ETHICS LEARNING OUTCOME: AN INTEGRATED LEARNING EXPERIENCE

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ABSTRACT

Professional Ethics is one of the professional skills included in the CDIO syllabus that needs to be acquired by engineering students since their first year at the university. Using the CDIO approach, we designed a model to develop competencies in Ethics and Social Role of the profession in students, and applied it to a course taken by all freshmen.

This model includes the following stages:

1. Set up a multidisciplinary team with experts in Ethics, course professors and teaching development consultants
2. Design and validate the Learning Outcome in Ethics and Social Role of the profession.
3. Set up the levels of achievement that will measure the progression of students in developing these competencies
4. Analyze the course sequences and identify a minimum path to develop the competencies
5. Set up a multidisciplinary team to develop the levels of achievement, including in it the professors of the courses involved.
6. Implementation and monitoring
7. Evaluation

This model was applied at the School of Engineering and Sciences of the University of Chile for its undergraduate programs.

In this paper we describe the development of the first level of achievement in the "Introduction to Engineering" course.

The experience obtained in building the model and implementing it in the "Introduction to Engineering" course has shown the importance of the integrated learning experiences (CDIO standard 7), as well as team work and crossing traditional discipline boundaries. These are necessary conditions for the proposed model to reach its goal.

KEYWORDS

Ethics, integrated experiences, Learning Outcome

INTRODUCTION

In the context of the modernization of the University of Chile, in 2007 the Faculty of Physical and Mathematical Sciences (FCFM) the implementation of curriculum reform and the CDIO approach is applied to the 13 undergraduate programs. Thus, following one of the CDIO standards (cf. Standard 4), the courses: Introduction to Engineering I and II are created. These are part of the Common Core mandatory courses for the students entering the undergraduate programs.

Looking for an integrated curriculum the development of generic skills like oral and written communication, ethics and teamwork is incorporated (cf. CDIO Syllabus2.5, 3.1-3.2) and are developed in conjunction with the expected technical skills and always in the context of engineering.

Reflecting about the development of generic competences in an interdisciplinary team we came to the conclusion that we could "teach" the professional ethics and then train future engineers in professional ethics only if it is considered as an integral part of engineering education, and not as an "annex" or "addendum" (before or after).This does not mean that the "theory of ethics" has been shelved, but it is inserted and operationalized in the development of projects undertaken in these courses. Moreover, treatment of ethics in this perspective leads "naturally" to establish a hierarchy of generic competences that allows the functional design of the curricular activities, and to position the education in ethics as a learning need that is not reduced just to a technique, because involves both a cognitive development and a commitment to society (which leads to work on critical thinking and the incorporation of the profession as a project of development and personal fulfilment).

HISTORY AND PERSPECTIVE

In a first attempt to introduce ethics, explicitly in the development of the course Introduction to Engineering and applying the proposed CDIO curriculum structure, an "external lecturer" explained what is ethics to the students, in special sessions that were scheduled in the course. Promptly it was seen that this form of teaching ethics does not work, since it is not meaningful to students because a clear relationship of engineering and ethics is not found, without addressing the potential ethical issues in real engineering.

On the other hand since the beginning of the implementation of the course Introduction to Engineering, the need of developing a reflection on "What is engineering?" was established. For this purpose, the formulation of Thomas Tredgold, "engineering is the art of harnessing the resources of nature for the benefit of man and society" [1] was used. In this formulation what engineering does and for what are highlighted. This formulation gave us the key to rise the ethical dimension from its basis: the discussion about aims and means in the framework of values and principles that ordered those. From this reflection and discarding the idea of "expert lecturer," a multidisciplinary working group was formed with the course teachers, counsellors in education, a philosopher and an anthropologist, that overcoming the barriers of different disciplines. By analysis of the strengths and weaknesses of this first stage, the team initiated a discover process of relation between ethics and engineering. In this context, the team conceptualized a narrow definition for the term of "professional ethics" and focused on the search for definitions of professional ethics in engineering from the work of the profession itself. With these definitions are designed integrated activities address both aspects where professional and personal and interpersonal skills, including ethics.

The team quickly comes to the conclusion that a first requirement, necessary to address professional ethics in engineering education is the conviction and a decision that we could "teach" the professional ethics. This is not a trivial matter, since it is a widespread opinion of teachers on ethics related training that "at this point a person does not change" or "this is the

house" and, on the other hand, what if we teach ethics legal frameworks governing the profession? Both prejudices are used to justify the dispensable of ethics training [2] .It is not the moment to discuss in depth these two prejudices, because what we want to enhance is that it is a decision first.

A second element concerns the ethical perspective that is adopted. This is an overview of the ethics of responsibility [3], *i.e.* the one that considers that decisions should be taken, analyzing and assuming the consequences. The ethical perspective is chosen considering in its formulation the aims pursued by the actions and resources to achieve them. And thirdly, a set of values and principles that frame the responsibilities, goals and resources are selected. Such are the institutional values of the University of Chile:
"In carrying out its work, the University responds to the requirements of the National Intellectual Reserve constituted as characterized by a social conscience, critical and ethically responsible and recognizing its mission as the content of care problems and needs of the country. To that end, it obliges the most complete knowledge of the national situation and its development through research and creative activities; postulates comprehensive, balanced and sustainable country, contributing to the solution of their problems from the university perspective, and tends to the common good and the formation of a citizenship inspired by democratic values, ensuring the safeguarding and enhancement of national and universal cultural heritage" [4].
Thus, it is clarified that the ethics that we teach in the Faculty of Physical and Mathematical Sciences concerns with that reflection that seeks to base the responsible decisions, being guided by certain moral principles. That is why the teaching of ethics begins with the definition about this "reflection", asking ourselves about what are the "professionals decisions"; what does it mean taking these responsibly, and giving the "moral principles" of the institution.

Later this team intends to "model" the process to establish milestones to facilitate the design of a strategy for its development and implementation through the curriculum. This model cold be used to developed other generic skills. The feasible model should meet the characteristics of undergraduate programs of our School of Engineering. After that a socialization period begins, with the authorities and then with the interested teachers in order to raise awareness, gather feedback and adjust the route path.

Note that throughout the process, conceptualization and implementation, the team has been monitoring and assessing the quality of each of the stages, making adjustments and corrections, generating metacognitive processes that have allowed transferring the experience of both the rest of the University of Chile and within the faculty.

THE MODEL

The model presented below consists of the following milestones and instances:

1. Set up a Multidisciplinary team with an Expert in Ethics, Engineering Professors and Teaching Development Consultants, who begin by sharing how the disciplines contribute to the development of professional ethics and what are the most important aspects of it.

2. Design and validate the Learning Outcome in Ethics and Social Role of the profession. A definition of the competence that is achievable by students at graduation and developable and evidential in the context of the University of Chile School of Engineering programs, is elaborated.

3. Set up the levels of achievement that will measure the progression of students in developing these competencies. We define a progression that allows the achievement of the competence at graduation.
4. Analyze the course sequences and identify a minimum path (figure 1) to develop the competencies. Some mandatory courses are selected to ensure that all students meet this minimum. Nevertheless, being highly desirable, it is promoted that also other courses train students in ethics.

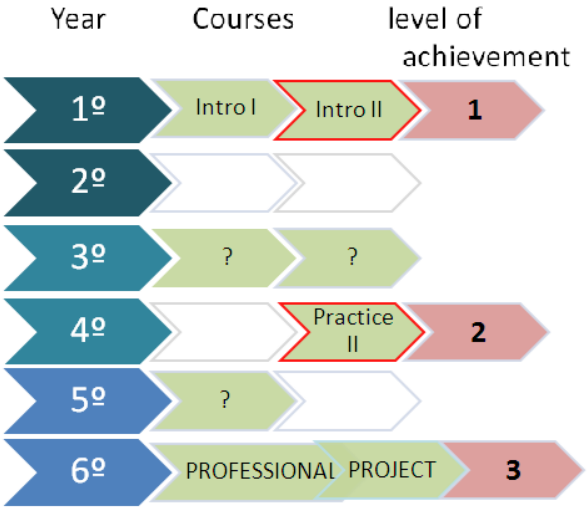

Figure 1 minimum pat

5. Set up a multidisciplinary team to develop the levels of achievement, including in it the professors of the courses involved. This team works according to the scheme shown in figure

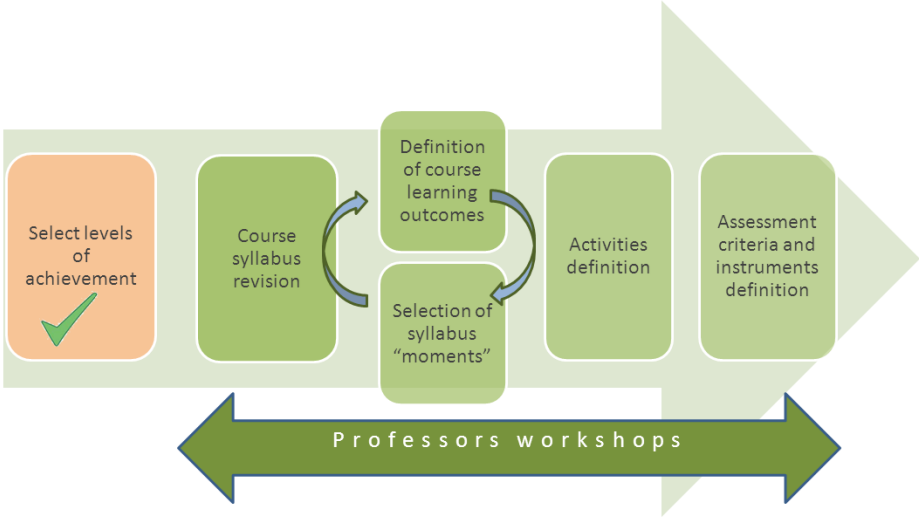

Figure 2: Work scheme

6. Implementation and monitoring. Continually review achievement levels, and activities, trying to adjust to the realities of the courses, to improve implementation.

7. Evaluation. Assessment tools are designed to check whether students reach achievement levels established.

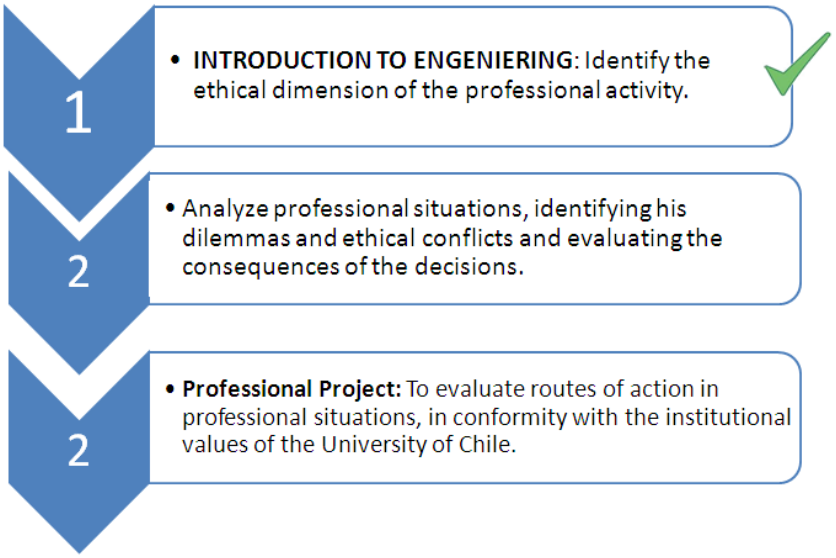

Figure 3: levels of achievement

EXPERIENCE IN THE INTRODUCTION TO ENGINEERING

The strategy used in this course is to incorporate in the approach of the first project to be realized in the course, some objectives and information related to ethical, social and environmental aspects, as well as the technical and economic.
The project involves the design and construction of a structure that will support raw materials for spraying near a river. For this, students are given objectives, background and requirements, summarized in the following areas: designing and implementing projects, design process, teamwork, report writing and oral presentations, the importance of ethical aspects, specific structural design, location structure, building structure and to minimize materials used.
Students gathered in working groups, must develop a prototype that meets the requirements raised, through the implementation of a prototype to evaluate materials, preparing sketches for rapid assembly, the preparation of blueprints, implementation of the final prototype and tests.
Once the project is finished, for three class sessions the issue is addressed as follows:

Session 1: Student groups are asked to discuss what aspects were considered in the different stages developed. Then they are asked to indicate the order of priorities assigned to different stages and project requirements. For students to reach their metacognition of learning processes, groups are given a table to rank their priorities. The result of this exercise showed that overall, students developed the project, giving greater importance to technical and economic aspects, leaving second place, even in some cases omitted, what relates to ethics, environmental or social impacts. That is, all aspects that despite being inseparable from a project, are now called "externalities".
The activity described above looks for two things: first, students recognize in them a common practice in engineering: de-emphasize aspects that have no technical or economic impact. In the second place, that students acquire a more holistic view of their projects, not only prioritizing issues to be "evaluated" or, in a future career, "paid", but also including in the implementation of a project all the possible foreseeable effects. In this session we discuss about this and are some cases of real engineering projects that demonstrate these omissions, which may even lead to fatal consequences. Finally, working groups are asked to discuss for the next session the reasons why those priorities were identified while developing the project.

Session 2: We analyze with students the required task, highlighting and examining some of the reasons given by students for not considering not "extra" technical issues. We establish

some basic distinctions, such as distinctions between legality and ethics, from the recurring argument about compliance with technical specifications.
The reflection is done by presenting some examples, in which engineering can find good solutions from the standpoint of environmental, energy, social, etc., without neglecting and even improving aspects of cost and functionality. We discuss about "what is to do well in engineering?" and "good for whom?" concluding that "Engineering can find alternatives." Furthermore, this point is reinforced with the Mission of the University of Chile and what is expected of engineers trained in it, leaving as homework reading the text "Ethics in Engineering" [5].

Session 3: We analyze the issues raised in the above text, in particular as regards the responsibilities of engineering. To stimulate discussion the teacher questions these responsibilities, taking a critical view towards the text from a technocratic position. From this counterpoint is generated a discussion that reinforces and helps to clarify these responsibilities. Concluding that "Engineering has a duty to assess all the impacts of a project and look for better alternatives," both when dealing with large projects, and when making small decisions.

CONCLUSIONS

Throughout the process of incorporating the teaching of professional ethics, the multidisciplinary team has experienced the "learning by doing", which has led to the development of a growing experience and mastery of the subject.

In this sense, experience, definitions and results of work of this team, lead to the conclusion that professional ethics is not an attachment, or an additional knowledge to deliver to future professionals. By contrast, professional ethics is a form of acting in all human endeavor, especially engineers, "it is not another piece of the puzzle" [6]. Considered thus, its teaching becomes more realistic and learning more meaningful since it is discovered and introduced in real situations in projects. Thus, it is not a matter of being technically "good" and also "ethical". Rather, it discovers and learns that a responsible exercise of the profession itself contains various commitments, including doing "well" our work, from several points of view, obviously including technical, since it is a minimum expected society of engineers, and based on certain moral principles, which every professional practice adheres to them, but that the University of Chile in its mission, defined as an active commitment to the common good and the comprehensive, balanced and sustainable development of the country. Thus, the experience of implementing integrated curricular activities where students evaluate their own behavior in a project, allows them to discover ethics as a fundamental component of the engineering profession.

The presented model has worked in our university because it has been formalized after being constructed step by step and the result of deep reflection on professional ethics. Therefore it is not intended as a "recipe" for instant application. It requires a thorough analysis of the local professional reality, of institutional values and the curriculum where applicable, seeking to educate competent professionals, and also the engagement of teachers.

Finally we are interested in highlighting the learning by the team that developed this proposal, who through continuous reflection about the processes which has led, implemented, monitored and evaluated, has generated important metacognitive processes. This has allowed widening the processes of support and advice to other teams of teachers, who want their students fully formed by the incorporation of generic skills such as professional ethics.

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Biographical Information

Héctor Agusto is Electrical engineer from the University of Chile (2001) with more than 10 years of academic experience, professor and researcher. Now is Professor in Mining and electrical engineering departments at Universidad de Chile, and is coordinator of introduction to engineering courses in the first year of the Common Core Program of the School of Engineering Engineering.

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