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Framework for Engineering Faculty Competencies: The Case of an Engineering School in Latin America

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WIP Framework for the development of faculty competencies: the case of an engineering school in Latin America

This Work in Progress paper presents the initial step towards the development of a framework for defining engineering faculty competencies, which will then serve as a guide for future faculty development and evaluation plans. The school of engineering at Universidad Icesi has been working for the last 8 years on curricular design with the goal of incorporating international standards based on the development of competencies and learning outcomes (ABET). The university's undergraduate engineering programs were accredited in 2017, which subsequently led to the identification of the necessity of implementing faculty development. Do professors in engineering schools need to improve and update their knowledge, skills, and attitudes in order to demonstrate their ability to guarantee the learning process of students under the requirements of engineering education standards such as ABET?

To begin answering this question, the initial step was to undertake a literature review on the competencies and skills required of engineering faculty members in order to identify the most frequently identified competences. This will be followed by the characterization of the current state of the development of faculty competencies in the school of engineering. After that, an analysis of the findings will be performed in order to propose a framework for the definition of engineering faculty competencies (focusing on CDIO standards 9-10) that will serve as a guide for faculty development and evaluation plans at the school level. This project is part of a larger one that endeavors to consider all CDIO standards (1-12) for the continuous improvement of an academic program. The findings can potentially be utilized to guide continuous improvement efforts at engineering schools with similar characteristics in Latin America or around the world. **Lightning talk. description**

Keys words: Competencies, faculty development, CDIO standards 9-10

Introduction

Within Latin America, the design of undergraduate programs based on competencies is accelerating. In Colombia, for example, there have been important modifications in the regulations set forth by the National Ministry of Education (NME) and formalized in Decree 1330 of 2019 [1]. One of the most significant innovations of the decree is the inclusion of the concepts of *competence* and *learning outcomes*, with the objective of guiding undergraduate programs in the training of professionals with skills to effectively become part of the workforce. While this approach is novel for the NME in the field of engineering, international organizations that promote standards in engineering have defined what students should demonstrate at the end of their educational process for more than two decades.

It is within this process that in the year 2000 the CDIO initiative conceived, designed, implemented and operated an established sets of competencies in three areas: specific, general, and engineering. These competences have been consolidated in the CDIO Syllabus [2], encompassing four groups of competences, namely: 1. Disciplinary knowledge and reasoning, 2. Personal and professional skills and attributes, 3. Interpersonal skills: teamwork and communication and 4. Conceiving, designing, implementing, and operating systems in business, societal and environmental contexts - the innovation process. More than 120 engineering schools [3] have adopted the CDIO model for curriculum design. Administrative processes have identified some limitations at the time of the model implementation by the professors of the discipline, primarily in the competence of the conceive, design, implement, operate cycle.

It is then assumed that a faculty member is expected to demonstrate her or his ability in the competencies proposed by the model. Specifically, CDIO Standards 9 and 10 address the issue of faculty training for the development of these competencies.[4]. With this in mind, the current research seeks to answer the question, do the faculties of engineering schools need to improve and update their knowledge, skills and attitudes in order to demonstrate their ability to guarantee the learning process of students under the requirements of engineering education standards such as CDIO or ABET? This paper presents the results of the first step of the research process aimed at answering the above question. It consists of a literature review of the competencies required of engineering faculty members with the aim of establishing a frame of reference that will allow for the construction of a model of faculty competences for the engineering school at Universidad Icesi.

Background and previous work

The primary research in the field of engineering competencies under the CDIO model can be found in documents on the website of the proceedings of the international CDIO conference, currently in its 15th version [5]. For this study, we have taken as the main reference Alexander Chuchalin's research , entitled "The CDIO Approach to University Faculty Advance Training for Research and Teaching Activities". In it, Chuchalin establishes the following classification of competencies for engineering professors : technical, pedagogical, social, psychological, ethical, didactic, evaluative, organizational, communicative and reflective competencies Additionally, we have utilized the investigative work of Ramón Bragós Bardía, which proposes six actions to promote the development of generic competencies in engineering with reference to framework standards 9 and 10 of CDIO, including: relevant experience in the industry, design of courses that develop these competencies, experience exchange activities with the industry, and mentoring by professors with extensive professional experience.

Methods

The method used for this step of the research consists of a literature review of the topic of competencies development for engineering faculty members, taking the CDIO model into account as a frame of reference. This literature review will provide an inventory of faculty competencies as described by the literature. Following this, a survey to identify faculty perspective on competencies will be designed and administered. The information provided by the survey will be analyzed and will subsequently form the basis for discussion and reflection with faculty members in order to find consensus on a set of faculty competencies. The design of performance indicators or evidence to support faculty evaluation and development will be a joint effort. The competences could be incorporated in annual review process and should guide faculty development plans.

Results and discussion

The initial literature review has allowed us to classify the research contributions on the subject of competencies for faculty into three groups: generic, specific and CDIO competencies. The associated papers and major findings for each group are summarized in Table 1.

Table 1- Main Findings

Group	Paper	Main findings
Generic competencies	Identification of teaching competencies that guide the development of training plans aimed at University teachers [6].	This paper presents a definition of competencies of university teaching staff regarding their teaching performance, excluding disciplinary competencies: 1. Interpersonal, 2. Methodological, 3. Communicative, 4. Planning and management of teaching, 5. Teamwork, 6. Innovation.
	Enhancing teaching skills: a professional development framework for lecturers [7].	This paper defines a framework of teachers' competencies in 6 domains and 11 subcompetencies: 1. Design and development of study plans, 2. Facilitation of learning, 3. Assessment for and of learning, 4. Holistic student development, 5. Dual professionals, and 6. Thoughtful professionals.
Competencies for Engineering faculty	Competencies and Performance of Engineering Professors: Evidence from a Brazilian Public University [8].	In this paper, three main competencies are identified: 1. Content/pedagogical knowledge. 2. Inspiring attitudes of innovation. 3. Emotional skills.
	Development and Validation of Evaluation Indicators for Teaching Competency in STEAM Education in Korea [9].	This paper defines seven areas for the evaluation of teacher competence in STEAM education: 1. Understanding of subjects, 2. Teaching-learning methods, 3. Inducing students to participate in learning, 4. Understanding of the students, 5. Learning environments and circumstances, 6. Evaluation of the students, and 7. Qualification.
	Faculty Competency Framework: Towards A Better Learning Profession [10].	This paper defines the competencies that an engineering teacher should have: 1. Complete understanding of the subject. 2.The use of appropriate pedagogical methods for meaningful learning, 3. Planning and executing an appropriate learning experience, 4. Identify the prerequisites and knowledge of the students, 5. Professional development and professionalism, and 6. Participate in active research.
	On professional and pedagogical competence development of technical university teaching staff [11].	This paper establishes a method for the development of professional and pedagogical competence: 1. A special component that includes: knowledge, skills, and the qualities necessary to teach a course; 2. a methodological component, which contains: knowledge, abilities, skills and qualities required for the effective training of students; 3. a sociological-psychological component, which includes knowledge, skills and qualities required for communication, motivation; 4. Self-psychological component, which provides the knowledge, skills and qualities necessary for self-diagnosis and self-improvement.
Competencies for Engineering faculty under CDIO Model	The CDIO Approach to University Faculty Advance Training for Research and Teaching Activities 12].	This paper classifies competences into the following areas: 1. Technique, 2. Pedagogical, 3. Social, 4. Psychological, 5. Ethics, 6. Didactics, 7. Evaluative, 8. Organizational, 9. Communicative, and 10. Reflective.
	Las competencias del profesorado en el entorno CDIO [4].	This paper proposes six actions to promote the development of generic competences in engineering related to: 1. Relevant experience in the industry, 2. Design of courses that develop CDIO skills, 3. Experience exchange activities with the industry, 4. Mentoring by professors with extensive professional experience, and 5. Seminars.

In order to choose the previous articles, a bibliographic review was carried out using the following selection criteria, considering that each article presents a study or research related to (1) the competences of faculty or (2) the competences of engineering faculty or (3) of the faculty competencies in the CDIO framework. In the initial search, 59 articles were identified in databases such as: ScienceDirect, SpringerLink, Publindex, CDIO Conference Proceedings, using the criteria described above. The articles found were reviewed and, by consensus among the researchers, 8 articles related to the topic were selected.

Conclusions and future work

This first step towards the development of a framework for the definition of engineering faculty competencies has shown that the identification of a standard set of competencies such as ABET (for student outcomes) does not exist in an explicit way for faculty.

Table 2. Classification of findings

Consolidated findings	Freq.	Classification
Skills in pedagogy / teaching methods - learning	6	Pedagogical
Skills in assessment and grading of learning outcomes	4	
Skills to design learning environments	3	
Self-reflection skills	3	
Communication skills	3	Generic
Innovation attitudes	2	
Planning and management skills	2	
Methodological Skills	1	
Emotional / interpersonal skills	5	
Ability to work in a team	1	
Complete understanding of the disciplinary area	3	Discipline based
Industry experience / career development	2	
Research skills	1	

The identified competencies in the eight papers listed in Table 1 are consolidated by frequency of appearance, tabulating the number of times each competence appears in the models proposed by the authors. The most frequent is the competence associated the pedagogy while the least frequent are associated with research and teamwork. In addition, these competencies can be grouped into three categories: pedagogical, generic and discipline based, as shown in Table 2.

The first category, pedagogical, is the most representative, followed by the generic and the discipline-based categories. This represents an opportunity for institutions to identify the relevant competencies according to their missions (teaching or research) and the standards that should be met in order to align faculty development and evaluation processes. The characterization of the current state of faculty competencies at the school of engineering is underway with the expectation that the proposed framework will be presented to the Dean by the end of 2021 in order to pilot deployment by the 2022 academic year.

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