INTERDISCIPLINARY FACULTY LEARNING COMMUNITIES IN ENGINEERING PROGRAMS: THE UCSC EXPERIENCE

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ABSTRACT

We're all in a way part of a *learning community*. But what makes a community of teachers a *Faculty learning community*? And how can that learning community generate exceptional results? This paper is an effort to share a systematic approach on how to achieve the above. It's the result of reflection over several experiences, but particularly one with a cross-disciplinary team. The proposal presented in this paper is applicable to any type of faculty learning community. The main experience that inspired this work actually started with the task of improving the Introduction to Civil Engineering course at UCSC. As many students were not acquiring the expected level of communication skills nor satisfactorily achieving other personal and interpersonal learning outcomes, a multidisciplinary team was set up in order to address these issues. This team included civil engineers, a language teacher/actor, a therapist in psychogenealogy and an industrial engineer/organizational coach with expertise in positive psychology. This group was set up and led by a civil engineering professor with experience in engineering education, the CDIO framework, and teaching communities. The result of this work went beyond the task at hand. First, the whole course was redesigned as an integrated learning experience with innovative active learning methodologies. This is now a complex course, embracing CDIO standards nº 1, 4, 5, 7, and 8, and taught by professors from four different disciplines. Secondly, an interdisciplinary faculty learning community was born in the process, as well as a model for interdisciplinary collaboration. The community's working methodology is clear, well-defined, flexible, reflection-based and shared by everyone. Our experiences with this faculty learning community, led by an experienced, engaged leader in a nurturing work environment, can be summarized into a set of best practices to be followed at each stage of the collaboration process.

KEYWORDS

Faculty learning community, personal and interpersonal skills, leadership skills, introduction to engineering course, Standards: 1, 4, 5, 7, 8, 9, 10.

INTRODUCTION

In 2010 the Universidad Católica de la Santísima Concepción (UCSC) created the *Centro de Innovación y Desarrollo Docente* (CIDD), a center to aid the development of teaching practices and boost teaching innovations that follow a student-centered approach. This center fosters the creation of faculty learning communities to promote the exchange of teaching experiences among faculty and the systematization of teaching innovations as well as the continuous improvement of pedagogical practices. Faculty learning communities, as local agents of change, encourage faculty to document their experiences and generate evidence of their results, and to share them with their peers so as to receive feedback and improve their pedagogical practices, either through active participation in internal and external activities such as teaching seminars and workshops, or through the publication of results in conferences, workshops and journals in engineering education.

The first faculty learning community at the School of Engineering was created in January 2012, and included members of the Computer Science, Industrial Engineering and Civil Engineering departments (Cárdenas et al., 2013). Its main goals were to promote active learning and to aid the transfer of successful experiences across sequences of courses in a program and also across engineering programs. Since then, other faculty learning communities with similar goals have been created. Even though these communities have been shown to aid the enhancement of faculty teaching competences (CDIO Standard 9), more effort is needed to facilitate multidisciplinary and interdisciplinary work among students and also among faculty.

Introduction to Civil Engineering Course, short description

In the year 2011, the School of Engineering at UCSC began implementing a CDIO-based curriculum (Loyer et al., 2011). As part of this reform, five engineering programs incorporated an 8 hour/week Introduction to Engineering course (CDIO Standard 4). In the case of Civil Engineering, this course focuses on developing personal and interpersonal skills, as well as on having the students understand the role of Civil Engineers in the world (CDIO Standard 7). Initially, this course was taught by Civil Engineers and by a professor of Spanish, who was in charge of teaching communication skills, such as written reports and oral presentations, tailored to the Civil Engineering context.

Course structure, as shown in figure 1, consisted in 2 hours/week of oral and written communication (OWC) classes and 6 hours/week of lectures and workshops focused on the different roles of a Civil Engineer. During the last quarter, students developed a final project related to one of the traditional Civil Engineering areas.

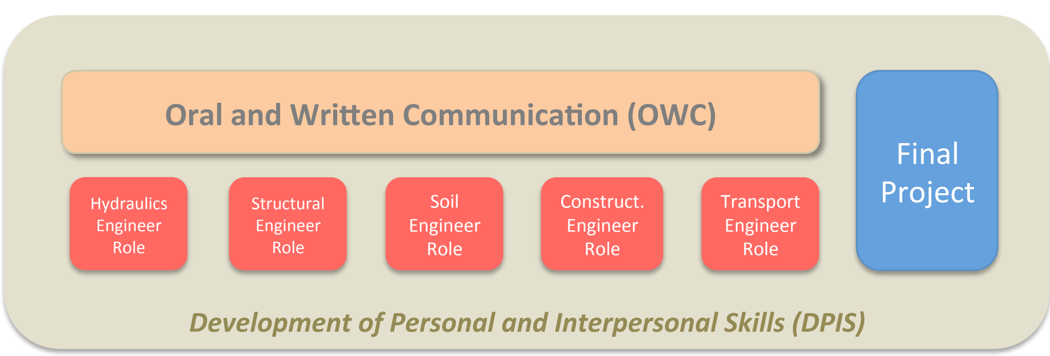

Figure 1: Original Introduction to Civil Engineering Course Structure

The course was mainly based on active learning (CDIO Standard 8), but in spite of the faculty's efforts, periodic evaluations showed that students did not acquire the expected level of communication skills nor satisfactorily achieved other personal and interpersonal learning outcomes, such as engineering reasoning and problem solving, attitudes, ethics, leadership, teamwork, among others. The main reasons were inadequate integration among the multiple activities designed for the course; insufficient communication and coordination between the faculty involved and the lack of a clear-cut responsibility for these other personal and interpersonal learning outcomes. Moreover, the engineers in the team followed their traditional collaboration way, where they relied upon the expertise of the non-engineers in the team instead of getting fully involved in their work: a high degree of involvement was not considered necessary by the engineers. This coincides with the observations about engineers' behavior in cross-disciplinary collaboration presented by Klein (1990) and Borrego and Newswander (2008).

FRAMEWORK

Social Learning Theory states that learning is a cognitive process that takes place in a social context and occurs through observation or direct instruction (Bandura, 1977). As such, the learning process benefits from being part of a diverse community of people sharing common goals. In this context, it is relevant to present the concepts of communities of practice, learning communities and cross-disciplinary collaboration as used in this work.

Communities of practice and learning communities

According to Wenger et al. (2002), communities of practice are "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis". Likewise, according to Baker (1999), a learning community is a relatively small group that may include students, teachers, administrators, and others who have a clear sense of membership, common goals, and opportunity for extensive face-to-face interaction. The relevant literature presents several types of learning communities, such as professional learning communities, faculty learning communities and student learning communities, among others. In particular, Cox (2004) defines a faculty learning community as "a cross-disciplinary faculty and staff group of six to fifteen members (eight to twelve members is the recommended size) who engage in an active, collaborative, yearlong program with a curriculum about enhancing teaching and learning and with frequent seminars and activities that provide learning, development, the scholarship of teaching, and community building".

Cross-disciplinary collaboration

Borrego and Newswander (2008) use "cross-disciplinary" to describe collaborations involving multiple disciplines, and they distinguish between multidisciplinary and truly interdisciplinary approaches to cross-disciplinary collaborations. In the first case, collaborators come together to work on a problem, each one contributing according to his or her own expertise. While the product of this collaboration may well be successful, collaborators might not learn much about the others' discipline. In contrast, in a truly interdisciplinary approach, collaborators work closely together in a more integrated way to solve a problem, combining their knowledge from their own disciplines to work toward a solution. At the end of a truly interdisciplinary collaboration, each collaborator is changed by the experience. Moreover, they, as well as Boix-Mansilla and Gardner (2006), argue that the level of integration for a collaborative project can be a predictor of the quality of the final results.

Truly interdisciplinary collaboration in engineering education requires engineers to work with educators and social scientists. Each disciplinary framework relies upon its own ways of approaching and understanding a particular problem, and requires some effort on the part of all collaborators to understand and appreciate their specific contributions. Each collaborator knows and understands the world according to his or her epistemology, which dictates which research questions, methods and goals he or she considers legitimate. Borrego and Newswander (2008) suggest that how a collaborator understands and appreciates the nature of knowledge will affect his or her collaboration with colleagues in different disciplines, especially if these disciplines are fundamentally different, as is the case between engineering and social sciences. In order to overcome these differences, they say that each collaborator must:

a) be able to identify his or her own epistemological framework and recognize its own inherent strengths and weaknesses,
b) learn enough about other ways of knowing and understanding to be able to respect them, and
c) be able to integrate new epistemologies into the collaboration.

INTERDISCIPLINARY FACULTY LEARNING COMMUNITY

When faced with a cross-disciplinary collaboration, the first question that should arise is whether to follow a multidisciplinary or interdisciplinary approach. However, engineers rarely ask themselves this question, but rather follow the multidisciplinary approach and tend to break up the work and divide the tasks among the experts (Muis & Haerle, 2006). Also, as mentioned in the framework section, one could expect better results from an interdisciplinary collaboration. Finally, if the results of the collaboration are expected to be something new or innovative, we recommend creating an interdisciplinary faculty learning community.

There are several models for faculty learning communities that can be adopted for a multidisciplinary or interdisciplinary faculty learning community. One of the main difficulties in cross-disciplinary collaborative work is the lack of integration of its members, due mainly to their different epistemologies as mentioned previously. Most authors state the importance of this integration, but don't necessarily give guidelines on how to achieve it. Borrego and Newswander (2008) propose having informal interactions in the collaborator selection stage in order to determine compatibility. While this is important, it may not be enough. So how can you make the collaborators work in an integrated way? We attempt to address this issue in the model presented below, which incorporates a set of activities in the inception phase.

Interdisciplinary Faculty Learning Community Model

Figure 2 presents two models for cross-disciplinary collaboration. On the left it shows the traditional multidisciplinary approach and on the right it presents our interdisciplinary model. Both models have two main phases, the inception phase and the collaboration phase, being their main difference in the inception phase.

The traditional multidisciplinary model includes three stages: identification of the problem or research question to be addressed; setting up the team and roles; and finally a working stage that can follow different working schemes or approaches.

The interdisciplinary model presented identifies four stages, adding another stage in the inception phase that focuses on the team integration or blending. The purpose of this integration is for collaborators to get to know each other and, most importantly, to get to know their ways of knowing and understanding the world. In other words, to familiarize themselves with each others' epistemology and aspects of their disciplinary knowledge that are important for the collaboration to succeed.

Since this new stage demands a learning process from the collaborators themselves, we approach it in the same manner as we do with our students: by using active learning. Collaborators from different disciplines design workshops and other active learning activities which are carried out by the team, thus learning in a more effective way about each others' disciplines and hopefully start the process of understanding each others' different epistemologies, a process that should continue throughout the whole collaboration (CDIO Standard 9). According to (Borrego and Newswander, 2008), *"truly interdisciplinary collaboration requires some effort on the part of the collaborators to understand and appreciate the contributions presented by various disciplinary frameworks"*. And this is where the active learning experiences were particularly effective. Each faculty really got to know well what the others were doing, therefore facilitating future communication.

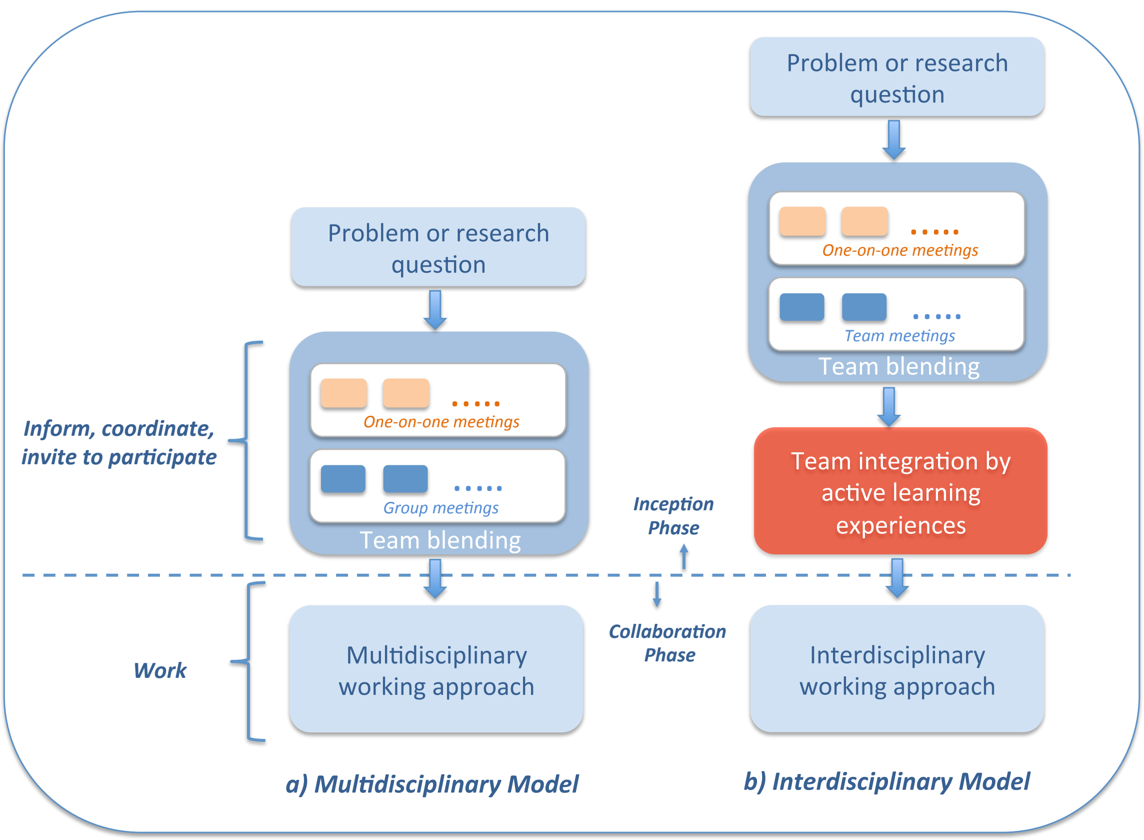

Figure 2. Multidisciplinary versus Interdisciplinary Faculty Learning Community Model

In the collaboration phase, an interdisciplinary working approach is followed. Work is organized through weekly structured meetings, during which:

a) the previous week's work is reviewed, analyzing what went well, what went wrong and how to fix it,
b) the work plan's progress is checked, and
c) the new week's work is organized, assigning tasks, responsibilities and timeframes. The work plan is also updated, if necessary.
d) Meeting notes are recorded and made available through a shared platform

Some key issues in this approach are selecting the team leader and having a good work environment. The team leader must help organize and articulate the work, motivate and engage the team and at the same time create a horizontal organizational structure, where every collaborator feels his or her contribution is visible to, and valued by, each team member as a whole by creating a supportive climate of openness, trust and mutual respect that promotes loyalty and cooperation. He or she must lead the team in forging the vision and goals, and also provide them with regular, clear, accurate and timely feedback.

Collaborative work benefits from meeting in a flexible, well-lighted work space, with food and tea, coffee and soft drink availability, where people feel comfortable and have fun working together. Even though extensive use of electronic collaborative tools such as Dropbox, e-mail, whatsapp, is essential, nothing beats face-to-face interaction to foster innovations and creative ideas.

RESULTS

The faculty learning community that inspired this work was actually born as a spinoff of a multidisciplinary team put together for the above mentioned Introduction to Civil Engineering course. As many students were not acquiring the expected level of communication skills nor satisfactorily achieving other personal and interpersonal learning outcomes, such as engineering reasoning and problem solving, attitudes, ethics, leadership, teamwork, among others, a multidisciplinary team was set up in order to address these issues. This team included civil engineers, a language teacher/actor, a therapist in psychogenealogy and an industrial engineer/organizational coach with expertise in positive psychology. This group was set up and led by a civil engineering professor with experience in engineering education, the CDIO framework, and teaching communities.

The initial task was to redesign the course, keeping the original learning outcomes and also integrating all the disciplines that were considered in the course. After contacting the collaborators, the leader held a series of one-on-one and group meetings with all potential collaborators, in order to inform them about the challenge, but most of all to listen to what they had to say. After the team was set up, a set of workshops and discussion sessions were organized (CDIO Standard 10). The resulting course has an innovative and complex design, which is further explained in the following section.

Introductory Civil Engineering: new course design and results

The main first result of this community was the redesign of the Introduction to Civil Engineering course. The new design is presented in figure 3, and at first glance you can see the integration of the different disciplines that are part of this course.

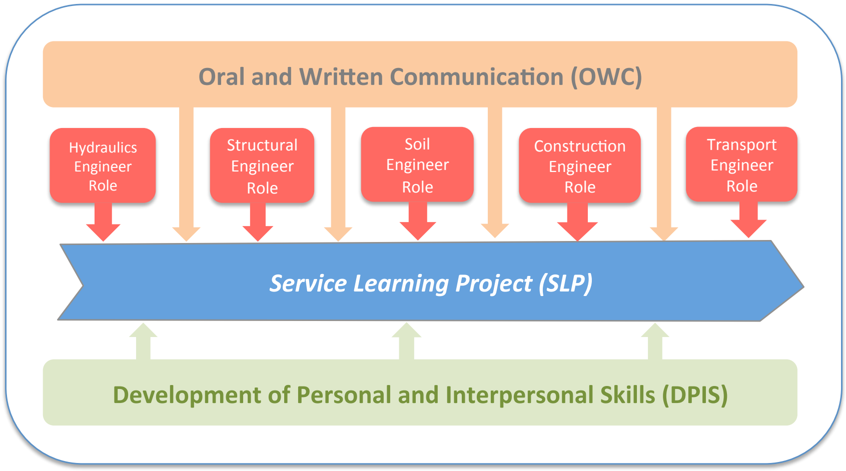

Figure 3. New Introduction to Civil Engineering Course Structure

The backbone of the course is a Service Learning Project (SLP) that is developed throughout the semester (CDIO Standard 5). Due to the nature of this project, it include the basic CDIO stages: Conceive, Design, Implement and, in some cases, Operate (CDIO Standard 1). The 8 class hours were divided into 2 hours of the "Engineering role" (ER), 2 hours of Oral and Written Communication (OWC), 2 hours of Development of Personal and Interpersonal Skills (DPIS) and 2 workshop hours, either for ER or for SLP (depending on the schedule). The main accomplishment of this course is that all course disciplines were integrated by means of the service learning project.

Students' perceptions of their learning outcomes

A survey of students' perception of their proficiency level was answered by 72 of the 120 students (60%) registered in the Introduction to Civil Engineering course during the first semester of 2015. The results presented in Table 1 show that students in general perceive high levels of proficiency in most of the CDIO skills. Although there was not a significant difference in their grades compared to previous years, the results shown in table 1 are consistent with the instructors' opinions of the same students in the following semester, where they noticed that they had higher confidence in their skills and attitudes.

Table 1. Students' perceptions of their learning outcomes

CDIO Skills	1	2	3	4	5
2.1. Analytical reasoning and problem solving	2%	10%	39%	27%	20%
2.4. Personal skills and attitudes	3%	11%	25%	38%	21%
2.5. Proffesional skills and attitudes	0%	10%	28%	38%	25%
3.1. Teamwork	3%	10%	29%	36%	20%
3.2. Communications	3%	15%	35%	30%	15%
4.1. External and societal context	1%	7%	25%	37%	28%
4.3. Conceiving, system engineering and management	1%	7%	25%	37%	28%
4.4. Designing	0%	13%	25%	40%	21%
4.5. Implementing	6%	11%	42%	30%	7%

Note: 1) To have experienced or been exposed to; 2) To be able to participate in and contribute to; 3) To be able to understand and explain; 4) To be skilled in the practice or implementation; 5) To be able to lead or innovate in

Interdisciplinary faculty learning community best practices

There is plenty of literature regarding best practices for interdisciplinary communities, faculty learning communities, professional learning communities, and so on. Our proposal's main difference is that it is organized according to their time of application, as is shown in Figure 4. The "Before" section shows best practices to be followed before the collaboration, the "During" section presents best practices to be followed during the collaboration, and the "After" section shows best practices to be followed after the collaboration has finished. The central section presents best practices to be followed throughout the collaboration process.

Figure 4. Interdisciplinary Faculty Learning Community Best Practices

CONCLUSIONS AND FUTURE WORK

This work presented an interdisciplinary faculty learning community, as well as a model for interdisciplinary collaboration. As a result of this community's work, the Introduction to Engineering course was redesigned as an integrated learning experience with innovative active learning methodologies, embracing CDIO standards nº 1, 4, 5, 7, and 8, and taught by professors from four different disciplines. At the same time, thanks to the interdisciplinary collaboration model, the multidisciplinary group evolved in a natural way from a team to an interdisciplinary faculty learning community. The community's working methodology is clear, well-defined, flexible, reflection-based and shared by everyone. Our experiences with this faculty learning community, led by an experienced, engaged leader in a nurturing work environment, was summarized into a set of best practices to be followed at each stage of the collaboration process. This approach addresses CDIO standards 9 and 10.

Our preliminary results are promising, but many challenges still remain. Among them, we must mention how to give team members more autonomy and less reliant on the team leader, how to make the team more resilient to changes in its membership, and how to transfer their know-how to other cross-disciplinary teams involved in other courses. Special mention must be given to the topic of teaching assistants, as they spend considerable face-to-face time with the students: they were not considered initially in the inception phase, and at the same time, they might change every semester.

Also, the issue of costs must be taken into account: creating and maintaining interdisciplinary teams with collaborators from many different disciplines is expensive in terms of money, time and resources, requiring a long-term commitment from university administration and staff.

Finally, more work is needed to evaluate the impact of this work in the medium- and long-term.

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BIOGRAPHICAL INFORMATION

Solange Loyer is professor of Statics, Mechanics, Introduction to Civil Engineering and Transport Engineering for the Civil Engineering program at UCSC. She is a Civil Engineer with an MBA. She was head of the Port Maritime Engineering Program from 2000 to 2006 but has devoted the last 16 years to her biggest passion: engineering education. She lead the curriculum reform under a CDIO approach for the Civil Engineering program in 2010. Her research and consulting interests are transport engineer and engineering education.

Marcia Muñoz studied Computer Science at the University of Concepción, and obtained her M.C.S. at the University of Illinois at Urbana-Champaign. Currently she is a faculty member in the Computer Science department at UCSC, where she also serves as the director of the undergraduate program. She leads the curriculum reform project for the Computer Science program. Her research and consulting interests are software engineering, machine learning and engineering education.

Marco Gómez is professor of Development of Personal Skills at UCSC since 2015. He is a therapist with a Diploma in Integral Psychology, specialized in Psychogenealogy and Psychomagic, with a Diploma in Shamanic Art-Therapy. He is a certified monitor of Laughter Yoga and Co-founder of CoCrea Consultants that developed the CoCrea Model of personal innovation based on self-knowledge. He is also instructor for Technical Training Organisms (OTEC) and does Educational Techincal Consultancy (ATE).

Hernán Silva is a part time professor of the Civil Engineering Department at USCS. He is an Industrial Engineer with a Diploma in Operations Management, Organizational Coaching and Human Capital Management. He has training in Appreciative Inquiry, Leadership, Positive Psychology and Healthy Organizations. He was Productive Plant Manager from 2002-2013, until he founded CoCrea Consultants, with the purpose of transferring his experience to future professionals and organizations.

Manuel Loyola is Professor of Spanish, Master in Arts and professional actor. He works at the Language Department at UCSC and imparts classes to under-graduate and graduate Language programs, Pedagogy Programs and Engineering programs. Since 2000 he is Director of the "Teatro del Oráculo" Company. He has won many grants for the development of theatrical projects and has had formal acting training in several countries as India, Bolivia, United Kingdom, Spain and Argentina. His company has presented in many stages in Chile and abroad. Finally, he has been advisor of the Education Ministry and the Ministry of Culture and Arts of Chile.

Felipe González is a Civil Engineer from the Civil Engineering Department at UCSC. He teaches Topography, Engineering Drawing, Construction and Introduction to Civil Engineering. He has implemented service-learning in his topography course since the year 2013. He also works as a Construction Inspector.

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