Intercultural and Interdisiplinary Communication Skills as a Component of Engineering Education: International Design Projects

Prof. Anna Friesel, Technical University-Copenhagen

Anna Friesel is Professor at the Center for Electro-technology, DTU Diplom - Technical University of Denmark, Campus Ballerup. She is also the president of the EAEEIE - European Association for Education in Electrical and Information Engineering, which is a European non-profit organization, with members from nearly seventy European Universities, most of them teaching in the area of Electrical and Information Engineering (EIE). Anna Friesel is a member of the IEEE Educational Activities Board (EAB) Faculty Resources Committee (FRC). The mission of the EAB FRC is "to promote the continued evolution of engineering education and the career enhancement of Engineering, Computing and Technology (ECT) faculty through quality programs/products/services designed to advance innovation in educating engineers". She is an Associated Editor in IEEE Transactions on Education. She collaborates regularly with many technical universities in Europe, Latin America and USA. Her research interests include mathematical modeling, system dynamics, control theory, and educational methods in automation, robotics, and in engineering in general.

Dr. Sergey Dubikovsky, Purdue University-Main Campus, West Lafayette (College of Engineering)

Sergey Dubikovsky is an Associate Professor at Purdue University in the School of Aviation and Transportation Technology. He teaches advanced aircraft materials and processes and advanced manufacturing and design process courses. His research focus is in immersive learning, problem- and project-based learning, international engineering education, globalization, lean Six Sigma. He worked previously in industry as a Design, Product, and Project Engineer. He has undergraduate and graduate degrees in Mechanical Engineering from South Ural State University (formerly Chelyabinsk Polytechnic Institute) in Russia and a PhD in Engineering Education from the Purdue University's College of Engineering.

Intercultural and Interdisciplinary Communication Skills as a Component of Engineering Education: International Design Projects

Abstract

Companies are designing and manufacturing products around the world and engineering businesses became global enterprises. Partnerships are formed with professionals from diverse cultures and backgrounds as business relationships are expanding. Each technical discipline and unique culture creates a wide range of interaction challenges. Good communication practices are essential for successful product development and business connections. Lack of successful procedures could result in a loss of business and, in some cases, even bankruptcy of a company. Communication is a mix of verbal and non-verbal interactions and etiquette. Therefore, the engineering students need to practice and to enhance their skills in communication, while working with projects in teams with students from other countries and cultures. In this paper, the authors describe their international projects where students from Denmark and the USA work together. For the USA students, it is a part of their senior design capstone course and for the Danish students it is an innovation and an interdisciplinary project, so called the Innovation Pilot [1].

The key learning objectives for training communication skills in order to work in global teams and manage projects are as follows:

- To understand the elements of culture and intercultural communication that impact the development of new technology and business interactions.
- To learn how to apply a model of understanding any culture, including one's own.
- To enhance students' skills in the dimensions of intercultural competence.

The authors give an account of their experiences for three semesters with three collaborative teams of students developing new high-tech test equipment for the engine test cell, which is located at Purdue University's School of Aviation and Transportation Technology. The focus in this paper is global interaction during the project work. The different phases of communication are described and analyzed. The paper concludes with the instructors' and students' lessons learned and recommendations concerning their experiences to communicate with each other long distance, across disciplines, and different time zones.

Introduction

In a global economy products are designed and manufactured by various companies around the world. Thus Engineering businesses have become truly global enterprises. Partnerships are formed across a wide spectrum of diverse cultures and social environments, as business relationships develop and expand. Each technical discipline and unique culture presents a wide range of interaction challenges. Good communication practices are essential for successful product development and business dealings [2]. Lack of successful procedures could result in a loss of business and, in some cases, even bankruptcy of a company [3]. To make the matter worse, communication is a mix of verbal and non-verbal interactions and etiquette, which adds an

additional obstacle to already complicated issue. Therefore, the engineering students need to practice and to enhance their skills in communication, while working with projects in teams with students from other countries and cultures [4,5,6,7].

This paper is focused on how intercultural and interdisciplinary communication skills could be developed and improved during international, interdisciplinary collaborative projects in student teams from Purdue University, Indiana, USA and Technical University of Denmark (DTU), Copenhagen, Denmark. The students from different academic fields and cultures are exposed to both interdisciplinary work, which is highly relevant for all engineers today, and gain experience with teamwork in an international setting, which is crucial in a highly globalized world. Purdue University has a large focus on aviation and educates engineers and engineering technology graduates for the aeronautical industry. Purdue has its own airport used for teaching, amongst a collection of aircraft engines, and training pilots. The described projects are based on an actual demand from Purdue's School of Aviation and Transportation Technology (SATT) to modernize and digitize measurements' equipment and checklists carried out when running tests on their aircraft engine. DTU students study either electronics or software technology and their task in these projects is to design and implement the equipment according to Purdue students' requirements. In addition, the focus of this cooperation is also on project management, project planning, process improvement and communication between two teams from different backgrounds [8], both in an academic and a cultural/language sense. The primary focus in this paper is on the aspects of international collaboration and communication, the challenges this can create together with running the projects with participants, who are working in different countries and in different time zones.

Forming international teams

Currently, three collaborative projects were successfully accomplished. All participating students volunteered to form the teams according to their interest in interdisciplinary and international projects, with appropriate professional knowledge. The DTU Diplom's students came from electronics and/or software design and technology programs. SATT students' task was to formulate the projects' goals and purpose and to explain the requirements of the projects for DTU's students. Basically, SATT students acted as customers. That particular role is not taught by any program and presents a challenge by itself. Following were the teams:

1. Fall 2017 semester: three Purdue students from the School of Aviation and Transportation Technology, three students from DTU Diplom from IT-Electronics (Embedded Systems program), all male students.
2. Spring 2018 semester: four Purdue students from the School of Aviation and Transportation Technology (one female and three male students), 3 DTU Diplom students from Electrical Technology program (Electronics, one female and two male students).
3. Fall 2018 semester: four Purdue students from the School of Aviation and Transportation Technology (one female and three male students), three DTU Diplom students from IT-

Electronics (all male), one DTU Diplom student from Software Technology (male), two DTU Diplom students from Manufacturing and Management program (both female).

The most important task from the beginning of the project was to introduce the students to each other. Every national team made a short presentation of each member including following:

- A picture;
- A description of own professional interests and experiences;
- Short description of their home city and countryside they came from;
- Their private interests and hobbies.

The first contact was via email and it was up to the students to decide future forms of the communication. As the matter of fact, all teams formed Facebook groups and established very soon communication by Skype and WhatsApp application. The faculty members from both universities required one to two weekly meetings at the beginning and just one weekly meeting later on to follow the progress of the teams. The instructors did not attend the meetings between SATT and DTU students. There were also differences in teams' composition through the semesters, which is important to know for successful supervision of the teams and management of their involvement in the project. All SATT students in the three projects knew each other from previous semesters and had worked together in teams before. The situation was not the same for DTU students:

1. Fall 2017 semester: all three students knew each other and they had worked together as a team before.
2. Spring 2018 semester: two of the students knew each other and worked as a team before, but the 3-rd student was "new" in this team.
3. Fall 2018 semester: four students knew each other and had worked together as a team before, but two students from the Manufacturing and Management program were new in/on the team and had not worked together with each other previously.

Differences in composition of the teams clearly affected outcomes of the teams working nationally and internationally.

Communication

There are several aspects concerning communication in the students' projects. In order to successfully complete projects the instructors needed to consider communication challenges in the following context:

1. Communication in interdisciplinary teams.
2. Communication in virtual teams.
3. Communication in international/intercultural teams.
4. Communication across time zones and on long distance.

All the identified aspects needed to be considered and analyzed separately and completely, because of their great impact on the results of cooperation between students.

Communication in virtual interdisciplinary teams

In many companies around the world teams of engineers from different branches and specializations carry out projects together to come up with solutions to extremely complex problems. Modern technology, including digitalization in all sectors of industry, requires expertise from several engineering fields, including in all cases combination of electronics and computer engineering with other technical fields. Therefore, it is essential for a modern engineer to communicate and convey technical knowledge in a meaningful way to engineers from another field [9]. This enables all team members to gain a full understanding of how to apply this knowledge in order to solve a problem. The fact that students from SATT use professional terms and concepts, which students from DTU Electronics or Software Technology never heard, made it necessary to ask follow-up questions for DTU students. It is the first and serious obstacle in a collaborative project, also because the first communication is usually made with electronic messages exchange. It is also time consuming, because of different time zones and different academic activities. After the first contacts by email, the students used Skype or other avenues to talk directly with each other. However, communication on long distance did not solve all challenges because of misunderstandings of specific professional terms used by both sides. Students assume that only about 25-30% of their problems with professional language challenges were possible to explain within the first two weeks via email along. That situation greatly changed after DTU students visited Purdue University and for the first time the students met face-to face. After the first 1.5-2 hour meeting many questions were answered and more detailed planning of the project was started. During that meeting at the SATT and the presentation of the large engine test cell, the DTU students were able to understand Purdue students' expectation for the project. Next, the very important step was to explain to the Purdue students what kind of competencies DTU students have and the possibilities they have to solve their problems. The whole project is very complex and can be divided into several parts, each requiring different competencies to find each solution. Once the DTU students learned about the existing equipment and their function, a part of the project suitable to DTU students' knowledge was selected and the project was formulated. Next, we will discuss the challenges that arise during teamwork when using certain lines of communication.

Lines of communication

Establishing the lines of communication between two parties, and analyzing the effect of the communication on the development of the project is an essential part of project's work and success[2]. SATT-DTU projects are international projects with teams separated by an ocean and several time zones and that is why, the obvious choice is to use e-mail as the main line of communication at the beginning of the projects. This was also the students' own opinion how best to start to communicate.

However, various complications surfaced very soon:

- *Communicating via e-mail is slow.*

Communication via e-mail slows the process of exchanging information. It took on an average (approximately) 5-6 days for each team to respond to a request. This had two adverse effects for both teams:

- ✓ it inhibited the efficiency of the development process, e.g. building the requirement specification;
- ✓ it served as a source of frustration between both teams, leading to potential tension and conflicts.

- *Communication via e-mail is signal-poor.*

  This refers to e-mail as a communication medium, which lacks detail. Signal-rich interaction enables fast feedback, utilization of natural (spoken) language, and enables sender and recipient to communicate in a personal manner. These are all elements which e-mail clearly lacks. The absence of these elements coupled with the lack of using native language which lead to misunderstandings between the teams and that can lead to conflicts.

However, the positive effects of communicating via e-mail included the following:

- *Communication via e-mail enables parallel communication.*

  Communicating via e-mail enables a sender to communicate with many at once; it is a parallel form of communication, which the teams utilized to their advantage. One sender could inform all parties, including the instructors at both universities about what was going on.

- *E-mail serves as an implicit way of documenting the process.*

  Writing e-mails to one another can (if used correctly) serve as a way of documenting the process from the beginning to the end. At the beginning of the project both teams used this feature of communicating via e-mail, although not intentionally. Using e-mail in this fashion couples with the disadvantage of impeding communication.

An essential part of good communication and successful development of the project is to appoint one member of the team on both sides (DTU and Purdue) to be responsible for communication. Identifying a designated person on each team responsible for communicating the groups' interests was thought to eliminate some potential misunderstandings.

DTU team visit to Purdue University and meeting the SATT team

During the initial project, the DTU team came to visit Purdue University about month and half into the project and very one involved experienced that it was a landmark in terms of elevating the efficiency of project development. Within two days of the visit, both groups started to interact with one another, to leave no unanswered or needed clarification questions, had no missed or unclear details about the project. This fact changed plans for the next two times the projects ran. Next two trips to Purdue took place two to three weeks into the project. This had a huge effect on the way both groups started to interact with one another. Studies show, that fundamental assumptions in terms of interpersonal norms and values between members of a group are important in forming a successful bond, and these norms and values can be strengthened through socialization.

Another and very relevant result of the personal meetings and socialization, is establishing a more efficient line of communication. During the meetings, both teams brought up their dissatisfaction with communication via e-mail. It was clear that both teams had, independently of each other, assumed that e-mail was not the best way of communicating, with an undisclosed wish of changing the line of communication to a more personal and efficient one. The teams arranged the future lines of communication to be instant messaging and video/Skype conferencing as their first priority. The effects of the visit to the US, where both teams met, were many, including the importance to establish a personal connection with the people you work with through socialization. Meeting each other and creating a common ground through shared experiences - creating a sense of friendship – meant that the development of the project, and the wish for mutual success, was essential to all members of the team. Additionally, the way the teams communicated face-to-face with one another became more efficient. This was evident in several ways: by the use of instant messaging and by fundamental assumptions of norms and values, which were no longer detached. After the initial personal contact, communication about students' wishes and concerns regarding the project became less formal and more efficient.

Cultural differences - expectations and effects

In a project with an international dimension, cultural differences will affect group dynamics between the involved parties. A common culture between groups involved in any project, be it leisure or professional, and it plays a large role in how well groups work as a unit. It is also a contributing factor as to how well a project will develop. Studies show [10,11], that a strong culture which creates a togetherness in a group (could be for instance a shared experience), will create a sense of belonging and will strengthen the success rate. This is just the opposite to the adverse effects of starting a project as a virtual group, where the involved members of each team have no common background with which they can create this form of togetherness. The conversations with the students revealed that both teams, going into the project, did have their own assumptions about what it would be like working with a team from the US/Denmark. Danish students expected from the beginning of the project that the US students to be very formal. This assumption was reflected by writing long, very formal e-mails to the US team. This turned out to have a negative effect on the efficiency of communication, since the US team felt that they also needed/had to be just as formal in their responses. Later it turned out, that this assumption of having to stay formal was false and for a time added to the potential cleft in the perceived cultural differences between the teams. In addition, both teams spent days composing formal correspondences with an assumption that everyone on the team must participate in writing a message. This approach slowed progress tremendously and created a perception that the other team does not respond in a reasonable amount of time, which led to growing frustration and tension. Moving away to more informal communication, where not everyone must be involved and more grammatical liberties were taken, allowed the teams to advance steadily and faster.

As the project progressed, the cultural differences did seem to merge into a somewhat universal culture, with the goal of succeeding with the project as the central force. This formed a sense of togetherness that both groups were in need of in order to communicate more clearly. The Danish team's visit in US-Purdue created personal connections with the members of the US team and diminished some of the negative effects that exist in a virtual group.

Findings

Our conclusions are based on following:

- we interviewed DTU and PURDUE students at the end of the DTU's students visit in USA-PURDUE about their impressions on communication and on cultural and social events during the visit.
- the final rapport have to include students' final conclusion on communication, interdisciplinary challenges, cultural and social experiences.

Based on three semesters experience with common projects with DTU and PURDUE teams, we summarized our findings in Table 1.

Table 1.

Communication before the visit	Mostly email communication added some Skype and WhatsApp conversations. . It took on average 1.5 to 2 weeks to get answers to the questions about project formulation; details about PURDUE teams system, to which DTU team had to design electronics or software. It slowed the process and was frustrating.
Communication during the visit	DTU students stayed at PURDUE students' homes and creating a personal connection was a landmark in terms of elevating the efficiency of project development. Socializing with each other had a huge effect on the way both groups started to interact.
Communication after the visit	Students used emails, messenger, Facebook and WhatsApp to answer questions, solve problems and challenges, and communication was much faster compared to the period before the visit. It took on average 2-3 days to get answers to the questions.
Interdisciplinary understanding, before, during and after the visit	It was difficult at the beginning for the students to understand each other professional terms, which are electronics and software for PURDUE students, and mechanics and aeronautics for DTU students. Again, it slowed the progress of the project, but face-to face communication (during the visit) made it much easier to explain professional terms. Also visit to laboratory and seeing the physical system made it clear for DTU students how the system works and what have to be done during the project. PURDUE students get also better understanding what competencies DTU students have. The positive impact of the visit was visible for the rest of the project.

Intercultural experience and understanding	Students on both sides have had their own assumptions about what it would be like working in team composed of Danish and American students. This fact made the first contacts very formal and reflected by writing long, very formal e-mails. This turned out to have a negative effect on the efficiency of communication and project progress. It should later turn out, that this assumption of having to stay formal was false and the visit of DTU students at PURDUE changed totally the students' assumptions of cultural differences between the teams. As the project progressed, the cultural differences did seem to merge into a "universal culture", with the aim of succeeding with the project as the central force.
Social activities and their impact on the project	According to all three teams, social activities are crucial for project success, especially because the most of the project work is done on distance, in different time zones and students represent different technical disciplines. Social activities during the visit made it possible to understand each other professional and linguistic, to adjust the expectations for the project development, and to adjust the methods of communication for the rest of the project.

Conclusion

The described collaborative projects for Danish-US teams started as a virtual group, implicitly meaning they are physically and socially detached. This led to a slow development of the project in the initial weeks from the start date due to suboptimal communication and a fundamental unwillingness to improve these conditions. The exchange of information was more formal, less frequent, and there was a risk of misinterpretation. This effect was evident in the early stages of the project prior to the face-to-face meeting between the groups was arranged. The choice of the lines of communication had also a great impact on the general rate with which the project would develop. In the early stages of the project, both groups utilized e-mail as the only medium for communication. E-mail is a signal-poor communication medium with slow response times and, therefore, the project development during these early stages was not optimal. Once the teams meet and socialize with each other, the common goals for the project become obvious and the project development accelerates. The cultural aspects of the project have also shown that a face-to-face meeting improves mutual understanding of each other privately and professional. At the same time, better and more efficient communication was established in the form of informal instant messaging and video contact combined with email, which led to greater motivation and potentially a better chance to succeed with the project. Another lesson learned from the projects understood that not everyone must participate in each exchange of information between the teams. After the tasks were divided between team members, a person in charge of the task could serve as a representative of the team and solve any problems related to his or her area of responsibility.

Bibliography

[1] Innovation Pilot- course description: http://kurser.dtu.dk/course/62999

[2] Dzenowagis, A.: "Intercultural communication in global business". Paper presented at PMI® Global Congress 2008—Asia Pacific, Sydney, New South Wales, Australia. Newtown Square, PA: Project Management Institute

[3] Detlev E. Jansen:" Intercultural communication in engineering: a research programme to investigate the cultural influences in the negotiation of engineering projects", World Transactions on Engineering and Technology Education, UICEE Vol.1, No.1, 2002.

[4] Friesel, A.: International Students' Projects as a Part of Engineering Education; Conference: American Society for Engineering Education (ASEE'2018); Salt Lake City, Utah, USA; Volume: Proc. of ASEE'2018.

[5] Ashworth,D., Friesel,A., "Preparing students for engineering tasks in industry - working in international teams with projects", Proceedings of the 37th SEFI Annual Conference 2009, Rotterdam, Netherlands, July 1–4, 2009.

[6] Sheppard, K., Dominic, P., Aronson, Z.: "Preparing Engineering Students for the New Business Paradigm of International Teamwork and Global Orientation", Proceedings: Enhancement of the Global Perspective for Engineering Students by Providing an International Experience, April 6-11, 2003; Tomar, Portugal

[7] Lawlor, B., Farrell, A.,Jordan, A., Strawbridge, J., Brabazon, D.,Casey, K.,Coughlan, A.: "Interdisciplinary Communication Skills - Facilitating Students from Different Disciplines to Learn with, from and about each other", 5th International Symposium for Engineering Education, 11 September 2014, University of Manchester.

[8] Smith, R. A., & Khawaja, N. G.: "A review of the acculturation experiences of international students". International Journal of Intercultural Relations, 35, 699-713.

[9] Geraedts, HGM., Päätalo,H.: "International collaboration in engineering projects on product innovation",. 41-st SEFI Conference, 16-20 September 2013, Leuven, Belgium.

[10] Schadewitz, N., Norhayati, Z., "Cross-cultural collaboration Wiki: evolving knowledge about international teamwork", IWIC'09, Proceedings of the 2009 international workshop on Intercultural collaboration, Palo Alto, California, USA — February 20 - 21, 2009

[11] Steers, R. M., Sanchez-Runde, C. J., Nardon, L. :"Management across cultures: challenges and strategies", Cambridge University Press, 2010.