Real-World Engineering Projects for International Student Teams to Become "Global Engineers"

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Abstract

Engineers in Europe and in USA play prominent roles in technology development for their respective societies, but there are differences in their carrier development and their future role in society depending on country and culture. We can expect that in the future, engineers work globally and change their place of residence, which means that international companies need engineers who understand the issue of working with other cultures and have worked in real world global with teammates and partners from other cultures and countries. Engineering programs in many universities include following elements in their syllabuses in order to train students as ”global engineers”:

- knowledge of languages and cultural skills,
- teamwork and group dynamics in international teams,
- knowledge of the business and engineering cultures in different countries,
- knowledge of international variations in engineering education and practice.

Joint students’ projects (from Purdue University in USA and Technical University of Denmark in Denmark) were established to ensure acquisition of these skills and capabilities through out common real-world projects provided by industrial companies. In this paper, we describe our experiences with three industrial projects performed by students from America and Denmark during which the students dealt with international standards, adapted to working with a different culture, and applied effective project management tools. As part of these projects, the Danish students visit Purdue University early in the projects while American students went to Denmark at the end of the projects in order to present the results of their work for the companies involved. The first face-to-face visit is absolutely crucial for the development of common goals in the project, as well as in order to establish the proper communication during the entire project work. The visit is always planned in cooperation with the American team as they are the host and provide both housing and activities for the stay of Danish students. Danish students stay with a couple of the American students and their mates and spend a lot of time socializing with them. By spending all this time together both parts of the team, Americans and Danish, are able to get a better idea of culture, language and professional skills. Participating in non-professional activities creates a friendly bond in which formalities and barriers are overcomes. For the same reason, communication become easier during the entire project work.

This paper describes different stages of forming international and intercultural awareness during project work.

Introduction

Working in teams on projects involving international partners is a very common situation in high technology industrial companies all over the world. Modern technology development requires specialists with a high degree of professional knowledge in all engineering branches. The process of developing innovative products and technologies is very complex and success in only achieved through teamwork and not by a single engineer. Many innovative companies have branches in different countries in the world and the companies' projects involve engineers and technicians from different countries. This is a common situation in companies all over the world and that is why industry requires engineers with "global" skills [1]. At the same time, more and more new technological skills need to be included in engineering programs/curricula and it is difficult to find "space" for this kind of training in university engineering programs.

The ability to work in teams and with projects involving international partners may differ a lot depending on the educational traditions of the engineers' homelands. The goal of most undergraduates studying engineering courses is to work in an engineering company and most likely in their home country. However, not all engineering students gain skills to work internationally as well as virtually during their education. Engineers of the future must be able to operate in a team-based, multidisciplinary world where international communication and cultural awareness are very important [2,3,4]. Graduates who have been introduced to the dynamics of a global, multi-cultural team will fit more comfortably into these challenging roles.

Many European universities signed mobility partnerships in order to exchange students and teachers/professors [5]. These agreements made it possible for engineering students to study abroad and to complete a part of their education in another language and experience new cultures. This is not always the case with students from outside Europe, as the educational systems are not always similar to the European systems and the costs of education differ from country to country. USA plays the important role in technology development and many European companies have branches and business connections in USA. Bilateral agreements between universities in USA and Europe give the students the possibility to study for one or two semesters in another country. This gives the students knowledge about another culture and language, but does not necessarily include the experience of working in virtual teams, which is very often the case in industrial companies. In this paper, we describe the way we work with our students during their projects to begin the process of gaining international and intercultural working skills.

Joint International, Multi-disciplinary, Virtual Teams

Numerous authors have promoted working on projects in teams for decades and many universities have adopted projects into their programmes using a wide variety of approaches [6,7]. The cooperation between Technical University of Denmark in Copenhagen (short: DTU), Denmark and Purdue University in West Lafayette, Indiana, USA, has as one of the goals to train students within the context of a multi-cultural, multi-disciplinary team, to become "global" engineers with the skills

to understand cultural differences and with ability to work interdisciplinary, across the time zones, communicate in English between native and non- native English speakers.
So far, three common projects with students from DTU-Denmark and Purdue-USA have been completed. For the American students the projects are their senior capstone projects and, for Danish students, the project is a component of a course called Innovation Pilot.
International companies from Denmark and/or USA generated the project topics:

1. Schneider Electric: “Automation Feasibility Project”. Participants were 3 students from Purdue and 4 students from DTU.
2. Cabin Plant:”Vibration Unit”. Participants were 2 students from Purdue and 4 students from DTU.
3. Danfoss A/S: ”Thermal Based Efficiency Measurement of High-Performance Power Electronics”. Participants were 3 students from Purdue and 4 students from DTU.

In the DTU-Purdue program, students work on the same project as one international and interdisciplinary virtual team but mostly geographically separated. Studies show [8] that virtual groups can work more efficiently than non-separated teams, except in situations where:

- the group members have no prior relationship to each other, or
- the project involves certain risk, or
- there is no fundamental trust between the group members.

For virtual teams in these situations, exchanged information and communications can be misinterpreted and the team members tend to act on their own without sharing the information with the other group. This can cause delays in project development. These potential factors exist in all of our projects and we resolved this risk by bringing the students together twice during the project. We arrange for each group of students to visit each other, USA-DK, to develop personal relationships between team members from both universities. The first visit takes place about 3-4 weeks from the initiation of the project with the Danish students going to the USA first. This visit is always a turning point in their project work, elevating the efficiency of communication and project development. During the visit and socialization, team members develop relationship with each other, which, in turn, results in more efficient communication and an appreciation for the disciplinary skills of their teammates. In each trip, the local students host the visiting students in their normal living condition for a complete immersion into the local culture. During the visit, students also participate in some regular classes with their teammates (both lectures and laboratory work), even though the classes may not be in their nature discipline. The reason for participating in classes is mostly to get an idea of their teammates students’ competencies, but also to experience the educational methods and customs in other country. All the students involved in three projects appreciated very much this immersion, to see and experience similarities and differences at both universities. It also helps students better to understand culture of their teammates.

Intercultural Competencies

Training our students to become “global engineers” includes improving their intercultural competencies. According to a study made by an international group of researchers from the Center for Intercultural Learning for the Canadian Foreign Service Institute [9], an interculturally effective person has three main attributes:

- an ability to communicate with people in a way that earns their respect and trust, thereby encouraging a cooperative and productive workplace that is conducive to the achievements of professional or assignment goals;
- the capacity to adapt his/her professional skills (both technical and managerial) to fit local conditions and constraints;
- the capacity to adjust personally so that she/he is content and generally at ease in the host culture.

We mean that students’ work with real-world projects in teams composed of students from different countries is an excellent opportunity to become an **interculturally competent engineer** with all attributes named above.

Intercultural Communication

Intercultural communication skills help us to communicate, or share information, with people from other cultures and social groups and solid language skills may be an important part of intercultural communication [10,11]. However, they are by no means the only requirement in order to be called ”global engineer”. Intercultural communication also requires an understanding that different cultures have different customs, standards, social mores, and even thought patterns. Durable intercultural communication skills include also a willingness to recognize and accept differences in all the named patterns and adapt to them.

Successful intercultural communication is dependent on personal approach, which means that one is striving to avoid misunderstandings and breakdowns. Intercultural communication requires both knowledge and skills. It also requires understanding and empathy. Effective intercultural communication is an important skill for anyone working across countries and continents, especially those working for multinational companies including engineers.

It is also crucial for anyone working with people from other cultures to avoid misunderstandings and behaving or talking in an un-intentional offensive manner. People studying languages often are confronted with issues of intercultural communication, but this is not the case with engineering students. That is why our projects are opportunity to present our students to intercultural communication.

In order to improve their intercultural communication, they need to learn:

- ✓ Basic knowledge of the cultures, organizations and institutions, history and general way of living of different communities and nations.

- ✓ Recognition that these aspects affect behavioral norms. For example, one need to be very careful when being sarcastic or making jokes.
- ✓ An understanding of how culture can affect communication and language. For example, people from Denmark are often said to speak more directly than native English speakers who tend to use more "polite" language. Scandinavians usually do not say "please" and "thank you" as often as American speakers do.
- ✓ The conventions that may govern behavior in certain specific intercultural environments, such as how the students should talk to their professors or employees to their managers.
- ✓ Awareness of other people's values and a willingness to recognize them when they are different from your own values.
- ✓ Sensitivity towards cultural stereotypes that may affect and interfere with intercultural communication.

Intercultural Awareness

In order to develop students' Intercultural Awareness, we actively stimulated the intercultural conversation with readings from "When Cultures Collide" [12] and "The Lonely Planet Guide" for Denmark [13]. These two references were used to support group conversations and reflections on their experience before and after the project completion. Provocative subjects included:

- Developing their awareness of their own views, assumptions and beliefs, and how they are shaped by their own culture.
- Asking them questions like: what do you see as "national" characteristics in your own country? Which "national" characteristic do you like and dislike in yourself?
- Asking them to take an interest and read about their teammates' country and culture, and start to consider the differences between cultures and customs,
- Avoiding making judgements, but instead to collect information, by asking their teammates neutral questions and clarify meaning before assuming that they know what is going on. Once the collected information is available, it will be possible to take action.
- Systematically reviewing their assumptions and look for help and advice by talking to specialists, professors, colleagues or friends who know more about the particular culture about which they are interested.
- Considering the other person's position (empathy).

Conclusion / Student Reflections

To be clear, these projects require considerably more effort from the American and Danish students than the normal senior capstone project. One of the side benefits to the American students is the heavily subsidized trip to Europe. For many Purdue students, this trip is their first trip outside the US. We find our students' opinions telling more than our perception of the course results.

From a Purdue student (American):
“During the project, the interaction between the team from Purdue and DTU has been smooth. Both teams have been very open about concerns and expectations. The problem has been long response time on questions regarding the project when using emails. The long response times happened from time to time slowing the project down. The visits by both DTU and Purdue students have been hugely beneficial as it created a more personal relationship between the two groups. It also made communication more relaxed and project work more intense, as well as it helped to answer many questions very quickly.”

From a Purdue student (American):
“Senior Capstone Projects have conjured many horror stories and rumors throughout the student body. Although it is a very time-consuming project and a high demanding course, it is extremely important to the development of a highly functional engineer in industry. On top of these high expectations, this project added another constraint of an international team. Despite all of these obstacles, I believe the team responded well to all the challenges it faced and adapted to make the best of the experience. Like the others, I believe that learning to communicating efficiently in a professional environment was a huge lesson to be learned throughout this course. The world is growing smaller as the global economy is expanding and it is becoming more common than not to be working alongside colleagues of different nationalities.
I believe that if there was one aspect of the course I would improve, it would be to establish strong standards and expectations of the group members at the beginning of the project. It is a common philosophy among management courses, that conflicts occur in the beginning of the formation of a team as members stumble around to find their niche and challenge each other’s knowledge and authority. However, it is important to understand that conflict is normal and necessary to create an innovative group of engineers. On the contrary, keeping in mind that each person has a different personality type, responds to stress and conflict differently, and perceives and communicates ideas in their own way. A huge part of business and life in general is being able to identify your own communication style, identify others’ preferences, and be able to cope and compromise between those two facts will ultimately yield the most meaningful relationships and productive work.
Culturally, it has been an amazing experience to be able to develop meaningful relationships with each one of the Danish students and spend the year working with them. I could not have asked for a more welcoming experience into one of the few countries I have been to outside of the United States. They helped me experience Denmark in the truest of lights and showed me a country that is truly beautiful from the cityscape to the people and cultural. I am extremely grateful to them and look forward to keeping a lifelong relationship no matter where in the world we are.”

From a DTU student (Danish):
“This project/course has been a great and good experience in terms of innovative and multidisciplinary work. The challenges along the way, has forced the team to think creatively, and the cooperation has been tested in various matters. The nature of this project has been considerably different from my previous experiences, and the multi-disciplinary and cross-cultural factor has been a great experience. One of the largest aberrations from traditional projects at DTU has been the standalone aspect for the team, and the major focus on project management and the process of efficient work. The tools obtained are the major experiences I will preserve for future engineering work.”
“The teamwork has been challenged at some points of the process, and the communication between the American and Danish team has been somewhat lagging at times, especially around December and January. The weekly meetings have been the central path of communication, and for future projects, I will prefer communication that is even more frequent.”
“The experience of working with the company was challenging and for the future, I will keep in mind from the beginning to get a well-defined scope of the work with restrictions clearly stated, to mitigate the risk of misunderstandings. Additionally, I have learned the importance of asking the right question, so the participants from the beginning are well informed, and well prepared to obtain the correct answer. This is one of the major experiences I have gotten, and of great importance, as it will be relevant in future positions.”

From a DTU student (Danish):
“This project has been a very good experience - an innovative process, in cooperation with some great people. Getting to know the Purdue team was an absolute pleasure. The Purdue students were very knowledgeable and had an unusual positive drive for hard work. Working closely both our supervisors, from Purdue and DTU, has been an outstanding honor, and both have been great guidance in all aspects of the project. The innovative and creative thought-process was one of my great weaknesses before this project, and the new methods of innovative-thinking, has improved my personal and professional creativity. The cross-disciplinary, and cross-cultural aspect has been a beyond positive experience, and personally as well as professionally I have gained a lot of positive experiences in this innovative, interdisciplinary and intercultural project, all of which can mature me as a participant for future projects.”

Acknowledgment

The authors wish to acknowledge the companies for their help and supervision during the projects. Without them, these projects would not be possible. The companies are: Schneider Electric, Cabin Plant and Danfoss A/S.

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