Experts in teamwork - A large scale course for interdisciplinary learning and collaboration

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ABSTRACT

Experts in Teamwork is a mandatory course at the Norwegian University of Science and technology (NTNU) for all master students, regardless of program, where the students work in interdisciplinary teams on real world projects, with detailed and explicit intended learning outcomes for personal and interpersonal skills using active and experiential learning approaches. In this study, we used a mixed method research approach with a quantitative analysis that capitalize on the course evaluation data from the last 10 years and a textual qualitative analysis of the project descriptions of some of EiT villages. Based on the empirical data, we discuss the extent to which the students perceive EiT as a valuable preparation for their work life, and what factors are important for the development and success of the EiT course in the light of the relevant scientific literature.

KEYWORDS

Interdisciplinary learning, project-based learning, cooperative learning, generic and transferable skills, course development, CDIO Standards: 2, 7 and 8.

INTRODUCTION

Engineering education has been criticized for neglecting to provide students with opportunities to develop skills that are crucial to practicing engineers (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014). These skills include, for example, communication, team-working, project management, and problem-solving (Berggren et al., 2003; Galloway, 2007; National Academy of Engineering, 2005). Engineering education aims to prepare students for their later work life, where they will work on questions that are unknown to us at the moment. Therefore, it is not enough to only equip students with the necessary discipline specific knowledge and skills, we must also teach them how to learn and how to collaborate (Kenny et al., 1998).

In 2015, *Nature* ran a special issue on interdisciplinary research (Nature, 2015), highlighting the importance of collaboration across disciplinary boundaries, and the UN summarized the great challenges that we face as a global society in their "17 goals to transform our world" (www.un.org/sustainabledevelopment/). All of these challenges require expertise from many different disciplines in order to fully understand and address them. *Communicating* and *collaborating* in *interdisciplinary settings* are key skills we need students to train and master. Interdisciplinary collaboration means that the contributors work together by integrating their knowledge and methods, and work is carried out jointly to achieve a shared goal by combining expertise from different disciplines (Choi & Pak, 2006). This is in strong contrast to

multidisciplinary collaborations, where the work is carried out independently, or sequentially, from each discipline-specific perspective, which greatly limits the possibility to integrate perspectives and utilize different disciplinary points of view (Viseu, 2015).
Interventions to improve engineering education, such as the implementation of active and collaborative learning, have mainly targeted first- and second year courses (Heitmann, 2005). Little work has been done to improve teaching and learning in later courses. It is, however, important to keep students interested throughout their education and help them to advance beyond simply memorizing knowledge (Balakrishnan, Lal, & Flattau, 2008).
During the 1990s several initiatives were undertaken by the Norwegian Ministry of Education with the aim of improving the quality of higher education. As a result, NTNU reframed itself as an innovative university concerning collaboration and interaction across disciplinary boundaries (Sortland & Erichsen, 2006). Continued work, including stakeholder analysis, resulted in calls for educational development to equip students with the necessary skills and tools to work across disciplinary boundaries.

> "The teaching of engineers shall produce candidates who possess fundamental knowledge of natural science, technology and society in general, who have acquired social abilities, are trained in team work and coaching and motivating of co-workers, are good in verbal and written communication, are able to use their competence to foster creativity and solve complicated and multifaceted problems, and can adjust to changing demands. Students have to be trained in teamwork, adjustment to changes in their professions and society, and be efficient in professional work." (NTH utredning, 1993)

Conventional lectures should be replaced by project work and self study in teams working on practical problems, to illustrate how the theory learnt on the bachelor level could be applied. A fundamental idea behind the desired change, was to prepare the students for life long learning, rather than considering the graduates as final products (Sortland, 2006). A consequence of this work was a major revision of the Master of Science program at NTNU during the 1990s (NTH utredning, 1993). The course Experts in Teamwork (EiT) was established in 2001 as a mandatory course at the master level, requiring a radical change of teaching, from lecturing and instructing to facilitating, i.e. to facilitate the development of abilities in cooperation, reasoning and decision-making in teams. The change was hard for many teachers, and it took several years of planning and testing to implement the desired changes (Sortland, 2001).
In this case study, we investigate the development and current status of the EiT course through the analysis of quantitative and qualitative data from 2007-2016. Through focusing on students interdisciplinary collaboration and their self-evaluated gain in collaboration skills, we address the following two research questions:

1) To what extend do students perceive EiT as a valuable preparation for their work life?
2) What factors are important for the development and success of the EiT course?

Based on the empirical data and through discussion of relevant findings in the scientific literature, we provide some general pointers on how to promote interdisciplinary collaborations amongst students and important consideration in the continuous development of large scale courses.

THE EXPERTS IN TEAMWORK COURSE

Since the original education development project, the EiT course has been continuously improved and developed further. Today, it is a compulsory 7.5 ECTS course for all master degree students at NTNU. With about 2000 students, EiT is NTNU's largest course, and engineering students collaborate on real world problems with students from other study programs, including non-engineering programs.

The central EiT staff organizes the course in cooperation with the faculties, and has academic responsibility for the experiential learning method supporting the development of the students' cooperative skills. The EiT staff also prepares learning materials and methods, and coordinates censorship, and is responsible for the hiring, training and supervision of all the village leaders and learning assistants. Finally, it is the EiT staff that is responsible for the continuous development of the EiT course.

The EiT course is organized in 70-90 classes which are called villages, with up to 30 students each. There are two types of villages: intensive villages takes place every weekday in a three-week period starting at the beginning of January, while semester-based villages takes place every Wednesday throughout the spring semester. Among the villages, 4 of 5 groups are Norwegian speaking, and 1 in 5 are international villages with English as a course language. The different villages are organized by the seven different faculties at NTNU and each faculty needs to offer approximately as many places as they have students participating in EiT.

Each village has a broad overall academic theme related to societal issues or challenges from working life. This theme forms the basis for the student team's project work. The village may have external partners that represent the theme, and who may be advisers or recipients of the students' work. The village themes are presented on the EIT website in the fall semester, and the desired combination of subjects in the villages is specified as a guide to help students choose a village. Students are allocated to the villages on the basis of their preferences, the village's need for competence in various disciplines, and the number of places in the village. The presentation of the village teams aims to describe possible projects and create interest for the village in order to recruit students from a wide variety of disciplines. In recent years, about 90% have been granted a place in the village they had chosen as first or second priority. Students tend to choose villages within their own faculty resulting in less interdisciplinaryity than desired.

The overall learning outcomes and methods are the same for all villages. Each village is run by a member of the academic staff, and two learning assistants, who function as facilitators for the groups. The intended learning outcomes for the EiT course include that after the course the student can:

- reflect on how their teamwork is influenced by their own behaviour patterns and attitudes, as well as those of others.
- take initiatives (actions) that encourage cooperation, and they can change their patterns of interaction if necessary.
- provide feedback to others in the team in constructive ways, and reflect on feedback from the team.
- have extended their perspective on their own specialized knowledge in their encounter with skills from other disciplines. They can communicate and apply skills they have developed in their own field in collaboration with students from other disciplines.

(A full list of the intended learningoutcomes for the course can be found here: https://innsida.ntnu.no/wiki/-/wiki/English/Experts+in+Teamwork) These learning outcomes are directly coupled to some of the CDIO standards such as detailed learning outcomes for personal and interpersonal skills (Standard 2), integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills (Standard 7), and teaching and learning activities based on active and experiential learning methods (Standard 8).

The underlying educational approach is based on *experience based learning* and *reflections* (Andresen, Boud, & Cohen, 1995). Instead of learning about cooperation, using a knowledge based learning method; students in EiT acquire cooperative skills by experiencing and reflecting on teamwork in practice. The experiences of the individual and the group in the

interdisciplinary team form the basis for reflection, evaluation, change and learning (Sortland (ed.), 2016). EiT use David A. Kolb's pedagogical model to describe the learning process (Kolb, 1984): (i) concrete experience – the student has to be willing to take themselves and their experiences as a starting point for reflection with the others in the team; (ii) Reflection on experience – team members verbalize thoughts, emotions and actions related to a common situation. One way in which this is supported in EiT is that students write personal reflections in their Book of Reflections during the day and team reflections at the end of every village day; (iii) Abstract conceptualization – the ability to identify and describe the team's patterns of behavior, attitudes and development adequately with support from relevant academic literature; (iv) Active experimentation – the ability and willingness to try out new behaviors to improve the dynamics in the team. The team must also consider and evaluate their new behaviors in retrospect (Sortland, 2016).

To promote experienced based learning, students in each village work in interdisciplinary project teams of 5-6 students on a self-defined topic coupled to the village theme based on the expertise each group member contributes. All projects that the students work with should be coupled to current challenges in society and the final project report and presentation should show how these problems where addressed through the combined expertise of the students. In addition to the project report, the students are required to analyse their teamwork and, based on their understanding, reflect on how they communicate, plan, make decisions, solve tasks, handle disagreements and relate to academic, social and personal differences. It is through these reflections that student teams should become aware of their group dynamics and learn how to collaborate in interdisciplinary teams. Team members perform reflection activities together, stimulated by facilitation, exercises in teamwork and feedback. To stimulate reflection in the student teams, facilitation is used as a pedagogical tool. The practice of facilitation in EiT differs from facilitation as described in organizational psychology and group leadership. The learning assistants, who function as facilitators, are older students who have received training in observing team behaviour and asking open questions. The input from the facilitators support the students' reflection about the team's dynamics and their individual contribution to the whole. The team's experiences are gathered in a separate process report at the end of the semester.

The final assessment in the EiT course is based 50% on the project report and 50% on the process report. Each group is given a group grade and there are no individual grades given to the students, but all students are required to perform and deliver a perspective evaluation at the end of the course that focuses on their individual development. More information on EiT including the course description is available at: www.ntnu.edu/eit.

RESEARCH APPROACH

As the purpose of the study is to investigate students' perceived value of the EiT course and factors that are important for the development and success of project villages in the course, a *mixed method* research approach was used. Johanson and Onwuegbuzie (2004) defined mixed methods research as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study". This approach combines the strength of both quantitative and qualitative research, allows for triangulation between different data sources to increase trustworthiness, provides a more comprehensive picture of the studied phenomena, helps to better explain the findings, and is particularly useful in the development and testing of hypothesis and instruments (Doyle, Brady, & Byrne, 2009; Ivankova, 2006).

Case studies are characterized as a *bounded* system – such as an individual, a group, a course or a program – chosen because it is "unique, experimental or highly successful" (Shaw, 1978). In the present study, the EiT course was chosen as an interesting case, as it is unique in its size, provides students with important skills for the 21th century, and has

successfully run at NTNU for many years. The quantitative data in this study was collected through a course evaluation instrument based on Likert scale questions between 2007 and 2016, with response rates above 80% in all years. We focus particularly on the evaluation data from 2016, which include answers from 1731 students from all 73 project villages (response rate 86,3%). The quantitative data was analysed using descriptive statistics to highlight general aspects of the EiT course, while Pearson's correlation was used to investigate the relationship between different measured variables (Borrego, Douglas, & Amelink, 2009). All quantitative data was anonymized and analysed using SPSS.
In order to further explore some of the quantitative findings in more detail, the village descriptions were analysed using a qualitative research approach. For the first step of the analysis, all descriptions were analysed using open coding, and in a second step a comparative approach was taken to better understand differences and similarities between the descriptions. All village descriptions were read and coded by two researchers to minimize investigator bias (Krefting, 1991).

RESULTS AND DISCUSSION

Student perceived relevance for work life

In first part of this study, the students' perceived relevance of the EiT experience for later work life is examined. One of main goals of EiT is to better prepare students for later work life and help them to acquire the necessary skills to work in diverse teams later on. In one part of the course evaluation surveys, students are asked to evaluate their own experience in the EiT course and how well it will help them in the future. A summary of the statements that students evaluate on a scale from 1 to 5 is given in table 1 together with the overall mean value for the entire EiT course. In addition, the scores for the three villages with the highest overall student satisfaction and the three lowest are given in the table.

Table 1. Students' perceived relevance of EiT for work life

	Mean for all EiT villages	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
Overall satisfaction	3,74	4,55	4,24	4,2	3,06	3	2,96
In the future, I will benefit from experience I gained in my group	3,78	3,9	4,24	4,4	3,18	2,71	3,18
I see more value in this type of work now than before we started	3,51	3,95	4	4,47	2,82	2,47	2,13
Working in the group has given me new thoughts and ideas about how to work together in the future	3,68	4	4,12	4,4	3,24	2,76	2,86
Experience from the group has increased my confidence in the importance of good teamwork	3,78	4,4	4,04	4,37	3,76	2,65	3,09

In general, the students perceive their EiT experience to be relevant for later work life and feel that it prepares them for future tasks. The students also acknowledge the importance of the EiT experience and think that it has stimulated new thoughts and ideas that will be valuable when working in teams in the future. Furthermore, it is important to note that there is a strong Pearson's correlation between overall student satisfaction and the four statements in this part of the course evaluation form, with correlation factors of 0.73, 0.75, 0.65, and 0.7, respectively.

While student satisfaction does not provide a comprehensive measure of course quality, we argue that it offers valuable information and a starting point for more in-depth investigation. In an extensive and careful meta-analysis of Student evaluation of teaching Uttl et al. (2016) found no correlation between student satisfaction and student learning. Student satisfaction do, however, correlate well with creating engagement and motivation for future work and studies. Students with a positive experience from working within interdisciplinary teams are arguably more likely to accept and function well in future teamwork (Tucker & Abbasi, 2016). The strong correlation between student satisfaction and the four other statements implies a connection that it is worth to explore further.

Another limitation of the current study is that it is built merely on students' self evaluations. In the future, it is desirable to perform a more thorough follow-up study that investigates students' reflections upon their EiT experience after they leave university and are active in the work-place. Also, the perceived value of EiT for companies and work places that hire students need to be investigated. These are important areas for further research, but in this current study we focus on the available data from 2007 to 2016.

Continuous development of the course

Students have been asked about their overall satisfaction with the EiT course since 2007, which makes it possible to look at the progress over time. While student satisfaction does not necessarily correlate with learning, as noted above, there is valuable information to extract from students' overall perception of a course. Figure XX shows a summary of the satisfaction data between 2007 and 2016. There is a clear increase in students' overall satisfaction from year to year until 2010. After 2010, the rate of change diminishes, but the trend of increasing satisfaction remains and the numbers stabilize at a high levels, with over 90% of the students somewhat satisfied, satisfied, or very satisfied. In the 2016 EiT course, only 7.1% of the students were dissatisfied or very dissatisfied.

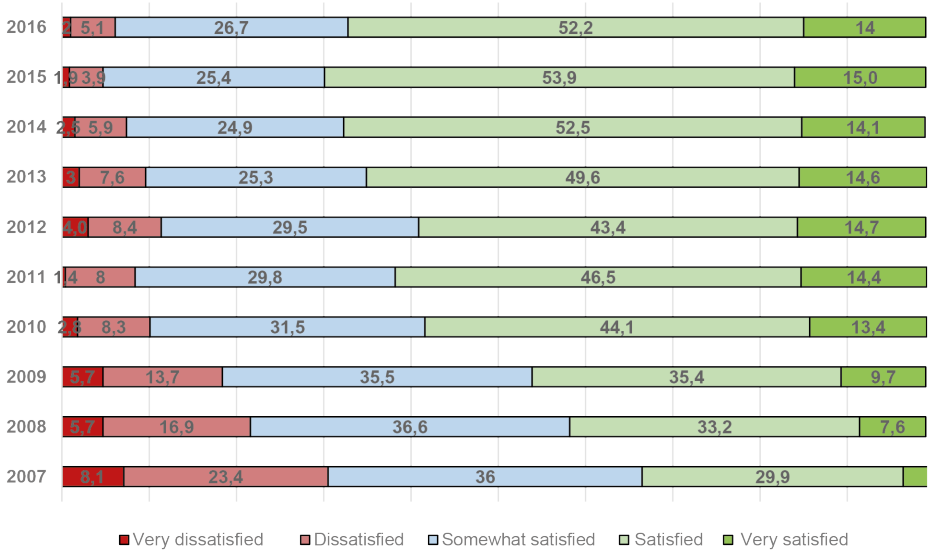

Figure 1. Students' overall satisfaction with the EiT course 2007-2016

Figure 1 illustrates the importance of continuous and sustained development of a course. In 2007 still as many as 31,5% of the students reported dissatisfaction to some degree, a number that has since dropped from year to year due to diligent work on improving both form and contents of the course. Instructional design for a course that deviates from conventional teaching-learning activities need to be evaluated and developed over a period of time. It is necessary to accept that improvements are made stepwise from year to year, requiring sustained effort from continuous development. This has been helped by a continuity in staff. Also, it has taken some time to establish a climate, and a culture, where students (and teachers) not only accept, but buy into the collaborative format of the EiT course. One aspect that we will examine closer in future work is how the students' attitudes to teamwork changes during the EiT course.

Project success factors

When taking a closer look at the students' overall satisfaction data from 2016, it becomes apparent that there are only small differences in mean satisfaction both between the semester-long and the intensive variants of the EiT course, as well as between students' disciplines of study. By contrast, there is considerable variation in student satisfaction on the project village level (2.79-4.55 on a scale from 1-5). The top three villages have student satisfaction scores of 4.55, 4.24, and 4.20, whereas the bottom three villages have scores of 2.96, 3.00, and 3.06.

Taking a closer look at these villages and their boundary parameters reveals that the top three villages are more diverse in their student population than the bottom three. Table 2 shows the number of different faculties that students come from in the six villages, as well as the interdisciplinarity index (i:index) for each village. The i:index is a measure of the variation within each village (0-1), where a high index means higher variation. It is calculated through equation 1 based on a harmonic series, where each additional student from the same faculty adds less and less to the index. The i:index is normalized to the number of students and the maximum possible diversity.

The villages with the three highest students' overall satisfaction scores have students from five or six different faculties out of seven faculties at NTNU. The high diversity in the students' disciplinary backgrounds is also obvious from the i:index for these villages that ranges between 0.88 and 0.73. The bottom three villages on the other hand have students from only four or even two different faculties, which greatly limits the disciplinary diversity of the students, with i:indices between 0.58 and 0.48. The correlation factor between students' overall satisfaction and the i:index for these villages is 0.95.

Table 2. Comparison of the top and bottom three villages of EiT in 2016

Project number	Students' overall satisfaction	Number of different faculties	Normalized interdisciplinarity Index
Project 1	4.55	6	0.88
Project 2	4.24	6	0.80
Project 3	4.20	5	0.73
Project 4	3.06	2	0.48
Project 5	3.00	4	0.58
Project 6	2.96	4	0.58

$$i{:}\,index = \frac{\sum_{n=1}^{\#\,students\ faculty\ 1} \frac{1}{n} + \sum_{n=1}^{\#\,students\ faculty\ 2} \frac{1}{n} + \sum_{n=1}^{\#\,students\ faculty\ 3} \frac{1}{n} \ldots}{Maximum\ possible\ diversity}$$ Equation 1

It is not unreasonable to assume that the variations in student satisfaction we observe between villages are influenced by differences in cultures among teachers and research cultures in the different departments and faculties. We can observe that the same village leaders consistently host satisfied teams. The framework of describing collaborations in terms of multi-, inter-, or transdisciplinary work can be a starting point for a closer study. Understanding of what collaboration entails varies between different teaching-learning and research environments, which likely has influenced the master students' understanding during the bachelor part of their studies. As a first step we would like to be able to achieve a finer resolution of data with respect to how satisfaction varies, and why it is so. Engaging the academic staff in the EiT-course will most likely change the staff's understanding of collaboration.

While the quantitative data offers some possible entry point to explore differences in students' overall satisfaction, it is difficult to understand the underlying reasons and how different aspects of the villages, the facilitators, and the students together influence students' learning experience. As a heuristic, we therefore used the project descriptions written by the village leaders, as an additional data source. As stated above, the project descriptions are used during the project selection phase to attract students to the different villages. The description is the first contact point for the students with the EiT course and the future project.

Looking closer at the project descriptions from the three top and bottom villages, there are clear differences in how the descriptions are written. The three villages with the lowest student satisfaction scores all had descriptions written in vague and technical language that potentially feels distant to the reader. The descriptions are impersonal and do not directly address prospect students.

Project 4:

> Phosphorus is one of the fundamental elements of life and it is essential for food production. Phosphorus cannot be replaced with other elements. Despite its significance, there are few studies on the consequences of a possible reduced access to phosphorous with respect to global food security.

Project 5:

> In the following, we will build on this definition. Note also that several sources use viability as a concept synonymous with sustainability. In this village, students are invited to participate in a research exercise where they will gather empirical data through the use of relevant websites, literature sources and interviews.

Project 6:

> The internet can be used to obtain information about situations, and to organize and manage manpower and material resources accordingly. The management in identical situations can range from simple and straightforward instructions, to instructions for autonomous vessels and equipment.

On the other hand, the descriptions for the three villages with the highest student satisfaction are written in a way that potentially feels relevant to a large number of students. The text makes it easy to identify with the project and the information is situated in everyone's daily life.

Project 1:

> The village will work on topics related to the interactions between consumption, design, and lifestyle, and wider social trends. The groups have great freedom to design their projects themselves.

Project 2:

> The brain makes us who we are, it contains our feelings, thoughts and moods. The brain enables us to travel back in time and into the future, and when you go around the world you're actually walking around in your memories.

Project 3:

> The starting point for this village is to look at how this technology affects us as humans in the public space, and how the space is affected by technology. What happens, for example, to the environment in a café when all the guests bring a laptop and spend the whole day there.

These qualitative differences between the village descriptions offer an interesting alternative entry point to better understand the differences between and reasons for the students' satisfaction with the EiT course. The differences raise questions about how the village leaders perceive their village and their own fields of research, and whether this has an impact on how they communicate about their village themes. To help the students to cooperate and become a team the village leader – the teacher – needs to be a facilitator. This is a large step for academic staff, changing from being a theoretical expert to an open-minded facilitator (Sortland & Erichsen, 2006). Due to the multiple intentions of the learning goals, the teacher needs be both a scientific expert and a mentor. How this should be performed by the teacher to maximise both the quality of the project work and the learning of teamwork skills is not fully understood, and might influence the result. It is difficult, however, to draw robust conclusions based on this information and more studies are needed to better understand what is happening in the villages. At the moment, we are able to observe that there are differences, but can say little as to their origins, or to what extent differences in attitude on how to work influence student satisfaction.

SUMMARY AND OUTLOOK

In summary, the EiT course is an example of large scale mandatory course with around 2000 students each year that promotes students' learning of collaborative skills in interdisciplinary teams through *experience based learning* and *reflections.* A central factor on the organizational level for the acceptance of the course, its continuous development and success is a permeant unit with academic and administrative staff that focuses on the implementation and development. It is through the step-wise improvement of the boundary conditions and support material, together with the establishment of a culture around the EiT course that the course could reach high levels of student satisfaction.

On the student level, we have identified interdisciplinarity as a key factor that drives students' overall satisfaction of the course and an increase in the perceived value of collaboration and relevance for later work life, where villages with a larger variation of disciplinary backgrounds score higher than more homogenous villages. More studies on the underlying processes for this effect are needed to better understand and interpret the situation. In the future, the interdisciplinarity index might be used to increase the variation in all villages further and provide even more students with rich interdisciplinary experiences.

Finally, the textual analysis of the village descriptions offers glimpses at the variations in how village leaders present their villages and how they might see their own role. While the village descriptions alone do not provide enough information, they point towards an interesting area for future studies. The results from this kind of studies can help to improve and develop the comprehensive preparation seminars and training, as well as support material that teachers in the EiT course have access to. These interventions can further support all teachers to adapt to their role and become facilitators for the students' learning.

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BIOGRAPHICAL INFORMATION

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