Detecting which teaching competences should be reinforced in an engineering lecturer training program

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1. INTRODUCTION

In Catalonia (Spain), each university is required by law to offer lecturers a learning framework. This requirement is met by specialized centers: at our technical university, *Universitat Politècnica de Catalunya* (UPC) this center is the Institute for Education Sciences (ICE), to which the authors of this article belong. This institute offers training to both new and senior lecturers. This training is voluntary because no specific teacher training background is required for teaching at the university, other than knowledge of the subject to be taught.

UPC only offers degrees in architecture, mathematics and engineering. We do not have schools and departments of psychology or education, or a tradition of social science methods among our faculty. Our lecturers do have the technical competences required for teaching, but not necessarily the professional competences required for good teaching practice. This is particularly problematic in university of engineering studies, which traditionally have one of the highest dropout rates in higher education.

The opinions of lecturers on their own teaching depend on the students they have had, the subject they teach, their previous experience and the beliefs that guide their work [1]. These beliefs are consistent with and depend on the teaching style of each lecturer, so they are fairly stable and resistant to change. It is difficult for a lecturer to

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change her or his beliefs, particularly if they are intuitively reasonable [2]. For such a change to occur, the lecturer has to feel somewhat dissatisfied. In addition, the lecturer must be offered an intelligible and apparently useful alternative; and finally, the lecturer has to find a way to connect these new beliefs with their previous ones [3].

Lecturer training in Engineering has been studied in recent years (e.g. [4] [5]). The studies focus on the methods and tools required for quality teaching practice. However, a paradigm shift in learning is taking place. In the European Higher Education Area we are moving from content-based to competence-based learning ([6] [7] [8]). We therefore believe that lecturer training should also be based on competences such as communication capability, and syllabus planning and management. To this end, the eight public universities of Catalonia (Spain) decided to start a joint project to define which competences a lecturer should possess. These universities account for 149,116 out of the 169,418 university students in Catalonia (88%).

2. METHODOLOGY

First, a literature review on these competences was conducted. The initial results were discussed in a focus group composed of 64 lecturers representing all fields of knowledge. When the study had been validated, six professional competences that a university lecturer should have were identified: Interpersonal, Methodological, Communicative, Planning and Management, Teamwork, and Innovation competences (a description of each one can be found in Appendix 1). Each competence was subdivided into several indicators: e.g. “promoting confidence” for the Interpersonal competence, or “using non-verbal language“ for the Communicative one. A total of 49 such indicators were found for the six competences. They are listed in Appendix 2, Finally, the results were endorsed by a survey among university lecturers, who were asked about the importance they gave to each competence and indicator using a forced Likert scale as “not important” (1); “somewhat important” (2); “important” (3); or “very important” (4). The survey was validated using the judges method with a total of 54 experts, and as a result some items were modified or eliminated. The questionnaire was sent to all of the 15,209 lecturers working in the eight universities, and a total of 2,347 valid responses (15.43%) were received. At our university we received a total of 503 valid responses out of 2,522 lecturers (19.9%).

This study was of special interest for us, because the ICE is the institute responsible for lecturer training in our university. We were therefore interested in determining which competences were most poorly perceived as important by our teaching staff. Furthermore, we wanted to know if there were differences in these perceptions depending on the area of knowledge, as the final goal of our study is to adapt our lecturer training program to the actual needs of our lecturers. To that end, we need to know which competences and indicators are perceived as less important for each group of lecturers in order to reinforce our training program by focusing on them.

Therefore, our first question was: “Which competences and indicators are perceived as less important to our university lecturers?” We decided that we would consider a competence or indicator as perceived of less importance if more than 15% of lecturers rated it as “not important” or “somewhat important” (answers 1 and 2)

Our second question was: “Do lecturers from different fields of knowledge in engineering have a different perception of the importance of the different lecturer competences and indicators?” It is important for us to detect whether there are

differences between fields of knowledge in order to create an adaptive training program, reinforcing some points depending on the lecturers who join every course.

Statistical analysis was conducted with the statistical software IBM SPSS^R for Windows, version 19.

3. RESULTS

3.1 Competences perceived as less important

We first calculated how many lecturers, in percentage, perceived each of the six competences as less important. The results are shown in Table 1. The figures are divided between lecturers from UPC and lecturers from other universities. Also, lecturers from UPC are divided into their corresponding areas of knowledge. UPC has five broad areas of knowledge: Architecture; Industrial Engineering; Information and Communication Technologies Engineering (ICT); Sciences; and Civil Engineering. The sample from Civil Engineering was rather small (n=12), so it was eliminated from this study due to lack of significance. Also, 50 individuals from UPC failed to state their field of knowledge, so they are considered only in the UPC 'ALL' column.

Table 1. Lecturers' perception of the importance of each competence. Each cell contains the percentage of answers with values '1' or '2' in the survey.

Competence	**UPC**					**Non-UPC**
	Archi-tecture	**Industr. Eng.**	**ICT Eng.**	**Scien-ces**	**ALL**	
Interpersonal (IC)	6.91	4.45	3.81	1.08	3.57	3.21
Methodological (MC)	8.05	3.82	3.81	4.30	4.77	3.04
Communicative (CC)	1.15	1.28	3.81	4.30	2.58	1.74
Planning and Management (PMC)	12.64	5.09	4.76	4.30	5.55	4.61
Teamwork (TC)	17.24	18.47	2.86	9.68	15.08	12.26
Innovation (InnC)	11.50	10.19	13.33	13.98	11.71	10.15
Sample size (n)	*87*	*157*	*105*	*93*	*503*	*1844*

The results show that the percentage of lecturers who valued a competence as less important (answers 1-2) was always higher among UPC lecturers than among Non-UPC ones. Also, there are great differences in the results for the different fields of knowledge.

3.2 Significant differences between areas of knowledge

We compared these results with those of other universities, searching for significant differences. We performed a one-way ANOVA analysis and found significant statistical differences between the groups with all fields of knowledge within our university and lecturers from other universities ($F=5.12$, $p<0.05$) when comparing the percentage of answers between 1 and 2.

As a post-hoc multiple comparisons test, we performed a Games-Howell test, in which the groups have different sizes and equal variances are not assumed. The

results show ($p<0.05$) a significant difference in the perception of 14 items in at least one of the groups studied. The results are shown in Table 2.

Table 2. Percentage of answers (1-2) of lecturers from an area of knowledge of UPC that differ significantly ($p<0.05$) from those of lecturers from the other universities.

Indicator	UPC	Non-UPC	Indicator	UPC	Non-UPC
	Architecture			**ITC Engineering**	
IC1	6.9	13.62	MC6	7.6	23.93
IC5	9.2	15.46	MC9	14.3	19.86
MC1	8.1	5.32	MC11	20.05	15.03
MC3	6.9	23.93		**Industrial Engin.**	
TC3	11.5	16.5	IC	4.46	3.21
TC7	18.4	24.35	TC7	32.5	24.35
InnC5	13.8	16.51		**Sciences**	
			CC8	15.1	19.43
			MC11	13.9	15.03

Architecture is the area of knowledge in which most items were found. The results marked in red are those in which the percentage of lower values is higher for lecturers of other universities than for our lecturers.

3.3 Indicators with lower valuations by area of knowledge

We finally detail all the indicators that were valued lower for each area of knowledge, and we compare these figures with those of lecturers from other universities. Items with a percentage higher than 15% in UPC, the other universities, or both, are shown in Table 3. Percentages higher than 15% are in red.

Table 3. Percentage of indicators with low values, perceived as of little importance (percentage of answers 1 or 2 in the survey) by areas of knowledge.

Indi-cator	UPC	Non-UPC	Indi-cator	UPC	Non-UPC	Indi-cator	UPC	Non-UPC
Architecture								
IC6	17.24	13.62	PMC6	19.54	10.36	InnC2	20.69	13.13
IC7	20.69	15.46	TC	17.24	12.26	InnC3	21.84	18.41
MC7	26.44	23.93	TC1	19.54	16.12	InnC4	16.09	12.37
MC9	20.69	14.71	TC2	22.99	16.50	InnC6	27.59	23.11
MC10	20.69	19.86	TC4	17.24	14.27	InnC7	27.59	16.51
MC11	20.69	15.03	TC5	21.84	15.46	CC6	13,79	17,09

Indi-cator	UPC	Non-UPC	Indi-cator	UPC	Non-UPC	Indi-cator	UPC	Non-UPC
CC5	19.54	17.02	TC6	18.39	14.59	CC7	12,64	16,44
CC8	19.54	19.41	TC7	25.29	24.39			
Industrial Engineering								
IC6	19.11	13.62	CC6	21.02	17.09	TC6	19.11	14.58
IC7	17.83	15.46	CC7	21.02	16.45	TC7	34.40	24.36
MC2	15.29	8.03	CC8	16.67	19.43	InnC1	15.92	11.21
MC4	16.56	11.61	TC	18.47	12.26	InnC2	17.19	13.13
MC5	18.41	13.71	TC1	22.29	16.12	InnC3	17.83	18.41
MC7	25.48	23.93	TC2	21.01	16.5	InnC6	28.03	23.11
MC8	17.2	17.04	TC4	19.11	14.27	MC11	14,11	15,03
MC10	16.56	19.86	TC5	17.84	15.46	InnC7	14,01	16,51
CC5	18.47	17.20						
ICT Engineering								
IC7	18.1	15.47	CC5	19.05	17.2	TC6	17.1	14.53
MC4	17.14	11.61	CC6	23.81	17.05	InnC1	17.1	11.21
MC5	16.19	13.78	CC7	19.05	16.44	InnC2	16.2	13.13
MC7	24.76	23.92	CC8	21.9	19.43	InnC6	33.33	23.15
MC8	17.14	17.04	TC1	18.2	16.2	InnC7	21.91	16.51
MC10	29.52	19.86	TC2	15.23	16.5			
MC11	20	15.03	TC5	15.24	15.46			
Sciences								
IC3	15.05	10.31	CC7	15.06	16.44	InnC4	18.28	15.28
IC6	17.2	13.62	CC8	15.06	19.43	InnC6	27.96	23.17
MC5	18.28	13.78	TC1	15.06	16.12	InnC7	18.28	16.51
MC7	30.11	23.92	TC2	18.28	16.5	IC7	12,91	15,47
MC8	18.28	17.04	TC4	15.05	14.27	MC11	13,98	15,03
MC10	16.13	19.86	TC6	15.06	14.59	TC5	12,90	15,46
CC5	16.13	17.2	TC7	22.58	24.36			
CC6	19.35	17.06	InnC3	21.5	20.63			

4. DISCUSSION

We can observe in Table 1 that there are no great differences between the perception of the competences by lecturers of UPC and that of lecturers of the other universities. The results from Table 2 reinforce this idea: very few competences and indicators have a statistically significant difference. However, not all competences are perceived in the same way: Teamwork and Innovation are clearly worse evaluated than the others, so the first conclusion might be that these two competences are the ones that need to be reinforced, but a closer look at the numbers may change our mind.

When we separate lecturers by their field of knowledge, we can observe great differences in their perception. For instance, Teamwork, which is the most poorly rated competence, is highly rated by ICT engineers (more than 97% of answers are "important" or "very important"). Also, Architecture lecturers rated almost all competences more poorly than the other lecturers, except for Communicative competences, which show the highest value in the whole table. Therefore, a lecturer training program must be adapted to the field of knowledge if we wish to target and strengthen the weak points of our lecturers.

In Table 3, we can see that some competences and indicators are unanimously well valued. For instance, the Planning and Management competence and all its indicators are well valued by lecturers from almost all fields of knowledge. The Communicative competence yields some apparent contradictions, as it is the most highly rated but the lecturers rate some of its indicators poorly. Similar results are found for the Methodological competence.

If we further analyze the indicators that are highly (or poorly) rated by lecturers from all fields of knowledge, we can observe some patterns: the indicators perceived as less important are the ones that change the traditional lecturer-student relationship. Lecturers give more importance to the scenarios in which they are the protagonists rather than those in which students have more responsibility and prominence. For instance, MC5 ("Apply different didactic strategies to improve communication between lecturers and students and between students"), MC8 ("Use new technologies critically and imaginatively to create learning situations and contexts that strengthen student autonomy"), MC 10 ("Use different formative assessment strategies") or CC5("Create spaces where students can freely express their opinions on the subject, the teaching or the learning process; gather this information and provide a response") are all poorly rated by lecturers from almost all fields of knowledge, whereas CC2 ("Explain with clarity and enthusiasm") is one of the best valued items.

The most poorly rated competence is Teamwork. It appears that a significant number of lecturers consider that teaching is an individual activity rather than a team-based one. Innovation competence is the second most poorly rated competence, in particular indicators InnC2, InnC3, InnC6 and InnC7. If we analyze what these indicators have in common, we observe that they promote activities outside the classroom (such as revising the learning-teaching process, defining the aim of the innovation, participating in innovation projects or transferring innovation results), while indicators concerning activities in the classroom (analyzing context, adapting and introducing innovations in class) are more highly rated.

There are also differences in the perception of indicators by lecturers from different fields of knowledge. Architecture lecturers are among those with the most extreme views: some of the best- and worst-rated items belong to this group. Communicative

competence is of extreme importance for them, and the indicators CC6 and CC7 ("Express thoughts and sentiments", and "Regulate the voice, intonation, emphasis and breathing for clear verbal expression", respectively) are well valued by those lecturers. However, the same indicators are poorly rated by lecturers from the other three fields of knowledge and also by lecturers from the other universities. Another example is MC11 ("Provide continuous feedback to stimulate student learning and autonomy"). This indicator is poorly valued by lecturers from other universities and architecture and ICT engineering lecturers, and better valued by lecturers from industrial engineering and sciences. In the case of ICT and sciences, the difference is statistically significant ($p<0.05$): they were poorly valued in the former and highly valued in the latter.

Therefore, we conclude that some indicators must be reinforced in an engineering lecturer training program for all lecturers that enroll in the program. However, this reinforcement must also be adaptive, depending on the field of knowledge of the lecturers.

Our training program is based on the above competences [9]. As elements for redesigning our training program in light of this research, the program will focus on raising awareness of the importance of competences that have been poorly rated in general. To achieve this, first all teachers of the program must be aware of these results, in order to reinforce the elements that are worse valuated. Also, as many of these items are related to an active role of the lecturer, we will incorporate training modules for making lecturers act outside their comfort zone to improve their performance and communication skills.

To adapt the program to the field of knowledge of the lecturers, our first idea was to divide trainees from different areas of knowledge into different groups, and to focus each course according to the people enrolled. However, we decided that it was better to have mixed groups but to change the way the trainees work together: we had observed that, in a group with people from different fields of knowledge, participants tend to group with people from the same field because they have common interests and find it easy to work together. We wanted to change this behavior and force them to work with people from different areas of knowledge. They start by discussing why they think some competences are perceived as more (or less) important in their field. Then, they design activities in which they must work on specific problems, thinking within their academic environment but also within that of their group mates. These changes will be incorporated in our training program in September 2016.

Before concluding, we would like to point out that this study is subject to some limitations: it is restricted to state universities in Catalonia (Spain) and the sample, however large, is neither random nor stratified. Nevertheless, we believe that the results can be extrapolated to other universities. Finally, we wish to remark that we found no statistically significant differences in mean ratings when lecturers were grouped according to gender or age, although—in contrast to the current percentage of women lecturers belonging to the universities studied—a higher percentage of women than men responded to the survey.

5. SUMMARY AND ACKNOWLEDGMENTS

We have presented a study on perceptions of teaching competences in higher education expressed by lecturers from a technical university. We have analyzed the results in order to determine whether lecturers from different fields of knowledge perceive these competences differently, and we have compared these results with those of other universities in the same geographical area.

As a result of our study, we have identified the competences and indicators that are significantly worse rated by our lecturers depending on their field of knowledge, so we are now able to introduce appropriate measures into our lecturer training program and to focus our pedagogical approach on raising the awareness of these lecturers of the real importance of these competences. As a future work, we intend to extend the study to a wider population and to further study the reasons why some items are perceived as less important, and what actions may be taken to improve those perceptions.

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APPENDIX 1: Description of the six competences

Interpersonal competence (IC): Know-how to help students to develop critical thinking, motivation, confidence, and the recognition of diversity and individual

needs. All this must be accomplished by creating a climate of empathy and ethical commitment that includes ethics in the professional practice as well as interaction with other individuals or groups.

Methodological competence (MC): Knowledge of the modern methods and strategies of teaching and learning, and awareness of different learning models. Lecturers must encourage and enhance learning as well as the development of personal and professional competences through the application of appropriate methodological strategies and evaluation, in accordance with the educational context and situation.

Communicative competence (CC): Lecturers should develop communication processes in an appropriate and efficient way, which means reception, performance, production and transmission of messages through various media channels and contextualized in a teaching-learning situation. These channels include face-to-face interaction as well as written documents or new media such as videos, interactive tools and social media software.

Planning and management competence (PMC): Know-how to design, guide and develop content, training and evaluation so that the results are measured and suggestions for improvement are made. Participation in interdisciplinary teams in a coordinated manner, in order to lead and/or assist in training and evaluation activities, generate new ideas and manage educational projects, with adaptation to new situations and needs according to the objectives and resources available.

Teamwork competence (TC): this competence is not about lecturers leading a group of students working together, but rather the ability of lecturers to collaborate and participate as a member of a group. It is about taking on responsibilities and commitments according to the common objectives, agreed procedures and consideration of the available resources.

Innovation competence (InnC): Know-how to create and apply new knowledge, perspectives, methodologies and resources in the different dimensions of teaching. A critical approach to one's own beliefs and methods, seeking new activities and strategies or quality criteria, all aimed at improving the quality of the teaching-learning process.

APPENDIX 2: List of indicators by competence

IC: Interpersonal Competence
IC1: Show an ethical commitment to education and the profession.
IC2: Develop reflexive and critical thinking.
IC3: Inspire trust and confidence in negotiations with others.
IC4: Show tolerance toward other points of view and behavior that do not damage people or society.
IC5: Create a climate of empathy (empathy understood as putting oneself in someone else's shoes, understanding their point of view).
IC6: Identify individual needs.
IC7: Respect cultural diversity.
IC8: Promote self-confidence.
IC9: Encourage motivation.

MC: Methodological Competence.
MC1: Use methodological strategies that stimulate student participation.

MC2: Apply methodological strategies that promote a sense of student responsibility for their own learning and that of their classmates.
MC3: Ensure consistency between outcomes, teaching/learning methods and assessment processes.
MC4: Design and develop teaching/learning activities and resources according to student characteristics, the subject and the learning context.
MC5: Apply different didactic strategies to improve communication between lecturers and students and between students.
MC6: Plan practical activities that encourage self-learning and the development of personal and professional skills.
MC7: Use new technologies critically and imaginatively to create learning situations and contexts that strengthen student autonomy.
MC8: Use new technologies selectively as a platform and medium for the development and improvement of the teaching/learning process.
MC9: Select and learn to use the new technologies belonging to one's field of knowledge.
MC10: Use different formative assessment strategies.
MC11: Provide continuous feedback to stimulate student learning and autonomy.

CC: Communication Competence
CC1: Structure discussion according to context, message and target audience.
CC2: Explain with clarity and enthusiasm.
CC3: Use definitions, examples and alternative explanations to facilitate understanding of the topic.
CC4: Identify communication barriers in the didactic context and plan strategies to facilitate good communication to students.
CC5: Create spaces where students can freely express their opinions on the subject, the teaching or the learning process; gather this information and provide a response.
CC6: Express thoughts, feelings and emotions clearly and confidently in order to facilitate understanding of what one wishes to convey; show respect for others.
CC7: Regulate the voice, intonation, emphasis and breathing for clear verbal expression.
CC8: Use body language as appropriate.
CC9: Listen carefully to understand others' point of view.

PMC: Planning and Management Competence
PMC1: Plan, manage and ensure teaching/learning processes according to established outcomes.
PMC2: Select and define the syllabus according to the relevance to curricula and professions.
PMC3: Plan and manage student training activities that facilitate learning and acquisition of competences.
PMC4: Design and manage assessment processes.
PMC5: Use follow-up tasks and resources to assess fulfillment of outcomes.
PMC6: Assess implementation of the program regarding learning and acquisition of competences; detect weaknesses and introduce improvements to ensure achievement of outcomes.

TC: Teamwork Competence
TC1: Direct, manage and/or coordinate teaching teams vertically and/or

horizontally.
TC2: Delegate and/or distribute tasks according to levels of competence within the group.
TC3: Carry out tasks effectively in order to fulfill the outcomes established by the team.
TC4: Act for the good of the team.
TC5: Facilitate adaptation of the team in changing situations.
TC6: Follow up tasks and activities undertaken by the group and introduce the changes required to achieve outcomes.
TC7: Assess cost-benefit balance in the work conducted by the team.

InnC: Innovation Competence
InnC1: Analyze the teaching/learning context to identify areas for improvement and apply innovative strategies and/or resources.
InnC2. Revise teaching/learning processes to seek new strategies for improving these processes.
InnC3. Define precisely the aim of the innovation to be undertaken.
InnC4. Adapt innovations to the characteristics and peculiarities of each context.
InnC5. Introduce innovations whose aim is to improve the teaching/learning process.
InnC6. Participate actively in projects and experiences of educational innovation.
InnC7. Evaluate and transfer innovation results and experiences to the teaching/learning context for improvement of educational quality.