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Students' And Lecturers' Perceptions On The Importance, Training, And Assessment Of Engineering And Lifelong Learning Competencies

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STUDENTS' AND LECTURERS' PERCEPTIONS ON THE IMPORTANCE, TRAINING, AND ASSESSMENT OF PROFESSIONAL AND LIFELONG LEARNING COMPETENCIES

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ABSTRACT

Professional competencies and lifelong learning (LLL) are essential components for success in the engineering profession. Whilst engineering education has primarily focused on providing students with the required technical engineering competencies, new visions emphasise the importance of LLL and point towards the need for acquiring the necessary competencies for LLL during their study programme. The importance of professional and LLL competencies is clear, but what are the views of the engineering students and lecturers? In this study, a comparison is made between students' and lecturers' perceptions on professional and LLL competencies. The survey focuses on three aspects: (1) how important are the different competencies in engineering practice, (2) to what extent are they taught within the curriculum, and (3) to what extent are they assessed? In addition, lecturers were also asked to declare to what extent they possess the different professional and LLL competencies themselves. When looking at the top five competencies regarding perceived importance, extent of teaching, and extent of assessment, there are great similarities between students and lecturers. However, clear significant differences do emerge when comparing perceived importance, extent of teaching, and extent of assessment. These findings may be of interest to engineering programmes when evaluating, adapting or completely re-inventing the curriculum.

1 INTRODUCTION

1.1 The need for professional and lifelong learning competencies

In addition to technical competencies, engineering graduates today are expected to develop strong professional or non-technical engineering competencies. These engineering competencies include problem-solving skills, communication and teamwork, project management, and professional ethics (Khoo et al., 2020). New visions also emphasise the importance of lifelong learning (LLL) and point towards the need for acquiring the necessary competencies for LLL during their study programme (Zheng et al., 2017).

Employers, however, indicate that engineering graduates obtain an insufficient level of professional and lifelong learning competencies when they graduate (Markes,

2006). This raises the question as to how students and lecturers perceive these competencies. In this study, a comparison is made between student' and lecturers' perceptions of professional and LLL competencies. Before explaining the methodology, it is worth defining what is meant by professional and LLL competencies.

1.2 Defining professional and lifelong learning competencies

In line with the OECD's Learning Framework 2030 (2018), a competency is defined as a combination of knowledge, skills and attitudes.

To define professional and lifelong learning competencies, two studies, focusing on engineers, were used. Firstly, a large-scale study conducted by ASEE (American Society for Engineering Education) (2018) resulted in a framework with the required competencies for engineers. Three key groups of competencies were identified as:

- Intrapersonal Competencies: Self-Directed learning, Lifelong learning, Intellectual, Innovative, Critical Thinking, Ethical, and Conscientiousness
- Engineering Competencies: Technical/Analytical, Scientific, Mathematical, and Innovative/Creative/Design Thinking
- Interpersonal Competencies: Communication, Teamwork, Leadership, Project Management, and Social Intercultural

Secondly, a systematic literature review by (Cruz et al., 2020), focusing on engineering education, concluded that the following five lifelong learning competencies can be defined:

- Self-reflection
- Locating and scrutinising information
- Willingness, motivation and curiosity to learn
- Creating a learning plan
- Self-monitoring

2 METHODOLOGY

2.1 Sample and procedure

Data was gathered from engineering students and lecturers. As part of the [Project Acronym] project, the survey was administered to students from different study programmes at three European institutions. Students were invited through electronic messages (email, message in LMS) or live encounters (lectures, lecture breaks). in the first weeks of the second semester to fill in an online questionnaire. Lecturers were invited via mail and the link was widely spread in the three institutions and in the SEFI network. A total of 99 students and 22 lecturers responded. Participation was voluntary and free of compensation. Ethical permission was granted by the university's Social and Societal Ethics Committee (G-2022-5292-R2(MAR)).

2.2 Questionnaire

Survey respondents were asked to indicate their perceptions, via a four-point Likert scale, on the following questions:

(1) How important do you think these competencies are in engineering practice? (1 = Not important, 2= Somewhat important, 3= Important, 4= Very important or I don't know).
(2) To what extent are these competencies taught in your engineering curriculum? (1= Not taught at all, 2= Somewhat taught, 3= Taught, 4= Exhaustively taught or I don't know)
(3) To what extent are these competencies assessed in your engineering curriculum? (1= Not assessed, 2= Somewhat assessed, 3= Assessed, 4= Exhaustively assessed, NA or I don't know)
(4) Only for lecturers: How confident are you in your own ability in the following competencies? (1= Not confident at all, 2= Somewhat confident, 3= Confident, 4= Very confident or I don't know).

In order to avoid survey fatigue, it was determined that providing a list of 19 competencies (i.e., each competence noted individually) would be too onerous on survey respondents. Therefore, some competencies (i.e., self-directed & lifelong learning and leadership & project management) were paired together and 'Engineering Competencies' were omitted since these are outside the scope of this study.

2.3 Analysis

The data was analysed to compare (1) the perceived importance, extent of teaching, extent of assessment, and competency level of a range of competencies, and (2) the perceptions of lecturers and students.

For the first part of the analysis, a Friedman test is applied. The data was arranged in a long data format to analyse the data using a repeated measures procedure. In this procedure each competency is measured multiple times with a different question, namely importance, taught, assessed and for lecturers also the competency level. For each competency it is tested if there is at least one significant difference between the questions. If the Friedman test is significant ($p < .05$), pairwise comparisons are tested to determine which questions differ significantly ($p < .05$) using the Wilcoxon signed-rank test. For the second part of the analysis, Welsch tests are used to determine significant ($p < .05$) differences between lecturers and students.

3 RESULTS

3.1 Students' perceptions

Students' perceptions are included in Table 1. A mean score for perceived importance, extent of teaching, and extent of assessment is calculated for each of the different professional and lifelong learning competencies, as defined in the introduction. The table also presents the results of the pairwise comparisons. Interpretation and discussion of the results is included in the next section.

*Table 1. Students' perceptions - Mean scores are between 0 and 4. Significant differences are marked with *(p<.05), **(p<.01), ***(p<.001), ****(p<.0001)*

Students' perceptions	M			Δ		
	Importance	Taught	Assessed	ΔImp. – Tau.	ΔImp. – Ass.	ΔTau. – Ass.

Self-directed and lifelong learning	3.13	2.37	2.02	0.76****	1.11****	0.35**
Intellectual, innovative and critical thinking	3.75	2.81	2.74	0.94****	1.01****	0.07
Ethical thinking	2.82	2.49	2.23	0.33*	0.59***	0.26*
Conscientiousness	3.36	2.31	2.09	1.05****	1.27****	0.22
Communication	3.53	2.72	2.74	0.81****	0.79****	-0.02
Teamwork	3.45	2.88	2.85	0.57****	0.60****	0.03
Leadership and project management	3.29	2.47	2.46	0.82****	0.83****	0.01
Social and intercultural thinking	2.73	2.17	1.84	0.56****	0.89****	0.33***
Self-reflection	2.99	2.74	2.49	0.25	0.50***	0.25*
Locating and scrutinizing information	3.25	2.74	2.69	0.51****	0.56****	0.05
Willingness, motivation and curiosity to learn	3.31	2.17	1.99	1.14****	1.32****	0.18*
Creating a learning plan	2.71	2.13	1.86	0.58****	0.85****	0.27*
Self-monitoring	2.98	2.41	2.06	0.57****	0.92****	0.35**

3.2 Lecturers' perceptions

Table 2 presents the results of the lecturers' perceptions. A mean score for perceived importance, extent of teaching, extent of assessment, and own perceived competency is calculated for each of the different professional and lifelong learning competencies. The table also presents the results of the pairwise comparisons. Interpretation and discussion of the results is included in the next section.

*Table 2. Lecturers' perceptions - Mean scores are between 0 and 4. Significant differences are marked with *(p<.05), **(p<.01), ***(p<.001), ****(p<.0001)*

Lecturers' perceptions	M				Δ			
	Importance	Taught	Assessed	Competency	ΔImp. – Tau.	ΔImp. – Ass.	ΔTau. – Ass.	ΔImp. – Com.
Self-directed and lifelong learning	3.86	2.63	1.80	3.25	1.23***	2.06**	0.83*	0.61
Intellectual, innovative and critical thinking	3.95	2.95	2.53	3.19	1.00***	1.42**	0.42	0.76*
Ethical thinking	3.50	2.24	1.80	2.75	1.26**	1.70**	0.44	0.75
Conscientiousness	3.55	2.59	1.93	3.44	0.96**	1.62**	0.66	0.11
Communication	3.64	2.95	3.13	3.13	0.69*	0.51	-0.18	0.51
Teamwork	3.59	2.95	2.75	2.88	0.64*	0.84*	0.20	0.71
Leadership and project management	3.32	2.57	2.25	2.81	0.75*	1.07*	0.32	0.51
Social and intercultural thinking	2.86	1.90	1.54	2.44	0.96*	1.32*	0.36	0.42
Self-reflection	3.18	2.43	1.71	2.94	0.75	1.47**	0.72	0.24

Locating and scrutinizing information	3.55	2.95	2.73	3.25	0.60*	0.82*	0.22	0.3
Willingness, motivation and curiosity to learn	3.48	2.50	1.79	3.44	0.98*	1.69**	0.71	0.04
Creating a learning plan	2.67	1.80	1.36	2.53	0.87*	1.31*	0.44	0.14
Self-monitoring	3.09	2.19	1.60	2.87	0.90**	1.49**	0.59	0.22

3.3 Comparison between students' and lecturers' perceptions

For the comparison between students' and lecturers' perceptions only the significant results are included here, since all the mean scores and differences are presented in Table 1 and Table 2. For the professional competencies (1) self-directed and lifelong learning ($p<.0001$), (2) intellectual, innovative, and critical thinking ($p<.01$), and (3) ethical thinking ($p<.0001$), lecturers indicate a significant higher importance in comparison with the students. For the lifelong learning competencies (1) self-reflection ($p<.001$) and (2) creating a learning plan ($p<.05$), students indicate a significant higher presence of assessment in the curriculum.

4 DISCUSSION

4.1 Perceived importance

The professional competency *Intellectual, innovative and critical thinking* is ranked as the most important by both lecturers and students. For lecturers this is followed by *self-directed and lifelong learning, communication, teamwork, conscientiousness, and locating and scrutinizing information*. For students, the top five further consists of *communication, teamwork, conscientiousness, and willingness, motivation, and curiosity to learn*. Both communication and teamwork are also ranked as highly important competencies in two review studies focusing on engineering (Male, 2010; Cruz et al., 2020). The most recent study, (Cruz et al., 2020), also found a third important competency namely lifelong learning. The perceptions towards LLL seem different since the lecturers emphasise the importance of LLL in general, whereas the students seem to value especially the attitudinal aspect of LLL, namely willingness, motivation, and curiosity to learn. For the professional competencies (1) self-directed and lifelong learning ($p<.0001$), (2) intellectual, innovative, and critical thinking ($p<.01$), and (3) ethical thinking ($p<.0001$), lecturers indicate a significant higher importance in comparison with the students.

4.2 Extent of teaching and assessment

According to the perceptions of the lecturers, the top five competencies that are taught the most are the same competencies as the ones that are perceived as the most important ones: *intellectual, innovative and critical thinking, communication, teamwork, locating and scrutinizing information, and self-directed and lifelong learning.* The students ranked the competencies in a different order, but there is much

similarity with the lecturers. The students' top five comprises: *teamwork, intellectual, innovative and critical thinking, locating and scrutinizing information, self-reflection, and communication*. Students thus selected self-reflection, which is a sub competency of lifelong learning. It could be that the lecturers' intentions to teach self-directed and lifelong learning are in fact often realized in teaching self-reflection. Lecturers perhaps view LLL in a more general and abstract level, whereas students focus on its more concrete and practical aspects.

In the assessment top five of lecturers, three interpersonal competencies are included: *communication, teamwork, leadership and project management*. The top five is further completed by *locating and scrutinizing information and intellectual, innovative and critical thinking.* Students' assessment top five consists of *teamwork, intellectual, innovative and critical thinking, communication, locating and scrutinizing information, self-reflection.* With engineering curricula becoming more student-centred to prepare students for the existing societal challenges (Hadgraft & Kolmos, 2020), assessment of the competencies mentioned above can be linked to teaching methods such as problem or project-based learning (Boelt et al., 2022; Ríos et al., 2010).

For the lifelong learning competencies (1) self-reflection ($p<.001$) and (2) creating a learning plan ($p<.05$), students indicate a significant higher presence of assessment in the curriculum compared with the views of lecturers.

4.3 Differences between importance, teaching, and assessment

For both students and lecturers, the importance of almost each competency in engineering practice is estimated to be higher than the extent to which they are taught. This is in line with the findings of (Nesterova, 2019) who stated that teaching staff recognize the importance of lifelong learning competencies, but do not consider them as primary teaching goals. Only *self-reflection* is estimated by both lecturers and students to be equally important as the extent to which it is taught and assessed. The difference between the importance in engineering practice and the extent to which it is assessed for *communication* is also not significant for lecturers.

Differences between the amount a competency is taught or assessed are limited. When a significant effect is detected, the extent to which the competency is taught is larger than the extent to which it is assessed. Students indicated this difference for *(1) self-directed and lifelong learning, (2) social and intercultural thinking, (3) willingness, motivation and curiosity to learn, (4) creating a learning plan, and (5) self-monitoring*. This includes four out of five lifelong learning competencies as well as the overarching lifelong learning competency. For lecturers this difference was only found for *self-directed and lifelong learning*.

The general trend for each competency is that the mean score is the highest for importance, followed by the extent of teaching, and the lowest mean score is for the extent of assessment. This raises the question whether this is due to the Likert scale used (e.g. very important is perhaps not exactly compatible with exhaustively assessed), or because there is indeed less assessment of the professional and lifelong

learning competencies, which may be reinforced by the fact that it is difficult to assess some of these competencies (Zlatkin-Troitschanskaia et al., 2015).

Studies show that in order for students to develop these competencies, it is important to give explicit attention to them (Murdoch-Eaton & Whittle, 2012; Qanbari Qalehsari et al., 2017). Consequently, explicit training and assessment will also be important. It might also be beneficial to do the explicit talking, training, and assessment of LLL competencies in as practical terms as possible and breaking it down to the level of LLL sub-competencies. Since merely talking in the level of LLL may not give students enough to relate to the concept and hence it may remain too vague and abstract to really receive attention and effort.

5 SUMMARY AND ACKNOWLEDGMENTS

Professional competencies and lifelong learning (LLL) are essential components for success in the engineering profession. In this study, a comparison was made between student' and lecturers' perceptions on professional and LLL competencies. When looking at the top five competencies regarding perceived importance, extent of teaching, and extent of assessment, there are great similarities between students and lecturers. However, clear significant differences do emerge when comparing perceived importance, extent of teaching, and extent of assessment. These findings may be of interest to engineering programmes when evaluating, adapting or completely re-inventing the curriculum. If programmes emphasize the importance of the professional and lifelong learning competencies, it will be important to explicitly mention, train, and assess them.

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