials we handed out to the customer could have been better, but like I said the customer was satisfied and that is the most important thing.

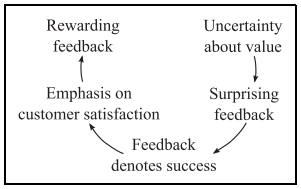

Figure 4. Pattern showing students' evaluation of the project's results.

Finally, students valued the feedback from the customer, especially when they could see that it was genuine and not just complimentary. They saw that their investment in the project had been worthwhile, and the satisfied customer was the best reward for their work.

Here, we can see how students' views of their project results evolved as they reflected on their work in light of the customer's feedback. Students' perceptions followed a pattern in which initial uncertainty about the results changed into a positive surprise as they came to understand the reality of the situation through the customer's comments. This was followed by an assessment of the whole project, for which the criterion was feedback from the customer. Because the project ended with a satisfied customer, which was seen as the most important factor, the project's goals were achieved. Finally, students felt rewarded by the customer's appreciation of their work and results. This pattern is illustrated in Figure 4.

Authentic project. In addition to evaluating the project outcomes, students reflected on their experiences and what issues had arisen as a result of the fact that they were completing the project for an actual customer. Working for a real customer with a real need was a motivational factor for the students. They were able to become familiar with how small businesses operate, and, because they knew their work had some meaning, they were more motivated and worked with a better attitude. They highlighted the difference from normal coursework, which was a positive factor. In addition, although they had their hands full with work for the customer, the team and the course setting supported the work.

Having a real customer also brought pressure to perform and finish the work. There may have been some difficulties with the project or even in students' attitudes, but the responsibility towards their customer kept them on the course, instead of withdrawing. They did not bring up their discomfort with teamwork because they did not want to increase the pressure caused by the customer. Prioritizing their customer also meant that the team did not necessarily put much emphasis on course requirements, and they considered successful completion of their project to be a matter of personal pride.

Through their work, students gained an understanding of the differences between academia and industry. They were able to see what the life of an entrepreneur was like, which gave them courage to consider entrepreneurship as a career opportunity. They emphasized how seemingly similar tasks in projects have different requirements when the project is done for a corporate customer. Students also recognized differences in working styles, as their customers, in most cases, were not interested in theoretical or methodological details but rather wanted to see the final results of the work.

Finally, the real-world project offered students learning experiences in general working life skills and working with a real customer. Depending on the customer, they were able to familiarize themselves with a new business domain, such as sustainable development. Working with a real customer was considered to be the best aspect of the course and project. As one student confirmed:

> Another important learning experience was the interaction with the customer. It is completely different to be planning some student activities or organize a large event, then work with real customer and realize a concrete project for them.

The overall positive experiences discussed above are well known from the project-based learning literature and, as such, are not surprising.

Discussion

This article presents the results of a thematic network analysis based on students' experiences of collaboration with their customers in a multidisciplinary project course with open-ended problems. The two global themes that summarize the students' experiences are Perceived status and Perceived value. Interestingly, we noticed that both global themes concern issues related to university–industry collaboration at an individual student level. Much of our discussion focuses on this linkage.

An interesting feature of university–industry collaboration is that university researchers and research units sometimes seem to let companies set the rules for collaboration. For example, Cyert and Goodman (1997) describe an event in which the university research team did not want to continue the collaboration project, but the company pressed them to continue for an additional year. Clear et al. (2001) recognized that the students did not challenge the conflicting demands of the customer and attributed this behaviour to their lack of confidence. In an example provided by James (2005), the faculty decided to take responsibility for finishing a project that began as a student project. These accounts demonstrate how faculty and students comply with the customer's needs and prioritize the fulfilment of the customer's expectations at their own expense. The same phenomenon exists in our analysis. Students' desire for compliance seemed to inhibit them from challenging their customers in project-related issues, and they completed even the tasks they found unpleasant, sometimes working for more hours than required.

Table 1. Classification of differences in working practices between academia and industry.

Scenario	Authors' analysis	Existing literature
Clarity of the work – fixed goals versus openness	Students are forced to work and deal with ambiguity; situation is reinforced by students' compliance	'Inherent conflicts' in university–industry collaboration due to different goals (Cyert and Goodman, 1997: 47); customers do not know what they want (Bond, 1995); courses are properly planned (Collin and Tynjälä, 2003)
Emphasis of the work – theory versus practice	Emphasis on concrete results demonstrates to students the differences between academia and working life	Applied research is shaped by industry, while researchers see it as an investment for the future (Perkmann and Walsh, 2009); difference in products is acknowledged (Cyert and Goodman, 1997)
Evaluation of results – scientific procedure versus value to customer	Students understand the value of their work through customer feedback	Not found in our literature review – we assume experienced researchers understand the differences in value
Two audiences – course requirements versus project work	Not found in our analysis – course emphasizes a focus on the project	Students find working with different requirements challenging (Collin and Tynjälä, 2003)

This challenge demonstrates the importance of interaction with the customer and the students' need for negotiation skills, which was also noted by Daniels et al. (2002). It is also in line with the findings of Isomöttönen and Kärkkäinen (2010), who identified a communication barrier between students and customers, suggesting that one reason for it was the students' inexperience of working life, which manifested itself in their timidity.

Based on our analysis and the existing literature on project-based learning and university–industry collaboration, we identified four scenarios of how differences in working practices emerge between academia and industry (Table 1). We call the first scenario 'clarity of the work', which refers to fixed and clear goals in academia versus openness in industry. The university–industry literature has reported 'inherent conflicts' in university–industry collaboration, as universities and companies have fundamentally 'different cultures' (Cyert and Goodman, 1997: 47). Bruneel et al. (2010: 859) argue that 'university–industry collaborations are likely to be plagued with conflicts' due to the different attitudes of researchers and companies. The authors classify these conflicts into those related to the different goals and needs and those related to intellectual property rights and university administration policies. The former type of conflict also appears in our data. In our analysis, this conflict stems from customers' uncertainty about their own needs and the changes they proposed to the agreed project plan. This conflict was exacerbated by students' compliance with customers' requests.

Regarding project-based learning, Bond (1995: 2c3-1) summarized a similar challenge as 'customers almost never know what they want', and Clear et al. (2001: 100) state that 'some conflict is inevitable' because students and customers have different goals. Changes and deviations to a project plan during the progress of the project are not uncommon in the real world, and this applies equally to project courses (Bond, 1995). This reality forces students to face a new situation, as work in normal lecture courses is properly planned according to pedagogical needs (Collin and Tynjälä, 2003) and significant changes are uncommon. In our analysis, the difference between university work and work in industry became apparent when students were forced to deal with customers' changing requests and ambiguity.

We call the second scenario 'emphasis of the work', which refers to the contrast between the theory-oriented approach in academia and the practice-oriented approach in industry. Projects realized in this course are mainly of the applied research and problem solving kind. Perkmann and Walsh (2009) identify and classify university–industry project types and note that applied, problem solving projects are generally shaped by industry's agenda. They posit that applied research does not generate results suitable for publication because it has different requirements from those of basic research. Cyert and Goodman (1997) note that the products of universities and companies differ. While companies look for more concrete applications, universities aim to create new knowledge. In our analysis, students recognized that working with a real customer and real-world problems had enabled them to understand the different requirements in industry because their customers emphasized the importance of useful and concrete results rather than the theoretical background of the work. Interestingly, while researchers appear to acknowledge that applied research does not provide results suitable for publication, they consider problem solving projects to be an investment for the future, and they hope that industrial partners will be more willing to participate in university-driven basic research projects after the successful completion of smaller, applied research projects (Perkmann and Walsh, 2009). Furthermore, Perkmann and Walsh (2009) assume that the researchers' motivation for participating in

the joint projects is the learning that happens through collaboration.

We call the third scenario 'evaluation of the results', which refers to scientific procedure in academia versus value produced for the customer in industry. Due to the open-ended nature of the projects, the topics and outcomes can seem unclear compared to traditional lecture-based courses, especially at the outset. Daniels et al. (2002) consider this to be a positive feature of open-ended problems, because students are forced to work on solving the problem instead of looking for the 'correct' answer. However, it can be hard for students to understand the value of their work and the expected results during the project. Our analysis shows that the only way for students to evaluate their work might be through the feedback from customers, and they realize the value of their work only at the end of the project based on comments from their customer. We believe that one reason for this lies in the nature of the projects: they are often developmental, leaving room for students' own creativity and ideation (as opposed, e.g., to software development projects). We did not find explanations for such uncertainty in the literature with regard to applied research projects in collaboration with industry. We assume that the researchers involved in those projects were usually more experienced and could thus evaluate their work and its value to the industrial partner more realistically.

We call the fourth scenario 'two audiences', which refers to the tension between course requirements in academia versus project work in industry. This scenario can be found in the work of Collin and Tynjälä (2003), who describe how customers and universities want to accomplish different objectives, and students find working with these distinct aims problematic. Issues connected with the type of work do not appear in our analysis, since one of the leading principles of the course since its inception has been to let students focus on their project and to keep 'unnecessary' work required by the university to a bare minimum.

One of the goals of the course under study is to provide students with a realistic working life experience, for which collaboration with a customer is essential. However, as discussed above, there is a built-in tension between universities and companies. The students' view of working with a customer is shaped by the university's influence, which may hinder the realism of the experience. Thus, there is the question of whether educational projects with real customers can fully mimic the business-to-business relationship of working life.

How important it is to remove all the challenges of student–customer collaboration in project-based learning? For example, Fincher et al. (2001) describe the ideal customer of a project course as being well informed about what they need. However, one might question whether having ideal customers in that respect is even necessary. The challenges caused by ill-informed customers might provide important learning experiences to students (assuming they are given the instructions on how to manage working with challenging customers). As discussed above, there is a natural tension between students ('learning') and customers ('business needs') when external customers are involved in project-based learning. Thus, it is the teachers' responsibility to ensure that the customers and project topics equally benefit these stakeholders. Clear et al. (2001) argue that teachers should be responsible for monitoring the projects and ensuring that students do not engage in projects with unreasonable expectations from customers. In our case, we rely heavily on a project contract to define the rights and responsibilities of each party to lessen the probability of conflicts and ensure students a safer learning environment. In this way, we hope to avoid or at least diminish the negative effects of conflicts and enable students to deal with challenging situations as learning opportunities rather than challenges.

Furthermore, Bruneel et al. (2010) argue that some challenges in university–industry collaboration can diminish over time as both parties gain more experience of collaboration and the related knowledge accumulates. However, when it comes to project-based courses, this is not possible, as each course instance presents a new group of students, and university policies might encourage favouring new customers over returning ones. Thus, the teachers are in a favourable position to accumulate and share this knowledge, and it is their responsibility to prepare each new group of students and customers to face the challenges (Isomöttönen, 2011).

The main contribution of this research is the structured view, presented as thematic networks, of how students experience interaction with their customers and working with a real customer. We are aware that several of the themes presented can be found in the project-based learning literature, but they are often presented in the form of anecdotal evidence. Our thematic networks correspond with the existing literature on university–industry collaboration. The same high-level themes are apparent in both student project courses with real customers and university-level collaboration, but they are discussed with different terms, and they materialize differently in practice. We found that the inherent conflicts of university–industry collaboration emerged in the students' reflections on how they experienced working with their customers. This student experience may differ from the usual business-to-business relationships in 'normal' working life, and this difference should be made clear to students.

As for future research, the discovered thematic networks call for a quantitative study with a focus on identifying the significance of different student experiences. We have also left out the customers' point of view. Their role in the interaction is arguably at least as important as that of students, so conducting similar qualitative research disclosing their viewpoints could be one direction for future research. For instance, analysing the potential compliance of

customers in relation to students would be an important topic based on our anecdotal observations of such behaviours during the courses. Finally, the similarity of the challenges in university–industry collaboration and student–customer interaction is not often discussed in the project-based literature. Thus, we recommend that researchers involved in project-based learning with real customers should give more attention to the research done on university–industry collaboration.

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