BRINGING ACTIVE LEARNING INTO ENGINEERING CURRICULA: CREATING A TEACHING COMMUNITY

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ABSTRACT

This paper presents the active learning teaching community created to assist the implementation stage of the CDIO-based curriculum reform currently underway at the School of Engineering of the Universidad Católica de la Santísima Concepción. The community is open to all engineering faculty, and at the moment includes members of the Computer Science, Industrial, Logistics and Civil Engineering programs. This teaching community promotes the use of active learning and information technologies in the classroom and provides instructors with a peer framework to support them while conceiving, designing, implementing and assessing innovations in teaching. It follows a peer-based model to aid the transfer of successful experiences across sequences of courses in a program and also across engineering programs. Among its main achievements, it has helped improve communication and strengthen collaboration among instructors of different areas, assisted in monitoring and evaluating the implementation of the curricular reform, inspired research in engineering education among its members, and contributed to the faculty development plan being implemented by the newly-created UCSC Teaching and Learning Center.

KEYWORDS

Active learning, teaching community, CDIO-based curriculum reform, engineering education, faculty teaching enhancement.

INTRODUCTION

This paper describes the active learning teaching community created to assist the implementation stage of the CDIO-based curriculum reform currently underway at the School of Engineering of the Universidad Católica de la Santísima Concepción (UCSC).

In 2009, our university established its institutional pedagogical model [1], a human-centered model based on four cornerstones: a learning-outcome and competency-based curriculum, a student-centered teaching and learning process, education based on ethics and the dialogue between faith and reason, and the integration of academia and society. This model is summarized in Figure 1.

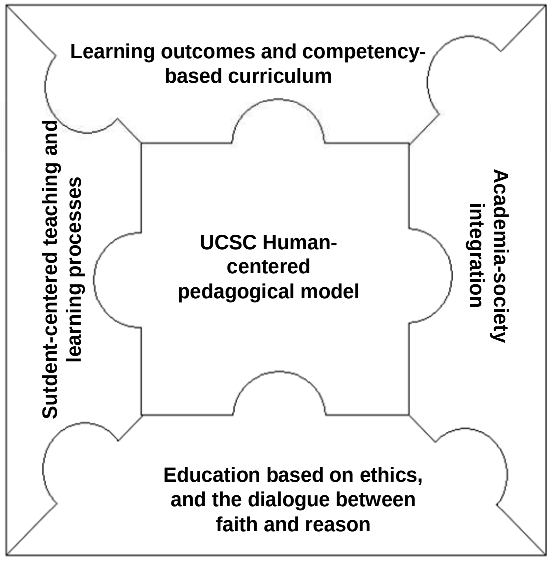

Figure 1: UCSC institutional pedagogical model

To this purpose, the university mandated curricular reform throughout all academic programs, and faculty education in student-centered teaching and learning processes. These two processes have been implemented gradually and progressively. To aid these processes, UCSC created the *Centro de Innovación y Desarrollo Docente* (CIDD), a center to aid the development of teaching skills and boost innovations in student-centered teaching and learning processes. This center offers a teaching skills program which certifies full-time and part-time faculty in five competences. Each competence is certified through 40 hours of work, which include a workshop, its implementation in a specific course, which is periodically monitored and guided throughout a semester, and a final report. Table 1 presents a brief description of each certification.

Table 1: CIDD Teaching skills program

ID	Certification	Description
PCP1	Learning outcomes-based course design	Educate faculty in designing courses based on learning outcomes and in developing course programs and syllabi using student-centered methodologies.
PCP2	Active learning methodologies	Educate faculty in the theory and practice of several active learning methodologies.
PCP3	Learning outcomes assessment	Educate faculty in learning outcomes assessment techniques.
PCP4	IT Use in teaching and learning processes	Show faculty how to develop instructional strategies and effectively apply information technology to the learning process.
PCP5	Teaching communities	Promote the exchange of teaching experiences among faculty, and the systematization of their teaching innovations.

In the case of the School of Engineering, its curriculum reform process follows a CDIO-based approach [2], taking into account the UCSC pedagogical model, and the Chilean national engineering accreditation criteria [3]. In 2008, this approach was applied to five engineering programs, the Computer Science, Industrial Engineering, Civil Engineering, Logistics Engineering and Aquacultural Biotechnology Engineering programs. The Conceive and Design phases have been completed to date, and the Implementation phase was begun in 2011. Several results of the first two phases were presented at the 2011 CDIO Conference [4], while the implementation phase relative to the first year of two engineering programs, Computer Science and Industrial Engineering, was presented at the 2012 CDIO International Conference [5]. In particular, these papers show the extensive coherence between the UCSC pedagogical model and the CDIO standards.

Faculty enhancement

Throughout the curriculum design process, the School of Engineering promoted faculty development and certification, especially in the first two pedagogical competences as defined by CIDD, as was described in [4] and is illustrated in Figure 2.

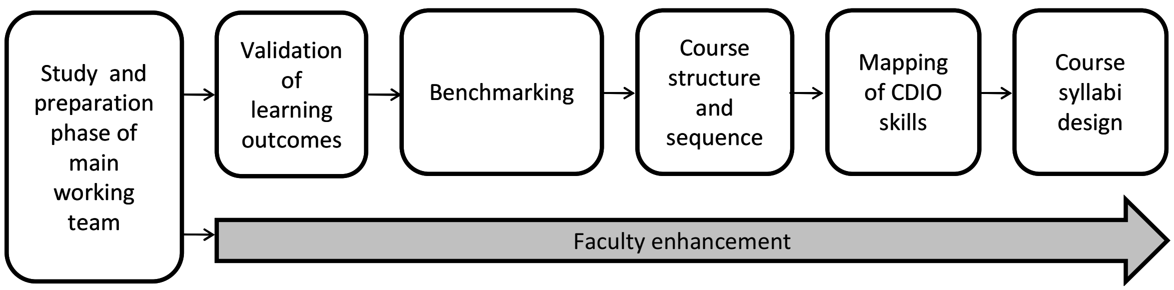

Figure 2: Faculty enhancement throughout the curriculum design process

Initially, this faculty enhancement focused on the curriculum design main working team and on first-year full-time and part-time faculty. This process has been slow, and it has been extended progressively during the implementation phase both to cover the last three CIDD certifications, and to include other faculty members.

Active learning

As part of the curriculum reform process at the School of Engineering, active learning (CDIO standard 8) has been incorporated across the curricula. Several active learning techniques [6, 7, 8] have been used, such as problem- and project-based learning, case studies, small group discussions, conceptual questions, debates, presentations, reflective memos, brainstorming, concept mapping, minilabs, problem sets, among others. Given that currently we are in the second year of the reform implementation, their effectiveness has been measured only for the introductory field courses in the Computer Science and Industrial Engineering programs, as is described later and in [5].

TEACHING COMMUNITY MODEL

UCSC envisions a teaching community as a voluntary association of faculty members with shared interests that work together to promote the continuous improvement of pedagogical practices through the exchange of teaching and learning experiences among themselves and with other teaching communities.

The first teaching community at the School of Engineering was formally created in January 2012, and initially included members of the Computer Science and Industrial Engineering departments [9]. Nowadays, it also includes members of the Civil Engineering department. The teaching community was designed to provide instructors with a peer framework to support them while conceiving, designing, implementing and assessing innovations in teaching. Its goals are:

1. To promote active learning across the engineering curricula and for supporting them while conceiving, designing, implementing and assessing innovations in teaching.
2. To leverage a peer community to motivate faculty development in active learning methodologies.
3. To aid the transfer of successful experiences across sequences of courses in a program and also across engineering programs.
4. To promote the use of information technologies in the classroom.

The Teaching Community Model is shown in Figure 3. In this model, the teacher designs, applies and assesses curricular activities for each course using active learning and available IT resources (goal 4). The teaching community encourages teachers to document their experiences and generate evidence of their results, and to share them with their peers so as to receive feedback about the curricular activity and thus improving and systematizing their pedagogical innovations (goal 1). The heart of the teaching community model lies in its regular meetings, where members reinforce this continuous improvement process by giving feedback and helping its members improve teaching innovations, and by monitoring compliance with the School of Engineering's program goals (goals 1 and 2).

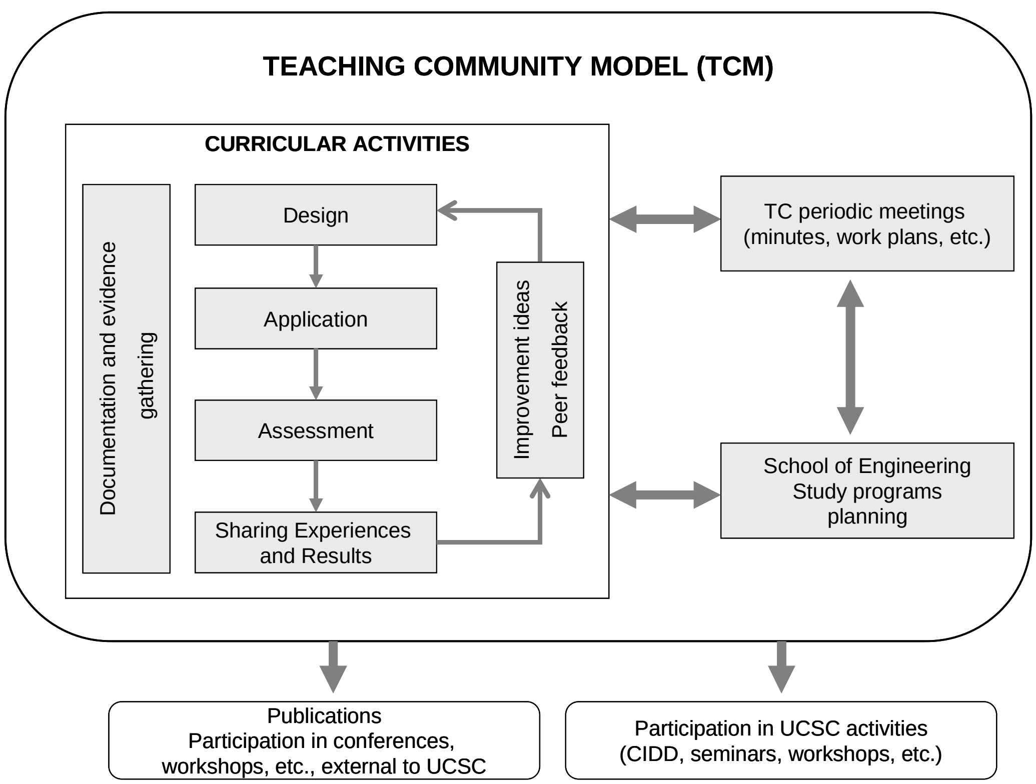

Figure 3: Teaching Community Model

At the same time, the teaching community divulges its teaching innovations through active participation in university-level activities such as teaching seminars and workshops. At the same time, it promotes the publication of results in conferences, workshops and journals in engineering education (goal 3).

TEACHING COMMUNITY ACTIVITIES AND RESULTS

In order to achieve its goals, the initial design plan for the teaching community specified several activities [9]. These activities included promoting active learning in engineering courses from the first year onwards, and the transfer of successful experiences across sequences of courses and across engineering programs, thus driving other faculty members to adopt active learning in their courses. These activities are described in detail in the following paragraphs.

Activity 1: Active learning in first-year engineering courses

As was mentioned before, active learning (CDIO standard 8) has been incorporated across the engineering curricula [5]. In particular, the first-year course load of the computer science program at UCSC includes two semester-length introductory courses, as shown in Figure 4.

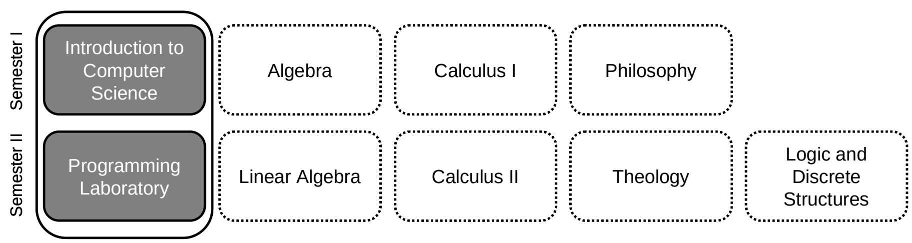

Figure 4: Computer Science first-year course load

In the Introduction to Computer Science course, students become acquainted with their chosen field and professional role and with the software lifecycle by developing a project from its conception to its operation. This course develops skills such as communication skills, planning, model construction, the elaboration of problem solving strategies, critical analysis and teamwork.

The second course is a Programming Lab where teams of students analyse computer science problems and design solutions following a structured approach. This course allows students to engage in programming and also to develop personal skills for self-learning and teamwork.

The first-year course load of the industrial engineering program at UCSC includes two semester-length introductory courses, as shown in Figure 5.

The Introduction to Industrial Engineering course prepares students for their academic life by giving them the tools necessary to understand the vision, activities and problem-solving skills of an industrial engineer, taking into account the scientific background and technological foundations of their field of action, and cultivating the ability to analyze problems and propose solutions through systematic decision-making processes. It also develops skills for independent work planning and team work, and gives students the basic tools to improve their communication skills.

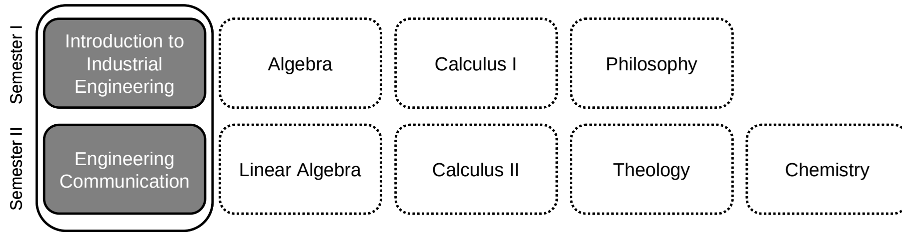

Figure 5: Industrial engineering first-year course load

The Engineering Communication course during the second semester provides students with several communications skills, particularly oral expression skills and the use of graphical display tools. Students also receive training on basic tools for project planning.

This activity contributes to the teaching community's goals 1, 2, 3 and 4 and its main results are:

- "Introduction to Engineering in the context of CDIO Curricular Reform at UCSC" presentation at the Latin American CDIO 2012 meeting, held in San Andrés, Colombia. March 2012.
- The article "Active Learning in first year engineering courses at Universidad Católica de la Santísima Concepción, Chile" [5], which was nominated for best paper at the CDIO Conference 2012, and invited for submission to a special issue of the Australasian Journal of Engineering Education (AJEE).
- The article "Modelo de evaluación de actividades curriculares de un plan de estudios basado en resultados de aprendizaje y competencias" [10] was presented at the XXV Congress of the Chilean Engineering Education Society (SOCHEDI).
- Students appreciate the use of information technologies. Table 2 shows the percentage of students who evaluate positively the use of IT tools in first-year courses to achieve the learning outcomes. In 2011, the use of IT tools in the first-year industrial engineering courses was surveyed at year end. Starting in 2012, the Programming Laboratory course is offered twice per year.

Table 2: Percentage of students who evaluate positively IT tools usage, per course

	Courses and their IT tools	2011	2012	
Computer Science	Introduction to Computer Science (Moodle, Alice, Lego Mindstorms Education Base Set, Python)	56%	83%	
	Programming Laboratory (Moodle, Flash Animations, Pseint)	52%	77%	82%
Industrial Engineering	Introduction to Industrial Engineering (Moodle, Youtube, Movie Maker)	81%	80%	
	Engineering Communication (Moodle, Microsoft Office, CMAP Tools, Prezi)		83%	

- Design of an active learning workshop for the Latin American CDIO 2013 meeting, to be held in Santiago, Chile, in April 2013. This workshop will present the application of the

Analysis–Design–Programming–Testing (ADPT) methodology in the Programming Lab course.

Activity 2: Transfer of successful experiences across sequences of courses

Computer Science

Twice a semester, faculty responsible for the courses in the Programming sequence of courses shown in Figure 6 meet to share experiences and discuss strategies aimed at solving common problems. This is similar to the communities of practice gatherings at Singapore Polytechnic [9].

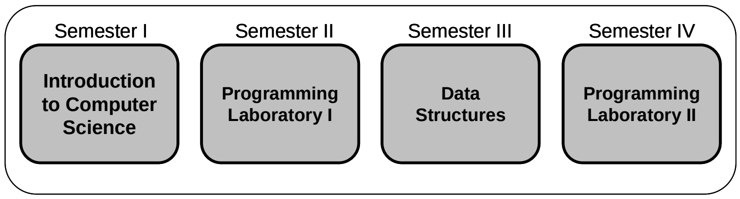

Figure 6: Computer science sequence of programming courses

Industrial Engineering

Faculty members responsible for the Introduction to Industrial Engineering and Engineering Communication courses shown in Figure 5 include members of the Industrial Engineering and Spanish departments, who meet periodically to discuss student progress and coordinate activities to help students achieve the expected learning outcomes.

Civil Engineering

During the last couple of years, faculty members responsible for the first part of the structural engineering sequence of courses of the Civil Engineering program, have been meeting informally to discuss students' progress and share their experiences and pedagogical innovations. As a first result of these meetings, the structural engineering sequence was redefined in a non-conventional manner, as shown in Figure 7, in the context of the School of Engineering curricular reform [4].

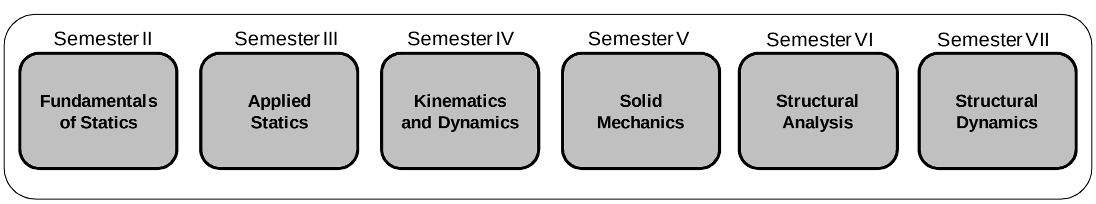

Figure 7: Civil engineering sequence of structural engineering courses

Motivated by this teaching community's experience, faculty members are planning to create their own teaching community focused on the complete structural engineering sequence of courses. They have recently received a university grant for this purpose. The first objective will be to formalize and systematize the work of this group, in terms of monitoring student progress and the achievement of the expected learning outcomes by the students throughout the whole sequence of courses. The second objective is to implement active learning in all of these courses, taking as a model the manner in which active learning was used in the traditional Mechanics course, as well as other successful experiences.

Activity 3: Transfer of successful experiences across engineering programs

A student experience from the Introduction to Industrial Engineering course has been transferred successfully to the Logistics Management course of the Logistics Engineering program. In the Introduction to Industrial Engineering course, students learn about the industrial engineer's field of work and role in society by creating videos in teams, in which they interview practicing professionals. In the Logistics Management course, students interviewed several management-level professionals from logistics-related businesses so as to contrast conceptual management elements with real-life experiences, and prepared video presentations which were evaluated using the same rubric used in the Industrial Engineering course.

Activity 4: Coordination of intensive PCP workshops

The pace of participation of School of Engineering faculty in the program course offered by CIDD shown in Table 1 was considerably slow. Because of this and motivated by an intensive workshop organized by the Civil Engineering department in July 2012, the teaching community coordinated with the CIDD an intensive two-day workshop on teaching skills program courses focused on competences PCP2 to PCP4 during January 2013, for Computer Science and Industrial Engineering faculty, which includes the Industrial Engineering and Logistics Engineering programs' faculty. As a result, CIDD course participation has increased significantly, reaching approximately 40% of School of Engineering faculty. In particular, Table 3 shows the percentage of Computer Science, Industrial Engineering and Civil Engineering faculty that have been attended CIDD workshops in the different PCP1 to PCP5 competences. It must be noted that faculty members that have completed their development will be granted certification only after the corresponding competence is implemented in specific courses to be completed by mid 2013.

Table 3: Percentage of faculty attending CIDD workshops, by department

PCP	Computer Science	Industrial Engineering	Civil Engineering
PCP1	50%	15%	77%
PCP2	50%	62%	77%
PCP3	50%	62%	77%
PCP4	33%	69%	77%
PCP5	17%	8%	8%

DISCUSSION AND FUTURE WORK

The driving force of the teaching community model is its periodic meetings, which conform to the community's yearly planning. The meetings' agenda addresses specific tasks for achieving the community's goals, and incorporate regular reviews of results and student feedback. These meetings are generally supportive, short and effective. This may be because the community members are self-motivated, open to teaching innovations, and have worked together since they were involved in the curricular reform processes for their respective programs, so they have built trust among themselves. They have also shared the faculty enhancement process together. Thus, the teaching community naturally follows a flat hierarchical organization.

On the other hand, the teaching community is still small and its members are mainly self-selected. In many cases, they are natural leaders empowered by the university to lead the curricular reform process. But, no senior administration officials have participated in the community yet. Even though the teaching community actively documents and publishes its activities and results, it has not had an outreach strategy to add new members that are indifferent or even resistant to change.

Future plans for the teaching community include: increasing its membership to facilitate the transfer of experiences and pedagogical innovations using active learning across courses and programs; inspiring research in engineering education among its members and promoting the dissemination of their findings; and establishing relationships with other UCSC teaching communities so as to promote interdisciplinary work among students. For instance, community members can organize seminars twice a year and maintain a website to show pedagogical innovations and have the chance to receive feedback from a broader audience, similar to the "Good Teaching Practice" wiki at the Technical University of Denmark [12]. At the same time, the School of Engineering at UCSC is committed to start incorporating Service Learning as a learning methodology, and has begun faculty development to this purpose. Several teaching community members are willing to work on strategies for combining these two approaches.

CONCLUSIONS

Even though our teaching community is relatively new and small, it has already made an impact in several engineering programs by using active learning and incorporating information technology tools. Its members are highly motivated to improve communication and strengthen collaboration among instructors of different areas. The teaching community has assisted in monitoring and evaluating the implementation of the curricular reform, and has also contributed to the faculty development plan being implemented by the newly-created UCSC Teaching and Learning Center (CIDD). The community's peer-based model to promote active learning methodologies has inspired research in engineering education among its members, which has already generated several national and international publications. The community's participation in the CDIO network has certainly been invaluable as a source of knowledge and guidance.

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BIOGRAPHICAL INFORMATION

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