Sustainable Energy Design through International Student Teamwork

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Abstract

A forward-thinking course format based on project-based learning (PBL) was employed in an undergraduate engineering course in the summer 2021. We believe this course is forward-thinking given the international, virtual, team-based format driven by industry-led cases and high-fidelity project-based learning. The course included students from two universities, the University of Pittsburgh and the Denmark Technical University, who are electrical engineering and sustainable energy design undergraduates, respectively. Each project team included students from both universities, and the course was run via web conferencing software given its international nature. The course was designed to prepare students for a globalized job market. An inherent objective was to introduce the implications and opportunities entailed by cultural differences between nationalities and personalities. The ongoing research objectives are to study student perspectives, development, and learning in this international, virtual, project-based-learning environment. Preliminary results from the initial offering of this course are presented along with the logistics involved in establishing and running the course.

1. Introduction

One of the benefits to having a Study Abroad program is contacts with faculty and instructors at international universities that can be leveraged in times of opportunity and need. During the COVID-19 crisis, travel abroad by university students for study or research was not possible. However, in such cases, is an impactful "international" experience still possible for students? Perhaps if you can get creative and be flexible, it is!

During the middle phase of the remote instructional period due to COVID (i.e., fall 2020), it became clear that travel abroad for coursework was not likely to occur in the summer 2021. Students from the University of Pittsburgh had typically traveled to Denmark during the summer for an international experience as part of electrical engineering coursework. During fall 2020, instructors and study abroad professionals from the University of Pittsburgh and the Denmark Technical University began meeting to brainstorm potential next steps and possibilities (if any). In lieu of travel, virtual research talks and company tours could be offered to students at both universities as "international experiences." However, upon getting very creative and with an open mind, this group decided to pursue a course to be co-taught by instructors from both universities that encompassed project-based learning in an international context for University of Pittsburgh and Denmark Technical University students. This seemed like a wonderful idea and a potential "positive" of the pandemic, but would require flexibility on both sides. One of the challenges was determining a schedule that would work for both, including both a timeframe to offer the course and a daily schedule given the six-hour time difference. A second challenge was in assessment and grading, as the two universities have completely different grading scales and systems. A process had to be established to enable joint scoring by the two instructors of each project team, which consisted of students form both the University of Pittsburgh and Denmark Technical University. Finally, while the University of Pittsburgh students were to be granted 3 credits, the Denmark Technical University students were to be granted (the US equivalent of) 5 credits. This was due to the summer course structure at both institutions. At the University of Pittsburgh, a summer course consisted of the same amount of contact hours as a three-course

during the fall and spring semesters. At Denmark Technical University, there is an intensive summer semester where students take one class which meets every day for 8 hours.

2. Literature Review

Project based learning is a method that has been often used in engineering education, with a significant literature base. Teaching methods are traditionally *deductive*, in which content is delivered before students must apply it (Prince & Felder, 2006). Project based learning (PBL) uses an inductive approach, in which the authentic problem or assignment is presented before students "receive" the content needed for a solution (Prince & Felder, 2006). Students are subsequently motivated to learn the necessary material, with the overall process reflecting professional reality to a greater extent (Sheppard et al., 2009; Prince & Felder, 2007; Prince & Felder, 2006; Edstrom et al., 2007). Inductive techniques are encouraged by the theory of constructivism, which maintains that such experiences push students to construct knowledge on their own, with possible self-adjustments as they learn from their experiences (Prince & Felder, 2006). A recent literature review of empirical studies of project base learning was conducted to identify the student outcomes that are typically assessed and how they are assessed in project based learning in higher education (Guo et al., 2020). Four categories of outcomes in PBL were identified via the review – affective, cognitive, behavioral, and artifact performance. The review recommended that more research be done on student learning processes with PBL (Guo et al., 2020).

Recent literature on project based learning (PBL) has examined it a virtual team setting. One study explored and encouraged shared leadership in virtual (online) PBL teams, which can impact intention to learn and knowledge acquisition (Darban, 2021). An additional theme that has been examined in the recent project or PBL literature is *international* virtual teams. This theme is discussed within the backdrop of technical challenges that that require cross-cultural collaboration and understanding, such as software development and the most complex challenges confronting our world, such as climate or humanitarian crises. To this end, the Global Virtual Team (GVT) initiative was developed at a Canadian university so geographically-distributed engineering students from universities across the globe could engage in engineering projects and subsequent intercultural learning (Ndubuisi et al., 2012). In a software engineering course, PBL was explored in relation to virtual group projects between a university in Mexico and one in Germany (Olivares-Ceja et al., 2017), in which students gained international experience necessary for today's software developers. In comparing perspectives from students who had completed this software course in the traditional, instructor-lecture style versus the PBL approach, the students in the latter cohort evaluated PBL to be more effective for deep knowledge and international-project experience (Olivares-Ceja et al., 2017).

3. Methods

3.1 Course Structure

The project-based-learning (PBL) course was designed to include minimal technical lecture by the instructors. However, a core component of the course was a series of guest speakers who spoke about some of the "soft skills" relevant to international teamwork. Five teams of approximately four students each were formed using the CATME team development software (www.catme.org). Teams were "internationally-based," with each team consisting of students from both the University of Pittsburgh and Denmark Technical University. There were six the University of Pittsburgh students and 15 Denmark Technical University students enrolled in the course. The teams were formed to have a least one student from the University of Pittsburgh and three to four students from Denmark Technical University. Thus, the experience for students was one of international, project-driven teamwork in a virtual setting. There were also differences in the educational background of the students, lending to interdisciplinary work. The University of Pittsburgh students were classic electrical engineers pursuing a power and energy concentration. Thus, they had in-depth background in electric power, signal processing, embedded systems, and circuit analysis and design. The Denmark Technical University students had the broader perspective of sustainable development, but with a focus on electricity since this is a key energy carrier. The inter-disciplinary background likely supported the proposal writing.

One of the challenges was determining a schedule that would work for both universities. Danish and U.S. academic schedules are different. Denmark Technical University offers a 3-week intensive semester from approximately June 4-25 each year during which Danish students take one course for 8 hours per day. Although the University of Pittsburgh does not offer such a semester at the same time of the year, the University of Pittsburgh instructor was able to recruit the University of Pittsburgh students to this unique "semester." In addition, there is a six-hour time difference between Denmark Technical University and the University of Pittsburgh. Prior to formalizing this course offering, the University of Pittsburgh instructor had to determine the contact hours that would be required during this timeframe to constitute a usual 3-credit course.

A course meeting schedule that was amenable to both universities was established that extended from Friday June 4 to Friday June 25, 2021. The course was held via Microsoft Teams, Monday through Thursday from 8:30 AM - 10:20 AM EST, which corresponded to 2:30 – 4:20 PM in Denmark. On the four Fridays during which the course was held, students had eight-hour days on the 11th and 18th and four-hour days on the 4th and 25th. During the eight-hour days, there were four hours of overlap time in which the Denmark Technical University and the University of Pittsburgh students were together via Microsoft Teams to work on their projects. On these 8-hour days, the Denmark Technical University students started class at 10:00 AM their time and were joined four hours later by the University of Pittsburgh students. After four hours together, the Denmark Technical University students could leave class for the day while the University of Pittsburgh students remained four more hours.

In addition, Microsoft Teams was used for team-based instruction. Each of the student groups formed their own team channel which was used for scheduling of meetings, communication, document storage, and more.

3.2 Industry Partners

Three industry partners in each country, for a total of six companies were recruited. The companies were chosen so that there was expertise in three core areas: electricity generation, electricity distribution, and energy infrastructure. There was one company from the US and one company from Denmark to represent each of these three areas. The instructors worked with each of these companies individually throughout the spring of 2021 to develop three unique cases which were applicable to both the US and Denmark. There were many iterations between the instructors and the industry partners in developing cases that were both interesting and applicable to the counterparts from each company. Each of the cases was presented to the students with a case theme, case owners, overview, and a demonstration of a real world application. These cases served as the basis for the R&D research proposal for a sustainable energy project that the teams were to ultimately submit.

The students worked with the industry partners for their respective cases to finalize their solutions. This included independently reaching out to the industry partners to communicate via email and set up virtual teleconferences.

3.3 Project Cases

The information presented to the students on the cases is detailed below:

Case 1 - Generation

Case Owners: US Industry Partner 1 & DK Industry Partner 1

Overview:

While renewable based generation is increasing within the energy system, conventional plants are still required for handling the inherent intermittency of renewables, and for provision of grid balancing services. At existing generation sites, grid infrastructure utilization varies with market mechanisms and demand. The objective for this problem is to propose a modernization strategy that increases infrastructure utilization for existing generation site infrastructure through efficient management of internal loading (lighting, heating, etc.) and integration of offshore wind, photovoltaics, and distributed energy resources.

Solution Requirements:

- Safe and reliable
- Economically feasible
- Applicable in US and Denmark, and therefore harmonizes standards
- Justify the relevance in future grid composition
- Considers the UN Sustainable Development Goals

Case Demonstration:

For this case, the Eastlake coal power plant near Willoughby, Ohio is hypothetically considered in operation with a rated capacity of 1,250 MW. While the utilization of this plant depends on the scheduled power generating, exiting infrastructure (e.g. transformers and cables), it represents a constant capacity. A conversion to a hybrid power plant where the conventional

power plant is supported by renewable generation such as offshore wind turbines in Lake Erie can be both an environmental and economic sustainable modernization demonstration case.

Case 2 – Energy Infrastructure

Case Owners: US Industry Partner 2 & DK Industry Partner 2

Overview:

The share of intermittent renewables increases to the point where the operation of traditional base-load power resources is affected. One of the inherent challenges of renewable generation is its variability making it a non-dispatch resource. In addition, there is a push for even more renewable generation that entails additional technical challenges, as a system relying on non-controllable generation can jeopardize the security of supply if production cannot cover demand. The local concentration of renewables connected to the distribution network approaches a situation where it affects sub-transmission and transmission system operation, hence new solutions to accommodate these and the inherent challenges must be explored. Meanwhile, renewable generation is typically placed in rural areas and the consumption, which is predicted to increase in the coming years, is concentrated in and around urban areas. The objective of this problem is to solve the challenges of renewables, namely the variability and their remote location. While improving the infrastructure might be necessary, it might not always be economically feasible or sufficient.

Solution Requirements:

- Safe and reliable
- Economically feasible
- Integrate an aggregation of distributed energy resources at a common coupling point in the transmission system
- Reflect on the operation of a power system with high shares of variable and distributed generation and consider ways to secure supply through operational management
- Emphasis on long- and short-term disturbances
- Considers the UN Sustainable Development Goals

Case Demonstration:

The Danish peak net consumption is 6,500 MW, and there is about 6,000 MW wind power capacity connected to the Danish power system. Currently, the power grid is balanced by strong interconnections with neighboring countries. However, the Danish transmission system operator knows of plans for an additional 16,000 MW of solar PV and 5,000 MW of onshore and close-to-shore wind turbines. Such remarkable increases in renewables pose a threat to the security of supply. This scenario can be considered as a valuable demonstration for the infrastructure case.

Case 3 – Distribution

Case Owners: US Industry Partner 3 & DK Industry Partner 3

Overview:

Sustainable coverage of energy demand in urban development planning is increasingly relevant in modern cities. Such development typically mixes residential, commercial and offices, and includes, but is not limited to, apartment buildings, grocery stores, shopping boutiques, fitness centers, academic research facilities, entertainment facilities, restaurants, and tech developer offices. As part of the development goals, the users' demands must be covered through integration of green technology such as electricity generation and service electrification, for example climate comfort through heat pumps and air conditioning or collective heating and cooling, and transportation through electric vehicles. The objective of this problem is integrating such technologies in urban development planning.

Solution Requirements:

- Safe and reliable
- Economically feasible
- Key performance indicators of the different energy demands within the development
- Impact of the development on the users and society
- Analysis of technology development impact after the development is completed
- Considers the UN Sustainable Development Goals

Case Demonstration:

In the city center of Copenhagen, the Danish Capital, is the municipality of Frederiksberg, which is the most densely populated municipality in Denmark. In the center of Frederiksberg is Frederiksberg Hospital, which will be moved in 2023 leaving an area with old buildings available for new development. One vision is to transform the old hospital to host residential, commercial and offices. Such transformation can be considered as a demonstration case for novel approaches to sustainable urban development planning.

3.4 Learning Objectives and Course Assessment

The course was focused on a set of concise and tangible learning objectives which were presented to the students on the first day of the class. These objectives, written using Bloom’s taxonomy verbs, are as follows

Learning Objectives

Upon completion of this course, student should be able to:

1. Analyze political influences on US and DK energy development

2. Formulate an R&D research proposal for a sustainable energy project. Communicate the proposed idea both through writing and oral presentation

3. Apply engineering design to produce an energy solution that meets specified needs with consideration of the UN Sustainable Development Goals and estimate the potential impact.

4. Evaluate the potential economic value creation of the proposed solution

5. Function effectively on an international team and develop a team charter that considers leadership, collaboration, goals, planning of tasks, and meeting objectives.

6. Provide a self & peer assessment relative to overall team performance.

The assessment of these learning objectives was conducted using four assignments. These assignments were (1) the development of a team charter, (2) a mid-course project check (i.e., oral exam) (3) final presentation, and (4) submission of the proposal manuscript. This is shown in the following flow diagram.

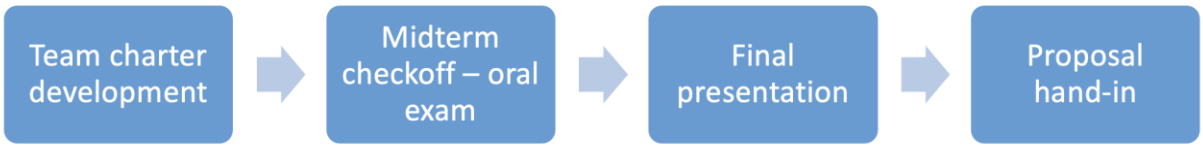

Figure 1: Assessment Flow Diagram

Each assignment was assessed using a rubric which was provided to the students for full transparency. While this assessment technique is quite common in US institutions, it was new to the Danish instructor and students. An example of a course rubric is shown below.

	3=Excellent	2=Good	1=Satisfactory	0=Unsatisfactory
Grammar & Mechanics (20%)	Clear, concise sentences. No grammatical errors.	Mostly clear, concise sentences. May have some minor grammatical errors.	Adequate sentence structure but may require editing for clarity/wordiness. Some grammatical errors, but these do not impede understanding.	Poor sentence structure. Writing may be wordy or difficult to follow in places. Many grammatical errors.
Content (60%)	Charter provides a precise level of detail to assure mutual understanding of the project direction. All aspects of the project are clearly defined and documented. Such aspects include but are not limited to: - roles & responsibilities - goals & objectives - opportunities - milestones - deliverables - overall project plan - risk/conflict identification and resolution strategy Charter identifies specific and reasonable success criteria.	Charter provides a sufficient level of detail to assure mutual understanding of the project direction. Various aspects of the project are clearly defined and documented. Such aspects include but are not limited to: - roles & responsibilities - goals & objectives - opportunities - milestones - deliverables - overall project plan - risk/conflict resolution strategy Charter shows some definition of success criteria.	Charter provides some details to assure mutual understanding of the project direction. Various aspects of the project are defined and documented, some with more clarity than others. Charter tries to define success criteria.	Charter provides some details to assure mutual understanding of the project direction. Some aspects of the project are not defined and documented. Success criteria are missing or not well defined.
Organization (20%)	Document organization is exemplary. Document is well formatted according to the assignment requirements.	Document is formatted as a charter.	Document is formatted as a charter, but its organization could be improved.	Document is not formatted as a charter, and/or Document has significant issues in formatting and organization.

Figure 2: Rubric for Team Charter

3.5 Guest Speakers

Learning objectives 5 and 6 in the previous section address many of the professional skills that are required to function in an international team. To address these skills, we invited guest speakers from industry and academia in both the US and Demark to provide information on the following topics:

- Cultural differences and similarities between the US and Denmark
- Challenges and opportunities of an international workforce
- Leadership in an international context
- International teamwork challenges and logistics
- The history of the US and Danish power systems

- Research and development
- Performing a literature review

These sessions were conducted using Microsoft Teams and were interactive with lectures, discussions, and breakout rooms.

3.6 Course Schedule

The following table shows the course schedule (names and companies removed for blind review)

Table 1: Course Program

Date	US time	DK time	Agenda
June 4	8.00 am	14.00	Short introduction to the course and to (Universities Blind)
	8.30 am	14.30	**Case pitch and "Company visits"**
	9.30 am	15.30	Short break
	9.45 am	15.45	**Challenges and opportunities of an international workforce** by Culture and Development Consultant, (Blind)
	10.45 am	16.45	Short break
	11.00 am	17.00	Course policies and student group break-out rooms
June 7	8.30 am - 10.00 am	14.30 -16.00	**Workshop on international leadership** by Director of Leadership Program, (Blind)
June 8	8.30 am - 10.20 am	14.30 - 16.20	**Teamwork challenges and logistics** by (Blind) from (Company)
June 10	8.30 am - 10.20 am	14.30 - 16.20	**The history of the US and Danish Power Systems** by GM Advanced Grid solutions, (Blind) and Inspector, Danish Energy Museum,(Blind)
June 11	8.30 am	14.30	**Midterm Evaluation with Company Case Owners**
June 14	8.30 am	14.30	**R&D application preparation** by Project Developer, (Blind)
	9.15 am	15.15	Short break
	9.30 am	15.30	**State-of-the-art literature review** by PhD students (Blind) and (Blind)
June 17	9.00 am	15.00	**DK and US Renewable Energy & Climate Policies** By Counselor in government-to-government partnerships, (Blind)

June 24	8.30 am	14.30	**Final Presentation**, Feedback and Evaluation – **Generation Case** (US Industry Partner 1 & DK Industry Partner 1)
June 25	8.00 am	14.00	**Final Presentation**, Feedback and Evaluation – **Infrastructure Case** (US Industry Partner 2 & DK Industry Partner 2) – **Distribution Case** (US Industry Partner 3 & DK Industry Partner 3)

3.7 End of Course Survey

An end-of course survey was distributed to the students to gather perspectives on their learning and skills acquisition because of the course. It consisted of a mix of closed and open ended questions.

4. Results

4.1 Direct Assessments

The five teams were assessed using the methods described in Section 3.4. This section gives the results of this assessment. Each of the rubric categories and their scores are shown. Note that each assessment has its categories weighted, as can be seen in Figure 2.

Team Charter:

Table 2: Team Charter Assessment

Team	Grammar and Mechanics	Content	Organization	Weighted Avg
1	2	3	3	2.8
2	3	2	2	2.2
3	3	3	2	2.8
4	3	2	3	2.4
5	3	3	3	3
Avg.	2.8	2.6	2.6	2.64

This result showed the students worked quite well as a team for their first assessment.

Midterm Check-Off:

For the midterm check-off, each student was individually assessed. Therefore, the mean scores for each category are shown on a 0-3 scale for N=21

Table 3: Midterm Check-Off Evaluation

Overview	Argument	Evidence	Implications	Structure	Prompting
2.33	2.52	2.33	2.14	2.33	1.90

This assessment showed that individually, the students had some difficulties. This reinforces their ability to work as a team. Overall, most of the students were able to achieve the between a 2 and 3 for most categories, but this required prompting by the instructors.

Final Presentation

The final presentation was assessed both as a team and individually. All categories were assessed as a team except for Individual and Questions. The Individual category simply was a measure of how well the student presented regarding grammar, and in addition, how much of the overall contribution to the presentation did they make. The Questions category was an assessment of how much the given student step did up to answer themselves, or augment answers given by their teammates.

Table 4: Final Presentation Assessment

Team	Content	Delivery	Organization	Creativity	Time	Individual	Questions	Visuals
1	3	3	3	3	3	2.75	2.25	3
2	3	2	3	3	2.8	2	3	3
3	3	2	2	2	3	2.4	2.2	2
4	3	2	3	3	3	2.5	2	3
5	2	2	2	2	3	2	2.5	2
Avg.	2.8	2.2	2.6	2.6	2.96	2.33	2.39	2.6

Proposal Document

The proposal document was purely assessed on a team level. This assessment is shown in the following table.

Table 5: Proposal Document Assessment

Team	Originality & Impact	Research Approach	Outcomes	Scholarship or Context	Relevance	Goals	Order	Conclusions	Style	Mechanics	Weighted Avg
1	2	2	2	2	2	3	2	2	1	2	2
2	2	3	3	2	2	2	2	2	2	2	2.2
3	3	2	2	3	3	3	3	3	2	3	2.7
4	2	3	3	3	3	3	3	2	2	2	2.6
5	3	2	3	3	3	3	3	3	3	3	2.9
Avg	2.4	2.4	2.6	2.6	2.6	2.8	2.6	2.4	2	2.4	2.48

4.2 End of Course Survey

On the end-of-course survey, we asked students the following questions:

1) Describe your perceived ability to work on an international team (or not) based upon this course.

We received 11 responses to this question. Interestingly, two Denmark Technical University students discussed the good opportunity to practice their English because of being on an international team. Because there were more Denmark Technical University students than the University of Pittsburgh students enrolled in the course, the teams did not have equal numbers of the University of Pittsburgh and Denmark Technical University students. Although two Denmark Technical University students raised this as an issue, one realized this was also a beneficial thing, as it forced the students to work as more of an international team. This is in contrast to simply splitting up the work based on convenience (i.e., location). Thus, although partially stated as an issue, one of the students actually realized this as a "benefit in disguise."

2) Describe how you may have obtained any new knowledge you've needed for this course or for the proposal.

We received 13 responses to this question. In these responses, students realized they had conducted necessary independent learning through literature or internet searches (6 students). Two students mentioned the efficacy of the guest speakers for their knowledge acquisition. One student indicated he/she was challenged in unique ways by the course, which led to new learnings. Specifically, *"Often our projects have a specific goal and we must have that as a target from the very beginning, why we are very aware of exactly how we are supposed to move forward. In this project, I think you did a good job in making it clear, that we should make our own decisions and take the project in our own direction. In fact, I think your choice of designing VERY open projects facilitated my learnings in this course."*

5. Conclusion

The course was seen as an overall success by the instructors. There was also evidence of this in the end of term surveys given to the students. The real value in offering a course such as this is that it can accurately simulate an international working environment. There are many companies who use international teams, especially in engineering. This course helps to adequately prepare students for similar work experiences after their graduation. In addition, the course provides great insight into American and Danish culture. Students even learned things about their own culture which they had previously never thought of.

We believe that a similar course should be offered to provide similar experiences. A course such as this should not be used to replace courses which students are able to travel abroad as was the case in 2021. This was simply out of necessity. Instead, a course like this could be offered in addition to a study abroad course to give students a greater understanding of the global engineering workforce that they are part of.

The greatest challenges in developing such a course are to align schedules and program structures between two universities. In addition, another challenge was to align the pedagogical

approach for both universities. In a collaborative effort such as this one, there needs to be a give and take between the institutions.

The key point being that it can be done, however, it will require flexibility on the part of both institutions. There were challenges that were experienced by the faculty, program administrators, and students alike, however, these challenges transformed into lessoned learned by all. If there is one great thing that the pandemic has taught everyone, it is that we often must be flexible to achieve our common goals. This course shows that it is certainly possible and that it provides a unique learning experience which teaches desirable skills which are not easily obtained otherwise.

References

Olivares-Ceja, J., Gutierrez-Sanchez, B., Brockmann, P., Kress, A., & Staufer, J. (2017). Project-based learning in an international virtual classroom to teach global software engineering. *Proceedings of EDULEARN17 International Conference on Education and New Learning Technologies, Barcelona, Spain*.

Darban, M. (2021). Learning in virtual student teams: an examination of shared leadership. *Journal of Research on Technology in Education*, 1-18. https://doi.org/10.1080/15391523.2021.1916800

Edstrom, W., Soderholm, D., Wedel, M. (2007). Teaching and learning. In E. Crawley, J. Malmqvist, S. Ostlund, & D. Brodeur (Eds.), *Rethinking engineering education. The CDIO Approach* (pp. 130-151). New York: Springer.

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research, 102*, 1-13. https://doi.org/10.1016/j.ijer.2020.101586

Ndubuisi, A., Marzi, E., & Slotta, J. (2021). Cross-cultural virtual team projects: International virtual engineering student teams. In *Developments in Virtual Learning Environments and the Global Workplace* (pp. 86-107). IGI Global.

Prince, M., & Felder, R. (2007). The many faces of inductive teaching and learning. *Journal of College Science Teaching, 36*(5), 14-20.

Prince, M., & Felder, R. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*(2), 123-138.

Sheppard, S., Macatangay, K., Colby, A., & Sullivan, W. (2009). *Educating engineers: Designing for the future of the field*. San Francisco: Jossey-Bass, 108-118.