FINDINGS IN PROFESIONAL TRAINING: COMPUTER ENGINEERING SCIENCE PROGRAM, UCTEMUCO

Marcos Lévano

Escuela de Ingeniería Informática, Universidad Católica de Temuco

Andrea Albornoz

Departamento de Lenguas, Universidad Católica de Temuco

ABSTRACT

This paper aims to show the professional training of programing engineers from Universidad Católica de Temuco (UCT), Chile. The experience is focused on the development of the students' knowledge of Being, Making and Knowing.
The paper displays how to evidence competences lined up with the educational model called CDIO (for its name in Spanish: Concebir, Diseñar, Implementar and Operar).
This new way of teaching has demonstrated to be beneficial for the curricular development of students. By some measurements, positive results during the course of the program and after they graduate were observed. Also, there were improvements in the teaching and learning of engineering.
The educational model for Computer Engineering Science in our university is based on five axes: education based on competences, meaningful learning, ongoing education, ICT, and Christian-humanist education. Theses axes are interconnected with four specific competences that are part of the curriculum program.
The question we try to solve in this paper is: Is it possible to improve the skills of students from the region of La Araucanía in a social, economic and cultural perspective, by teaching and learning based on education that allows the student to discover, expand and exploit the improving professional training and human capital skills? The process of evidencing competences meets with the model CDIO being adapted to the program. The progression in the validation of competences is reached through a number of activities of teaching and learning, and the implementation of this process is achieved in several moments during the program in the four stages of CDIO. Those activities are carried out in laboratories, in interaction with the environment, in tasks of use cases, in simulations and in workshops.

KEYWORDS

Competences, CDIO, knowledge, educational model, learning.

INTRODUCTION

Several trends have boost changes in teaching ways around the world. Some of these trends are globalization, advancements in technology and the new organizational structures of companies and job organization (Lévano and Herrera, 2012). A variety of international

initiatives have ended up becoming models, methodologies, and educational practices that have been incorporated to higher education. A common denominator in many of these educational proposals is the orientation towards education based on competences or skills. Competences are those behaviors, abilities, and visible aptitudes that people contribute in a specific field of activities to function effectively and successfully.

Since 2008, UCT has initiated a project of curricular changes in all its programs, in an effort to improve all the academic processes of the university. This project is built centered on a new educational model based on competences and focused on the students. It has been elaborated and developed during the last years.

The alumni from Computer Engineering of our university poses a good background in basic sciences, engineering sciences, management of specific contents (ICI, 2009). The new setting (ICI, 2009) of the program was developed by making questions to employers, ex-students, other universities, international organizations specialized in the area of computer engineering science (mainly from the Association for Computing Machinery) (ACM/IEEE, 2008; CE2004, 2004; IT2006, 2006), consultations on studies about teaching engineering (CDIO model) (Crawley, Malmqvist, Östlund, Brodeur, 2007), (Brodeur et al., 2002), (Poblete et al., 2007), and studies about higher education in Chile and some future changes (OCDE - Organization for Economic Co-operation and Development, and World Bank) (OCDE, 2009), (CNIC, 2010).
This study addresses the process in which how to evidence cognitive and metacognitive processes is demonstrated (Flavell, 1979) in order to achieve the competences. The process of evidencing competences meets with the model CDIO being adapted to the program. The progression of it in the validation of competences is reached through a number of activities of teaching, and learning and the implementation of this process is achieved in several moments during the program in the four stages of CDIO.

This paper shows the educational model based on competences implemented in UCT and also it displays a set of specific competences developed and implemented in the program of Engineering Computer in UCT. It also describes the framework of the validation of skills, the improvements in the curriculum, the results, conclusions, and finally, the references.

UCT EDUCATIONAL MODEL

In our university, we define competence as: “to know how to behave, using our own means and outside resources in order to solve real problems in an effectively and ethically responsible manner” (COMP, 2008); (ICI, 2009); (Kri et al., 2013). We also distinguish two kinds of competences or skills, generic competences, which are shared among all the programs and the specific competences which are directly related to the areas of study of each program.

The educational model in our university (MEUCT, 2008), is based on five axes. Therefore, the Engineering Computer program is set in the same way (ICI, 2009).

1) Model of education based on competences: we are committed to managing the quality of learning, so we have implemented four specific competences that are vital for the education and development of the students (MEUCT, 2008) and ten generic competences stipulated by the university (COMP, 2008); (Kri et al., 2013).
2) Significant learning focused on students (MEUCT, 2008).

3) Ongoing education: we hope that our students keep studding after they graduate, in post graduate levels that develop and increase the complexity of the development of the human resources among the students.
4) Information technologies in the process of learning and teaching: based on what is stipulated in the curriculum, we have intensively incorporated ICT as an important part of the evaluation and teaching processes in all the subjects of the program (ICI, 2009).
5) Humanistic and Christian education: our globalized society demands ethical professionals with robust knowledge about their specific area of study, ability to face problems from different perspectives, and a high capacity for handle a variety of competences or skills.

These abilities are developed throughout the five years of study by the validation of the generic competences (ICI, 2009).

ENGINEERING COMPUTER SCIENCE PROGRAM

The curriculum program operates based on four specific competences according to the stipulations of the university (see figure 1).

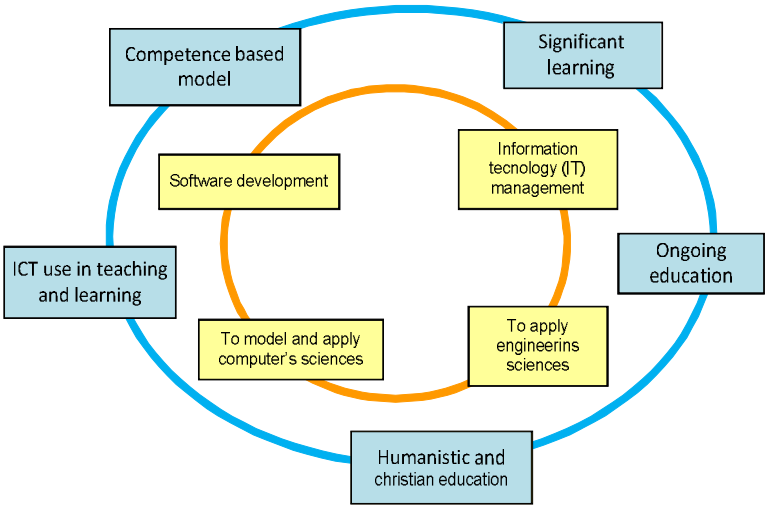

Figure 1. UCT educational model: general and specific competences.

Software development: the students are able to give solutions by the development of software for specific problems, by using a software engineering approach integrating technical, ethical, social, legal and economic aspects (ICI, 2009).

ICT using in teaching and learning: the students are able to manage hardware and software technology systems in an organized way, in order to automate management systems and production processes (ICI, 2009).
Modeling and application of computer science procedures: the students create and apply solutions related to informatics to solve real problems, applying computer science methods, taking care of abstract, logical, and scientific aspects of science. To do so, they use algorithmic methods in the automation process of engineering information (ICI, 2009).

Application of engineering science: the students implement mathematical and engineering models, as well as models from basic sciences by using logical and reasoning skills, in order to engage themselves in problems of analysis and design of technological systems based on software, linked to engineering special areas (ICI, 2009).

COMPETENCES VALIDATION PROCESS

The competences validation process was developed based on the following strategies:

Work meetings: these meetings are performed by an executive board of teachers in the area of computing and other disciplines. The function of these meetings is to evaluate and discuss some situations like: how to distinguish learning difficulties among students, how to generate communication between teachers, choosing advanced students to assist partners having difficulties, developing projects to support the student community, discussing about mechanisms to validate skills and competences and to develop evaluation guidelines.
The topics can be gathered as followed:

- Problems of specific students (check behavior in each group)
- Methods to validate generic competences
- Performance of each group
- Discussion of topics in a vertical way

There is a coordinator who keeps records of these issues and who moderates and prioritizes topics addressed and the actions to be derived from these meetings.

Integration of competences workshops: Evaluation processes have been carried out every year to evaluate the integration of the development of competences in a horizontal way. They are practical workshops to generate challenges, creativity, and innovation among students in several ways, for example, on a personal or attitudinal level, and how to use their knowledge.

Feedback: feedback is done at every moment, in all the subjects. It is accomplished through a learning resource center and also, it is done by all teachers. Feedback takes place in mixed hours, in which the teachers work individually or in groups with the students, as stipulated by the educational model. The objective is to solve analytic, application, or knowledge problems.

Peer tutoring: it is developed in each subject that allows intervention of other students. The objective is that older or advanced students help their partners. To do so, focused peer tutorials and tasks with the learning resource center are promoted.

Advisory services for teachers: every year, this strategy allows teachers to improve their pedagogical practices. They participate in workshops, training and guided classes. They are supported by the teaching innovation center of the university.

Record book: we keep track of all the generated and validated knowledge that students achieve in the different topics of the educational process. It allows validating competences, making self-assessments and making interventions in weak areas in medium term.

Control and tracking of professional training: in this stage of the educational process, we check, orient, guide and evaluate the validation of the competences in the work place. The

evaluations are made taking into account our own formative discipline and the rules of each place of work in which the professional training is done.

Learning guidelines: it is based on the triple instrument according to the methodology, the assessment and learning outcomes or objectives of the subjects. To develop the guidelines, we worked on activities based on the development of the knowledge of knowing, being, and making.

ALIGNMENT OF CDIO WITH THE CURRICULUM

The alignment of the process of CDIO (Crawley et al., 2007) with the curriculum has been implemented based on the development of the graduated profile. A Computer Engineer graduated from UCT has a set of competences and a robust basis in engineering sciences that allows him to work in the areas related to software development and ICT. To enhance characteristics that are highly demanded by the working market, and to promote the identity seal of the university, we have boosted the competences of team work, creativity, and innovation (ICI, 2009).

Scheme of competences development

The process of developing competences in environments occurs in the classrooms, laboratories, visits, professional job practice, workshops, seminars, and final papers, all as described in the educational model proposed by the university. The process of experiencing the developing of competences goes along with the contexts of active, reflexive, conceptual and application experimentation (Kolb, 1984; Kolb y Fry, 1975; Bloom et al., 1956), see figure 2.

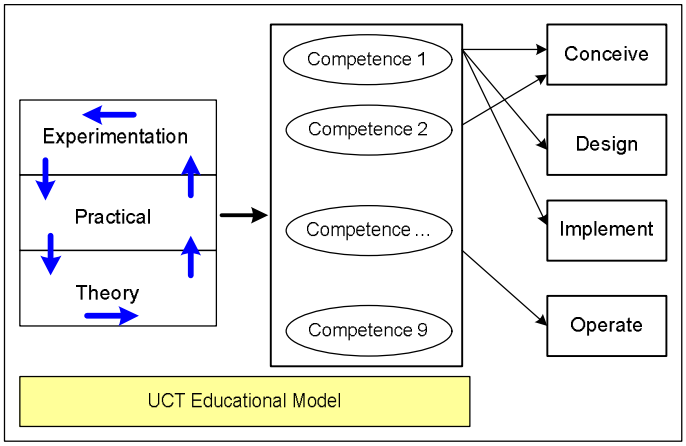

Figure 2. Scheme of competences development in the educational guideline.

In this section a part of how generic competences with the subjects of discipline are connected in the first two years is exposed, as showed in table 1. To exemplify, we just show four generic competences out of the total nine that exist on the curriculum. There are nine generic competences that must be developed in three levels: ethics, focus on quality, respect for diversity, creativity and innovation, autonomous learning, English language, teamwork, knowledge management and oral and written expression. When graduating, students must validate up to the level three for each of the nine generic and specific competences.

Table 1. Generic Competences (GC) Level and Subjects (ICI, 2009).

Subject / Level	Generic Competence 1			Generic Competence 2			Generic Competence 3			Generic Competence 4		
	I	II	III	I	II	III	I	II	III	I	II	III
ICT basic introduction												
Programming I												
Robotics and programming				X								
Introduction to management systems database												
Christian education							X					
Maintenance and systems management	X											
Programming II												
Projects Robots												
Client Server applications development										X		
Integration workshop I												
Networking												
Programming III				X								
Hardware architecture												
Introduction to the development of business applications.	X									X		
Programming for system integration					X							
Microcontrollers												
Graphical interfaces for the user				X								
Mark-up language												
Business application development	X									X		
Integration workshop II												

In table 2, the relationship between generic competences and CDIO model is shown. Generic and specific competences go along together during the process of validation, and each subject can incorporate two or more generic or specific competences.

Table 2. CDIO Model and Specific Competences.

Specific Competences	C	D	I	O
ICT management	X	X	X	X
Modeling and application of computer science		X	X	

Software development	X	X	X	X
Application of engineering science		X	X	X

CDIO in the development of specific and generic competences

During the first year “to operate” is worked, while “to implement and to operate” are worked during the second and third year. During the fourth year “to design, to implement and to operate” are worked. Finally, during the fifth year “to conceive, to design, to implement and to operate” are worked altogether. During first year we begin with the vertical implementation and during second year we implement the horizontal integration of competences. This process is sequential and it is also combined along the subjects and the years. For example in figure 3, basic science knowledge is developed in activities inside the subject, because that course is focused on fundamental knowledge. That knowledge is manifested in a horizontal way of competences. In the figures 4 and 5 below we can observe what happens during the rest of the years.

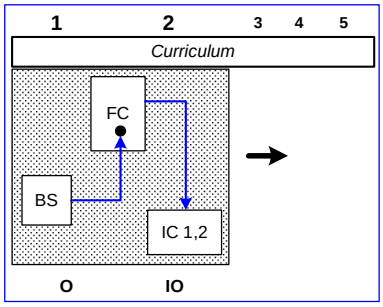

Figure 3. To operate (O); to implement and to operate (IO).

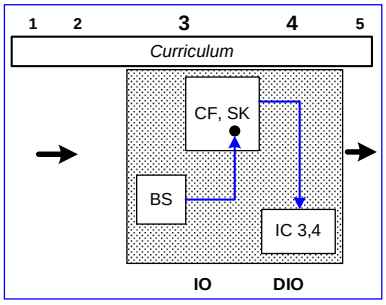

Figure 4. To operate (O); to implement and to operate (IO).

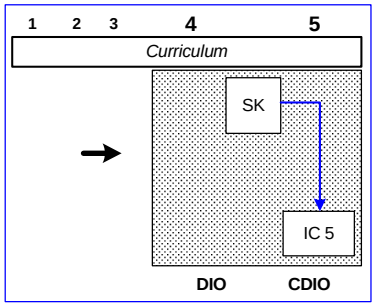

Figure 5. To operate (O); to implement and to operate (IO).

Note: (FC) fundamental knowledge; (BS) basic sciences; (IC) integration competences; (SK) specialty knowledge.

RESULTS

Based on the curricular structure of the curriculum

- 83% of alumni note that the program makes it possible to face the process of obtaining the academic degree and professional title without drawbacks.
- 85% of alumni consider that the program gives an education that allows facing the process of obtaining the academic degree and professional title without drawbacks.
- 95% of alumni consider that some of the contents were repeated in two or more subjects unnecessarily.

Effectiveness of the studying process

- 78% of alumni believe that the university do cares to diagnose the conditions of entry of its students to adapt contents and teaching strategies.

- 82% of alumni consider that the curriculum was consistent with the identity seal of the program.
- 87% of alumni note that the curriculum and subject programs were delivered without inconvenient.
- 86% of alumni consider that evaluations were always based on clear and known criteria.
- 96% of alumni think that they always had known the criteria and requirements for graduation and obtaining the degree.
- 91% consider that the criteria for obtaining the degree were adequate.

Employability of graduates

Table 3. Graduates tracking survey (2012-2013). From Computer Engineering Science Program.

Graduates tracking survey results	
Well timed employability (working in other areas)	Less than 3 months (90%); 3 or 6 months (9%)
Employability (working as an engineer)	85% of Adequate employability
Place of work	Araucanía (55%); Metropolitana (36%); Antofagasta (9%)

CONCLUSIONS

The competences based model of the curriculum of Computer Engineering Science from UCT does have some relevant elements for a program that pretends to be modern and innovative, according to what is expected from a university program in XXI century.

Ways of teaching: this new model of education is developed under the concept of competences and also under the concept of formation on engineers with the model CDIO (Brodeur et al., 2002; Crawley et al., 2007); it is made according to the guidelines given by the Association Computing Machinery, the Association Information Systems and the Computer Society. The model contains a new way of looking higher education in Chile, according to OCDE and the assessment criteria of the CNAP.

Competences in the curriculum: the School of Informatics of our university develops four specific competences: software engineering, ICT management, modeling and application of procedures in computer science and application of engineering sciences (ICI, 2009). The competences are divided into three levels of complexity in engineering and engineering sciences experiential learning. The levels of organization of the curriculum are built on reasoning and disciplinary knowledge, skills and personal attributes also professional and interpersonal competences as established by the norms of CDIO (Poblete et. al., 2007).

Order of the curriculum: the discussions of the Executive Board of Schools about the vertical integration help to maintain the order of the curriculum. This means that courses can be adjusted by knowing what topics and methodologies are being applied in other courses.

This also suggests the generation of joint activities in various courses. For example, a project one subjects that can use resources learned from other subjects.

Motivation: By having in his first two years a lot of specialty subjects, students can clearly see what their profession is about, and where they are going. They can get early achievements, which motivates them to advance and deepen issues specific to their specialty. Moreover, support and words of praise from top executives in companies of regional IT has an impact on them. That generates a valuable relationships and connections with companies and well future employability opportunities.

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BIOGRAPHICAL INFORMATION

Marcos Lévano received his Bachelor's degree in Computer Science in 2001. In 2002 he graduated from Computer Engineering Program at Universidad Nacional de Trujillo, Peru. In 2005 he received the Master degree in Computer Engineering Science at Universidad de Santiago de Chile. Since 2006 he has worked as a teacher in the Computer Engineering Science Program in Universidad Católica de Temuco. Currently, he is the Head Master of the program. His main research areas are education, media, communication & education and pattern recognition in clustering.

Andrea Albornoz received her first academic degree in English Spanish Translation program at Universidad Catolica de Temuco in 2015. Currently she is working on her final research paper to obtain her final degree to be a professional translator. She is working as research assistant of Professor Marcos Lévano in the Engineering Computer Program. She is co-author of two papers dealing with IT presented in IADIS 2016 and EANN 2015. Her research areas are educational research, media and communication. She has been invited to cooperate in the project of innovation in teaching from the Engineering Computer Science Program at Universidad Cátolica de Temuco.

Corresponding author

Prof. Marcos Lévano
Escuela de Ingeniería Informática
Universidad Católica de Temuco
Manuel Montt 056, casilla 15-D
Temuco, Chile
0056 - 45 - 2 205688
mlevano@inf.uct.cl

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