Team Negotiation Strategies in Entrepreneurship Education: Patterns Found in Engineering Students from Northern California and Santiago de Chile

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Abstract

A new way of doing engineering is rising. Particularly, accreditation criteria and local demands are requiring schools of engineering to transform engineering education by embracing entrepreneurship and innovation. Students need to be more prepared to address challenges of the industry through effective engineering design process. Nonetheless, we expect teams of students to be able to overcome friction in any entrepreneurial endeavor with little or no instruction on how to work and orchestrate dissonance. This paper showcases context sensitive qualitative information from a team negotiation study conducted in two educational settings in North and South America. We describe two bottom-up negotiation strategies that become a shared pattern between the two research sites. Additionally, both group of students described a new mindset for doing things and solving real problems. Being comfortable with ambiguity is an emergent expected outcome from a new way of teaching and learning engineering. A convergence in the negotiation patterns is expected from collecting information in other research sites. The techniques are visual in nature and have the potential to be transferrable as concrete tools for a universal framework for any engineering design curriculum.

Introduction

The importance of integrating team-building strategies into the engineering curricula concerns universities around the world. Not only engineering accreditation agencies are requiring teamwork assessment, but the professional workplace is expecting graduates that are prepared to be productive in cross-functional teams\(^1,2\). From an innovation point of view, team negotiation strategies are crucial for engineering design. Negotiation techniques entail the ways that individuals deliberate, discuss or communicate in order to achieve a particular temporary or long term agreement or consensus. In this line, Hargadon and Bechky (2006) propose a model of innovation where problem solving is addressed by group interaction, as opposed to just one individual effort\(^3\). Negotiation techniques are needed in order to recombine past experiences of different individuals, and lead to new insights. Nonetheless, engineering schools often dismiss teaching negotiation techniques that might be relevant for developing high performance teams\(^2\).

Techniques for achieving temporary settlements are relevant to engineering students’ training. Innovation driven projects usually have to work with ambiguity\(^4\). Teams that manage multiple points of view are more prepared to face that challenge because they allow the existence of healthy conflict. Although the interest in Project Based Learning (PBL) courses has increased, the assessment of conflict and the capacity of taming uncertainty remains as an unresolved issue in most engineering curricula. In order to allow the recombination of ideas to happen and keep the differences that drive innovation, engineering students need to improve their efficacy in working together within diverse perspectives and ambiguous challenges.
According to our experience in industry and academia, we had repeatedly seen that teams used certain artifacts to bridge communication amongst its members. These identifiable objects were coined as Boundary Objects (BOs) by Star and Griesemer in 1989\(^5\). BOs are flexible artifacts that can live in the intersection of different knowledge worlds without losing their identity. They facilitate communication among groups, besides enabling particular negotiation spaces called trading zones\(^6\). In this paper, we ascribe to the idea that boundary objects and trading zones empowers diverse teams to embrace innovative design and entrepreneurial efforts.

This paper reports a context-sensitive study of team negotiation in two educational settings. It describes team negotiation patterns evidenced on a nearly one-year ethnographic research in a top ranked university in Northern California. Data is qualitative and rich in detail, in order to theorize from praxis and bridge gaps in teamwork literature. In order to see if the negotiation patterns were similar 9,507 km south from Northern California, we studied a similar group in Santiago de Chile. Based on the idea of boundary objects and trading zones, we identified techniques that were used in both educational settings to achieve temporary settlements while going from divergent tasks to convergent ones. Although these results are not conclusive, these techniques contribute to engineering education by informing how future engineers could be more prepared for joining the workforce or starting their own business. Future work may involve doing more case studies in other contexts.

**Engineering design and negotiation for a comprehensive entrepreneurial curricula**

For a long time, the common focus of engineering education was on an established model (based on the Grinter report of 1956) where the craft of engineering is imparted only after the students have gained a strong basis in mathematics and science\(^4,7\). Whether this is the current case or not, even conventional curriculum relies heavily on the design process, as most of the sub-disciplines in engineering require the practicality of design skills in modeling and converting ideas into realities. Additionally, ABET (specialized accreditation agency for programs for engineering worldwide) has encouraged the existence of capstone project-based courses to ensure that graduates are prepared for real-world, practical applications of engineering principles in industry\(^8,9,10\).

Beyond the importance of science and mathematics fundamentals, global efforts are changing engineering education by emphasizing professional skills and active learning. In 1997, ABET changed to an outcomes-based approach known as Engineering Criteria (EC) 2000\(^11,12\). The implementation of the EC2000 not only transformed engineering schools, but also engineering classrooms across the world. Early studies have explored how individual professors integrate what students need to attain regarding the needs of the industry with their course assessment\(^13\). Later on, Lattuca, Terenzini and Volkwein (2006) found further evidence of the impact of EC2000 on student experiences and learning outcomes\(^14\). Today, because of EC2000, communication skills and multidisciplinary teamwork need to be embodied in any learning process. Thus, engineering design activities and project-based learning has become strategic for many engineering schools.

There have been serious attempts to make engineering design a systematic discipline. In the United States, it started with the work of individuals like Henry Dreyfuss on ergonomics in the ‘50s and individuals like Horst Rittel and Bruce Archer in the ‘60s at Berkeley RCA. Later on,
user-centered approaches emerged in the Bay Area from Xerox PARC (Palo Alto Research Center), one of the biggest exponents of this trend. Today it seems design is in one of its most evident pivot points as an enabler of innovation and multidisciplinary work in modern organizations and startups. Fast paced advances in technology and organic growth of communication systems have resulted in a kind of micro-segmented global network, so now problems have become more and more ill-defined and multi-layered. Nonetheless, the instruction of these new design abilities is not always organized or methodic.

In Chile, engineering design has recently become crucial regarding the New Engineering 2030 initiative, launched by the National Agency for Innovation and Development (CORFO) in 2013\textsuperscript{15}. By financing strategic plans of the country’s leading engineering schools, CORFO intends to transform engineering education towards national competitiveness and productivity. In order to educate future engineers that are more prepared to address the challenges of the industry, engineering schools need to incorporate more teamwork, hands on learning, and practical experience within the industry\textsuperscript{15}. Moreover, an entrepreneurial spirit is supposed to be developed in any project-based course, so students become more inspired with technology development and product design.

For Pontificia Universidad Católica de Chile (UC), New Engineering 2030 has been the opportunity to validate existing efforts to create an innovative and entrepreneurial curriculum. Since 2013, the Engineering Design and Innovation major (www.di-lab.cl) has imparted project-based courses that prepare students to:

1. be comfortable with ambiguity and ill-defined challenges,
2. be able to overcome team conflict,
3. acquire critical thinking and problem solving capabilities with a bias on making,
4. focus on people-driven innovation,
5. manage information through visual thinking strategies,
6. and adapt to a fast moving world.

Engineering design is a learning discipline that has been discussed over decades. Design strategies not only address the embellishment of an artifact, but also the process behind defining meaningful stages for services, systems and experiences. This form of the design process has become key to entrepreneurship since it is a way to make ideas and future realities tangible to others. However, more research is needed in order to understand how it could be easily integrated within an engineering curriculum. Today, engineers not only need to demonstrate technical excellence in the application of science, mathematics and engineering principles, but also require effective ways to understand individuals involved in any entrepreneurial venture. The design process, as a social process, is effective in involving the end-user, end-customer and even understanding the aim of potential investors. This study provides a new perspective for understanding how engineering students diverge and converge in a design process conducted in different educational settings. Thus, more innovative teaching methods are implemented along the expectations of global and local agencies.

**Research Question**

This study describes a context-sensitive effort for understanding team negotiation patterns in engineering students from different countries. Qualitative information was collected and analyzed
from two different research sites. The first research site (hereinafter Research site 1) is a prestigious university in Northern California. The second research site (hereinafter Research site 2) is a selective university in Santiago de Chile. By contrasting the findings from these two research sites, the following questions expect to be answered:

- What are individuals from different educational settings doing to bridge communication among diverse team members? How do they do it? Are they successful?
- How are exchanges and settlements performed through the use of boundary objects and trading zones? Are there any similarities in different educational settings?

We studied engineering courses at both research sites that entailed ambiguous open design space challenges, managing a team and a corporate partner.

**Methodology**

Exploratory research was conducted to inform engineering education about team negotiation patterns embedded in project-based courses in engineering design. A qualitative approach was used to describe boundary objects and trading zones emerging from engineering students’ teamwork.

*Participants Research Site 1: Students from Northern California University*

During 2011-2012, we launched an ethnographic 9 month-long study with a particular community of students taking a mechanical engineering design course. This course worked in local and global teams (as it partnered with foreign universities) to solve ill-defined challenges proposed by (usually) a Silicon Valley based company. The course looked to yield innovative solutions from an engineering design point of view. Thirty-two students were organized in 9 teams.

During the nine months, we saw the students nearly every day, for more than ten hours. In an exploratory manner, we would hang out and closely witness the processes they were going through. We followed 5 of those teams closely and kept contact and did less detailed work with the other four. The outcomes of this research overlook the partnering international teams since, in four of the five teams, they didn’t play a strong role in the development of the solutions.
Students were usually high achieving students coming from prestigious undergraduate programs around the world. As Figure 1 shows, 5 of them had undergone the product design program at the same university. 6 of them were doing a “coterm”, which allowed them to begin work for a master degree while finishing their undergraduate studies. 12 of the students had a bachelor degree in Mechanical Engineering, only two in the same university. All of those who didn’t attend this specific higher education establishment indicate that their undergraduate programs were more based in theory and less about carrying out a project. This marked a difference in their undergraduate academic training. From 18 students, 6 of them were women. Ages ranged from 22 to 24 years old. The students created the teams after undergoing two short exercises with no stakes involved. Most of the students had not met before and they usually worked in a space (big room) dedicated to the course. This room was accessed with an ID card and the teams could use it 24 hours a day.

Participants Research Site 2: Students from Santiago de Chile

Having the outcomes of our first research in 2012, we decided to see if the phenomenon was present in other sites. During 2015, we launched an ethnographic 6 month-long study with a particular community of students taking an engineering design course in Santiago de Chile. This course partners with organizations to solve ill-defined challenges. With a convergent and divergent process, the teams look to propose innovative solutions for their counterparts. 17 students were organized in 6 teams. During 4 months, the researchers attended all of the classes and followed the students to their meetings in and off campus.
Students from this course were all enrolled in the major of engineering design and innovation. A concentration of 100 credit hours at an undergraduate level. As Figure 2 shows, from a group of 17 students, 9 of them are pursuing a professional title in mechanical engineering, 3 in IT management, 1 in software engineering, 2 are articulating with a masters in engineering and 1 is articulating with a master degree in the US. So even though the group is made of engineers interested in engineering design there are different flavors to pursuing their engineer professional degree. This means that their academic training was slightly different. From 17 students, 3 of them are women. Ages ranged from 20-22 years old. The students created the teams after undergoing two short exercises with no stakes involved. Most of the students had met before the course or had classes together; this does not mean they had work as teams. Unlike the students of the Northern California University, they did not have a room dedicated to work on their projects. Nonetheless, there was a room dedicated to their classes and a workspace where the teams usually met for prototyping.

The Research Process

The ethnographic research process with the Northern California group entailed was longer than the one undertaken in Santiago de Chile. This was because the first ethnographic work required an extra exploratory stage at the beginning where we had to be open to phenomena and to understanding the best way to raise data. Nonetheless, it is important to note that the only difference is at the beginning. The refined process is shown in Figure 3.
1. After acquiring informed consents, an ethnographic process that worked with: participant observation, visual ethnography (recording and analysis of visual data), time-allocation studies, etc. Data collected included videos, pictures (taken by the researcher and by the students), self-reported information published in blogs, field notes and documents produced by the teams during the course.

2. Using the data collected, we identified some visual artifacts and negotiation practices that the students used. These were turned into cultural probes that were used as elicitation triggers during group and individual interviews. The interviews were scheduled in advance with the students and were held in a specific room where these were recorded in film using a couple of different digital devices to ensure the caption. The information obtained during the individual interviews was not showed to the teams. This allowed team members to explain their dynamics with no restrain. We triangulated the data from the interviews and the ethnographic data collected previously in order to achieve qualitative validity.

3. In a non-sequential way, the data collected was analyzed, in the case of our research site 1, in an iterative way though in vivo coding and grounded theory. This was made using analog coding, that being, with no use of any specific QDA software. In the case of the University in Santiago de Chile, the analysis was refined. Our scope was clearer, but we gave the space for other themes to come up. Codes assigned used some themes identified in the first research site, which were part of a codebook. In the second site, we used Dedoose, a cloud-based software where you can access data from any computer connected to the Internet (with a password).

Results and Discussion

Bottom Up Negotiation Strategies

As Minneman (1991) indicates, negotiation should be a focus for engineering design education to form professionals that can perform better in group situations. Our approach to depict the way innovation driven teams negotiate is far from being a top-down strategy to work with teams in educational settings. The negotiation strategies observed sound logical, nonetheless, there has been little theorization from praxis in the present literature.
With a focus on observed behavior, we have identified teams of students, in both research sites, built a *trading zone* \(^6\). This is an ephemeral context that is constructed by the team members in situ and lasts while the project lasts. This common context entails a *shared world of meaning* that is inherent to the particular task the team is attaining. To set up this trading zone, they agree on behavioral principles (rules of conducts) and a shared epistemology that is inherent to that particular task. A trading zone is not necessarily tangible, yet is afforded by the materiality of boundary objects (BO) and the space involved. Through the use of BOs, the differences of opinion can be expressed in a common language, thus putting the respective opinions at the center of the dispute and reducing the opportunity for the dispute to become personal. For the sake of time, we will just present two of the most applicable strategies used in this shared world of meaning:

*Figure 4. Images from “Third Platform”*

**Tool 01: Enabling trading zones through a third platform**

One of the key patterns observed repeatedly during team negotiations was the presence of a physical two-dimensional platform. This is what we have defined as a *third platform*. This was a material platform that served to externalize the individual’s ideas and to make them explicit for the rest of the team. Similar to a boundary object, the third platform is material. As figure 4 shows, it is embodied in the form of white boards, large pieces of papers, Google Docs in a computer screen, a TV screen and an IPad, among others. The third platform hosts the intangibility of the trading zone in a similar way that the space does, making it visible. Instead of being a three dimensional space, it is a two dimensional one.

It is important to notice that these platforms can be reset to their initial state without leaving a trace of the interaction. “We erase the whiteboard a bunch of times,” one of the students stated when noting about the ephemeral quality of the platform. If they were not erased, it seemed that the negotiation was not settled. A non-erased whiteboard was “like having an ongoing discussion,” a student, affirms. In the same fashion, the paper rolls have a continuous format that allows them to roll the paper up and start again when the negotiation is over, another one indicates: “the thing that has worked well is that the roll of paper like stays in one spot for a long time until it fills up and we roll it. It’s like per project. So each section is a pretty well encapsulated record of a two week or three week period when we’re working on a certain project.” As surprising as it may sound, students do keep record of what happened while utilizing these surfaces. They record their collaboration through pictures, and share or archive them in file
managers like Google’s Picasa. They served to contextualize: “we did this (take pictures) so we can have a reference point about what we were talking about”. These records have the potential to reconstruct a past situation that portrays the way a community interacted, similar to how an archeologist sifts through a site. They could also be useful in the future assessment of the education process by analyzing in detail the context where the negotiations were made, and see step-by-step how the teams were able to reach agreement.

![Figure 5. Images from “Sticky Notes”](image)

**Tool 02: Using Sticky Notes, a boundary object to negotiate in larger teams**

These boundary objects shown in Figure 5, were usually present with large groups of individuals involved in the negotiation (i.e. when externals were invited to a meeting). “There were just too many people to have everybody write on the board,” a student remarks. Sticky notes entailed little squares that have an adhesive on one of its sides and that could be placed on a surface. They showed to be useful when there were large amounts of information or concepts to decide. With sticky notes, the teams could handle a lot of information at the same time. One of the participants indicated, “you can keep adding and adding.” They can be moved around (usually for hierarchical, categorizing or clustering purposes) or taken away from the platform, and to be a great image to show in the student’s portfolio. “If you do post its, you must be doing something creative,” a visitor to the program asserted. When considering the impact that the Silicon Valley culture has on the course, this becomes more than a small detail. Having a colorful picture in your portfolio could be good for the job market. “You are more than a traditional engineer,” says a student. This is true, based on the conversations with instructors and SV consultants; you are perceived as more creative.

The way the sticky notes are used is very straightforward. The students write their ideas or concepts down on the pieces of colorful paper. They usually use a strong marker that can make the words or sketches visible from a distance. Then, these are pasted on a whiteboard (third platform), a wall (a spatial affordance) or large format paper. Then, while discussing, these are moved around, trashed or replaced. This makes them great for negotiation, as nothing in them is definitive. Finally, the students converge in one decision.

**A Vision of a “New Way” of Doing and Learning Engineering**

Apart from the behaviors captured, we identified recurrent themes in both research sites. These themes are directly related to a new way of learning and doing engineering and are based on the
experience of taking the two PBL courses we worked with. In various situations, the participants talk about a new way of doing engineering.

There is a shared perception that the teams acquire a new mindset of doing things. They do not just seek for a right or wrong solution but, in their own words, they try to figure out “what is the real problem”. They always ask themselves the “why”. As they mention, this is a major difference for them when comparing the course with the rest present in the engineering curriculum. On the other hand, the idea of getting comfortable with ambiguity is a major outcome in these courses. Students learn that information coming from real contexts is usually imperfect and they learn how to deal with it. They explain that with some classical engineering courses, they learn about theory and then they work for a right answer. When faced to these PBL innovation driven courses, they were bothered by the amount of space there was to work. During the class they learned how to deal with these situations and to move forward without paralyzing. Most of the students find this new thinking to be applicable to other courses they are faced to.

Finally, students were eloquent about the learning that these courses had on a more reflective way to team up. In both settings, individuals recognize that is important to dedicate time to teaming since it is crucial to the final outcome. In different interviews, it becomes clear that individuals are conscious that becoming a group is different than becoming a team. Conflict in teams was observed and perceived overall in the stages were students went from a divergent phase to a convergent one. When teams need to reach consensus or at least settle on something, they test if the team is up to negotiate successfully or not. Teams are not really aware of the use of boundary objects even though they use them over and over again. Nonetheless, they are conscious about trying to improve the way they interact among each other in order to improve final outcomes. The researchers can safely indicate that teams that used more negotiations strategies and that were aware on their team interactions performed better in the course and, compared to their classmates, achieved better projects.

Conclusion

Our research methodology proposes a framework that can be used to study different populations in diverse latitudes. In this study, we have made the case for understanding the importance of negotiation strategies in an engineering curriculum that satisfies both global and local criteria. We had a peek into the culture of two project based learning courses in two different educational settings, in order to explore how students perceive teaming in the context of a curriculum that embraces innovation and entrepreneurship. In this paper, we have set the stage for bottom-up teaming strategies that could be incorporated in any engineering program. Two were presented here, but more could be extracted by further analysis. Undoubtedly, a new way of doing engineering is rising, and students across the world are starting to feel more prepare to face entrepreneurial endeavors as a collective.
References