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The Development of Skills in the ICT Sector: Analysis of Engineering Students' Perceptions about Transversal Skills*

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When starting a career, many engineering graduates possess the necessary technical knowledge but present serious behavioural mismatches. The lack of transversal skills, such as working well in teams and successful time management, can represent an important handicap in their careers and the resulting limitations can significantly impair their capability to undertake the roles that companies expect from them. In the present study, 297 ICT engineering undergraduate and post-graduation students were surveyed about their perceptions about their proficiency in and the importance of transversal skills. Findings showed that students rated more highly the importance of transversal skills than their own perceived proficiency in those same skills; post-graduation students (Bologna second cycle) perceived themselves as being more proficient in the vast majority of the transversal skills analysed, and revealed less skills' gaps in comparison with undergraduate students (Bologna first cycle). The results also showed that, in comparison with companies' representatives, students tend to value the generality of transversal skills, suggesting that students are aware of the importance of transversal skills for their future professional roles, but lack a differentiated vision about these skills. These results emphasize the need to invest in initiatives to promote the development of transversal skills during the students' university studies and also alert to the importance of a regular interaction between education systems and companies.

Keywords: transversal skills; ICT engineering; undergraduate students

1. Introduction

The ICT (Information and Communications Technology) sector faces continuous challenges arising from the technological, economic and organizational transformations that took place over the last decades. To adapt to these transformations, companies demand engineer professionals who are equipped not only with relevant technical skills, in order to respond to the immediate needs and the sector's tendencies, but also with a set of professional skills more related with personal and relational attributes. Engineering problems are not only resolved with technical skills. Graduate students are being recruited not only by their academic and technical preparation but more by "their ability to identify non-technical aspects of problems, the interaction between these aspects and possible solutions" [1, p.283].

Transversal skills are transferable behaviours that can be used within a wide range of functions, activities and contexts. Unlike technical skills, transversal skills, also called professional skills, can be applied on a long-term basis, since they are less prone to be affected by technological changes. Due to the competitive advantage they provide, it is increasingly important to master these skills together with the hard or technical skills in professional engineering contexts [2]. This importance is mentioned by engineering accreditation organisms [3], referring that engineering programs must provide outcomes related, for example, with the ability to communicate effectively and to engage in lifelong learning.

In recent years, companies frequently point out difficulties in finding graduate engineers equipped with the skills required by this new professional environment. An integrated vision of the ICT sector, a sound scientific background, and an ability to cope with technological and organizational changes, are some of the most frequent weaknesses indicated by employers. In fact, Higher Education engineering programs provide opportunities for technical knowledge acquisition and skills development, offering students a good preparation to succeed as competent professional engineers. However, engineering *curricula* emphasise technical skills, which are easier to teach and evaluate in comparison with transversal skills and, generally, do not offer many opportunities to prepare students about equally important non-technical aspects of their profession. These education shortcomings are

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particularly felt in relation to skills such as planning, organization and inter-personal communication, which are fundamental to work within a team [4]. In addition, it is also frequent that during their studies, students develop very little awareness about the professional world, its specificities and demands. As a result, when starting a career, many engineering graduates present professional mismatches and limited knowledge about the activity sectors and businesses where they become involved. These circumstances can represent an important handicap in the development of their careers, resulting in limitations of their capability to undertake the roles that companies expect from them.

In line with this, there is a consensus in engineering education literature that highlights the urgency to help students acquire a broad range of transversal skills. To promote skill development it is necessary to identify these skills and guarantee that students understand their relevance to their professional future [5]. Several studies have already tried to understand students' perceptions of the importance of transversal skills in a work context [6–7], but literature comparing students' perceptions with companies' perceptions is scarce.

European universities are engaged in the Bologna process that restructured higher education degrees. In most European countries, a three-year first cycle (bachelor's degree) is a technology or pre-engineering degree, that can be followed by a two-year second cycle (master's degree), which is considered the professional engineering degree [2]. This study aims to understand students' perceptions about the importance of transversal skills for their future careers and their own perceived proficiency in those same skills, and to identify potential differences between study cycles.

2. Method

2.1 Participants

A sample of 297 undergraduate and post-graduation engineering students, 256 males and 41 females, of four Portuguese public universities participated in the study. The ages of the participants ranged from 18 to 38 years (M = 22.18, SD = 3.043). 91.20% of the participants were full-time students (N = 271). One hundred and forty students were attending first cycle studies, and 157 students were attending second cycle studies.

Students were enrolled in Telecommunications and Electronics Engineering, and Computers and Telematics (55.90%); Informatics, Computation, and Electronics (12.80%); Electronics and Computers (9.40%); Industrial Electronics and Engineering of Communications (20.60%), other related courses (1.30%).

Twenty companies' representatives (ICT operators and suppliers) rated the importance of transversal skills for their business activities.

2.2 Instrument and methodology

A list of 29 transversal skills was conceived based on literature and on findings of several studies [8–9]. This is not an exhaustive list, but it covers the most common transversal skills that engineering employers expect students to possess [10]. Using a 5 point Likert scale (1 meaning a minimum importance, and 5 a maximum importance), participants were asked to self-evaluate their proficiency in the skills at the present moment (Proficiency—P), and to rate the importance of the same skills for future employment (Importance—I).

The research questions addressed in this study were: (1) how do students rate their proficiency in a range of transversal skills, at the present moment?; (2) how do they rate the importance of the same transversal skills for future employment?; (3) in which transversal skills do students indicate significant gaps?; (4) how is the importance of the skills related to the perceived proficiency in these skills?; (5) what is the difference (or not) between students' perceptions of transversal skills in relation to their study cycle; and (6) how different are the perceptions of the importance of transversal skills held by students and companies' representatives.

3. Results

Histograms of the ratings for skills showed that the data was not normally distributed. The participants, in particular the students, used the upper end of the scale. As skills have been measured on an ordinal scale and do not meet the distributional assumptions of parametric statistics, nonparametric tests were used to analyse data [11–12]. Mean scores for skills analysis were used in different studies [6]. Table 1 shows students' mean rates in relation to their self-assessed proficiency in transversal skills and their importance for future work. It also presents the skills' gaps. Mean ratings for all skills were above the middle of a five-point scale. Regarding skills' proficiency, higher ratings were found for "responsibility" (14) (M = 4.18), "continuous learning" (26) (M = 4.11), "listening" (6) (M = 4.09) and "meeting deadlines" (17) (M = 4.01). Lower ratings were found for "time management" (11) (M = 3.45) and "creativity and innovation" (21) (M = 3.50).

Regarding skills' importance, students gave a higher importance to "meeting deadlines" (17) (M = 4.57), "time management" (11) (M = 4.45), "teamwork" (1) (M = 4.42), "responsibility" (14) (M = 4.41) and "work organization" (12)

Table 1. Skills' mean rates for current proficiency and importance for future work, skills' gaps, and correlations between skills' proficiency and importance

	Proficiency (P)		Importance (I)		Gaps	Correlation between P and I
Skill	**M (SD)**	**Mdn (IR)**	**M (SD)**	**Mdn (IR)**	**Wilcoxon**	**r_s**
1. Teamwork	3.89 (0.05)	4.00 (0)	4.42 (0.67)	5.00 (1)	–9.503*	0.396**
2. Oral communication	3.68 (0.89)	4.00 (1)	4.21 (0.80)	4.00 (1)	–7.950*	0.155**
3. Written communication	3.70 (0.77)	4.00 (1)	4.07 (0.74)	4.00 (1)	–6.160*	0.198**
4. Foreign languages	3.66 (0.88)	4.00 (1)	4.23 (0.74)	4.00 (1)	–8.413*	0.177**
5. Networking	3.71 (0.82)	4.00 (1)	4.18 (0.75)	4.00 (1)	–8.117*	0.392**
6. Listening	4.09 (0.78)	4.00 (1)	4.25 (0.75)	4.00 (1)	–3.031*	0.358**
7. Conflict resolution	3.77 (0.80)	4.00 (1)	4.14 (0.81)	4.00 (1)	–5.822*	0.186**
8. Argumentation	3.69 (0.77)	4.00 (1)	4.07 (0.75)	4.00 (1)	–6.205*	0.099
9. Information sharing	3.96 (0.83)	4.00 (2)	4.03 (0.78)	4.00 (1)	–1.147	0.262**
10. Intercultural relationships	3.91 (0.84)	4.00 (2)	3.83 (0.89)	4.00 (1)	–1.289	0.231**
11. Time management	3.45 (0.97)	3.00 (1)	4.45 (0.71)	5.00 (1)	–11.286*	0.065
12. Work organization	3.65 (0.89)	4.00 (1)	4.32 (0.89)	5.00 (1)	–8.424*	0.073
13. Autonomy	3.82 (0.83)	4.00 (1)	4.31 (0.73)	4.00 (1)	–7.693*	0.184**
14. Responsibility	4.18 (0.83)	4.00 (1)	4.41 (0.85)	5.00 (1)	–3.673*	0.249**
15. Goal orientation	3.84 (0.80)	4.00 (1)	4.10 (0.73)	4.00 (1)	–5.024*	0.340**
16. Pressure tolerance	3.68 (0.93)	4.00 (1)	4.15 (0.79)	4.00 (1)	–6.417*	0.138*
17. Meeting deadlines	4.01 (0.87)	4.00 (2)	4.57 (0.67)	5.00 (1)	–8.788*	0.224**
18. Problem solving	3.86 (0.70)	4.00 (1)	4.25 (0.77)	4.00 (1)	–7.311*	0.319**
19. Systemic vision	3.62 (0.81)	4.00 (1)	3.99 (0.74)	4.00 (0)	–6.907*	0.425**
20. Cost estimation	3.63 (0.95)	4.00 (1)	4.07 (0.83)	4.00 (1)	–6.636*	0.313**
21. Creativity and innovation	3.50 (0.89)	4.00 (1)	4.23 (0.73)	4.00 (1)	–10.456*	0.348**
22. Persuasion	3.65 (0.85)	4.00 (1)	3.94 (0.79)	4.00 (1)	–4.510*	0.254**
23. Adapting to change	3.76 (0.81)	4.00 (1)	4.20 (0.80)	4.00 (1)	–7.172*	0.265**
24. Proactivity and initiative	3.74 (0.83)	4.00 (1)	4.14 (0.76)	4.00 (1)	–6.372*	0.216**
25. Attention to detail	3.86 (0.85)	4.00 (1)	4.10 (0.73)	4.00 (1)	–4.322*	0.314**
26. Continuous learning	4.11 (0.70)	4.00 (1)	4.26 (0.76)	4.00 (1)	–2.958*	0.263**
27. Flexibility	3.98 (0.73)	4.00 (0)	4.18 (0.67)	4.00 (1)	–4.422*	0.372**
28. Decision-making	3.89 (0.85)	4.00 (1)	4.05 (0.81)	4.00 (1)	–2.746*	0.097
29. Leadership	3.67 (0.89)	4.00 (1)	4.07 (0.80)	4.00 (1)	–6.653*	0.277**

Notes: IR = interquartile range; * $p < 0.05$, ** $p < 0.01$.

(M = 4.32). The median of 5.00 was found for all of these skills. Students gave a lower importance to ''intercultural relationships'' (10) (M = 3.83), ''persuasion'' (22) (M = 3.94) and ''systemic vision'' (19) (M = 3.99). The mean importance ratings ranged from 3.83 (''intercultural relationships'') to 4.57 (''meeting deadlines''), showing that students consider that these general transversal skills possess a high importance for their professional practices.

As noted in previous studies [6, 13–14], students rated the importance of transversal skills more highly than their proficiency in the same skills, and this can be used as a measure of the skill's gap. Fig. 1 illustrates students' skills' ratings for proficiency and importance. A Wilcoxon signed-rank test was used to analyse medians. Significant differences were found between ratings of all skills, except for ''intercultural relationships'' (10) and ''information sharing'' (9). That is, students' ratings revealed gaps in 27 of the 29 skills analysed. The most evident gap was found for ''time management'' (11) ($Z = -11.286$, $p \cong 0$), however other 6 skills' gaps showed mean differences superior to 0.50, and these were: ''teamwork'' (1), ''oral communication'' (2), ''foreign languages'' (4), ''work organization'' (12), ''meeting deadlines'' (17) and ''creativity and innovation'' (21).

This study aimed to understand how the importance granted to the skills is related to the perceived proficiency in these skills. In the last column of Table 1, the Spearman coefficients are presented, for correlations between the same skills concerning proficiency and importance ratings. In general, the proficiency in the skills is positively correlated with the importance granted to them. That is, the higher the students rated themselves in what concerns proficiency, the higher the importance they attributed to the same skills. Only ''argumentation'', ''time management'', ''work organization'' and ''decision making'' present no significant values.

According to Hemphill [15], correlation coefficients higher than 0.30 should be considered as having large magnitude effects. Taking into account this view, ''systemic vision'' proficiency ratings are highly and positively correlated with importance ratings ($r = 0.425$, $p \approx 0$). Taking this data into consideration, positive and significant correlations were also found for ''teamwork'' ($r = 0.396$, $p < 0.01$), ''networking'' ($r = 0.392$, $p < 0.01$), ''listening'' ($r = 0.358$, $p < 0.01$), ''goal orientation'' ($r = 0.340$, $p < 0.01$), ''problem solving'' ($r = 0.319$,

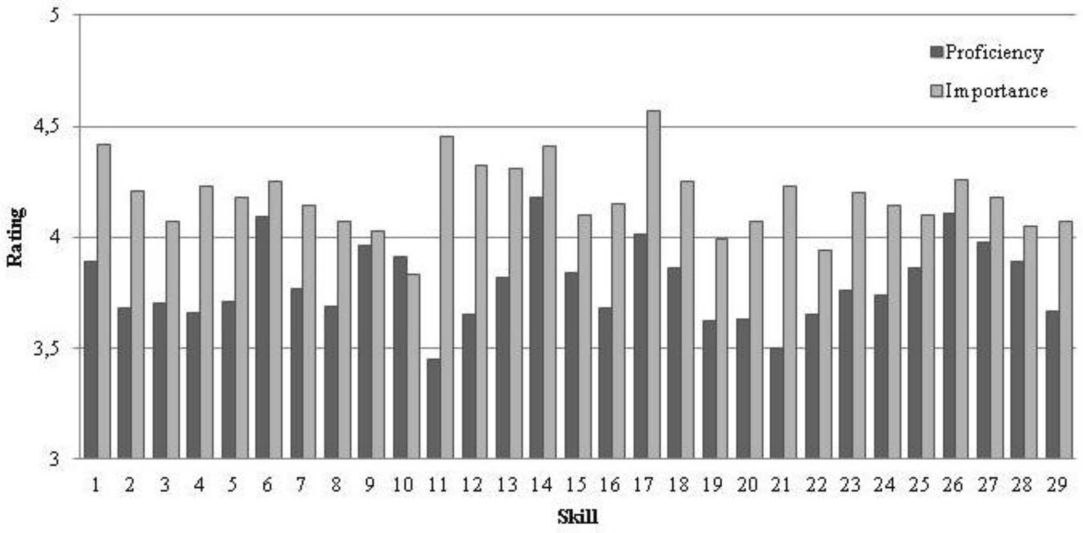

Fig. 1. Students' skills' ratings for proficiency and importance.

$p < 0.01$), "cost estimation" ($r = 0.313$, $p < 0.01$), "creativity and innovation" ($r = 0.348$, $p < 0.01$), "attention to detail" ($r = 0.314$, $p < 0.01$), and "flexibility" ($r = 0.372$, $p < 0.01$).

A Mann–Whitney test was used to analyse possible differences between first cycle and second cycle students' ratings. Concerning proficiency in the skills, results showed that second cycle students rated higher than first cycle students in 22 of the 29 skills. However, significant differences were only found in "flexibility" ($M_{1st} = 3.89$, $M_{2nd} = 4.06$, $U = 9460.500$, $p = 0.028$), and "proactivity and initiative" ($M_{1st} = 3.61$, $M_{2nd} = 3.86$, $U = 9429.500$, $p = 0.032$). This means that second cycle students consider themselves more proficient in those skills. Concerning the importance granted to skills, differences were found between study cycles, with higher ratings of first cycle students in 18 of the 29 skills. However, only a significant difference was found in "oral communication" ($M_{1st} = 4.35$, $M_{2nd} = 4.12$, $U = 9553.000$, $p = 0.036$). Thus, first cycle students attributed more importance to "oral communication" than second cycle students.

In the present study, the skills' gaps within study cycles were also analysed. It was found that first cycle students revealed gaps concerning all of the assessed skills except for "information sharing" and "intercultural relationships". Second cycle students revealed gaps in all of the skills except for "information sharing", "responsibility", "proactivity and initiative", and "flexibility". These results suggest that second cycle students are more able to work in group contexts and that could be explained by the curricular activities that these students experience in the development of their thesis projects.

Finally, the comparison of students' perceptions with representatives' perceptions about the importance of transversal skills showed significant differences in 20 skills (Table 2). Companies' representatives granted a higher importance to the following transversal skills, in comparison with students: "information sharing" (9), "time management" (11), "autonomy" (13), "responsibility" (14), "goal orientation" (15), "pressure tolerance" (16), and "meeting deadlines" (17).

4. Discussion and future developments

The results show that students perceived transversal skills as being valuable assets for their future careers, and tended to recognize that their proficiency in many of the required transversal skills was lower than the levels they reported as necessary in the labour market. The analysis of skills' gaps indicates that students need to improve their proficiency in transversal skills, particularly in what concerns "time management", "teamwork", "oral communication", "foreign languages", "work organization", "meeting deadlines" and "creativity and innovation". These skills could be promoted by collaborative learning strategies [1] with strong workgroup requirements, such as project-based learning initiatives [16].

Regarding study cycle differences, the second cycle students perceived themselves as more proficient compared to first cycle students, in the majority of the transversal skills analysed, most significantly in "flexibility" and "proactivity and innovation". These results can be explained by the fact that second cycle students have reported more

Table 2. Comparison of the perceptions about the importance of transversal skills between companies' representatives and students

	Representatives		Students		Gaps
Skill	**M (SD)**	**Mdn (IR)**	**M (SD)**	**Mdn (IR)**	**Wilcoxon**
1. Teamwork	4.35 (0.67)	4.00 (1)	4.42 (0.67)	5.00 (1)	–0.546
2. Oral communication	3.65 (0.81)	4.00 (1)	4.21 (0.80)	4.00 (1)	–3.040**
3. Written communication	4.70 (0.47)	5.00 (1)	4.07 (0.74)	4.00 (1)	–3.773**
4. Foreign languages	4.35 (0.67)	4.00 (1)	4.23 (0.74)	4.00 (1)	–0.569
5. Networking	3.30 (0.98)	3.00 (2)	4.18 (0.75)	4.00 (1)	–3.931**
6. Listening	4.20 (0.83)	4.00 (2)	4.25 (0.75)	4.00 (1)	–0.215
7. Conflict resolution	2.90 (0.64)	3.00 (1)	4.14 (0.81)	4.00 (1)	–5.446**
8. Argumentation	3.00 (0.73)	3.00 (0)	4.07 (0.75)	4.00 (1)	–5.446**
9. Information sharing	4.40 (0.88)	5.00 (1)	4.03 (0.78)	4.00 (1)	–2.412*
10. Intercultural relationships	3.15 (0.93)	3.00 (2)	3.83 (0.89)	4.00 (1)	–3.146**
11. Time management	4.80 (0.41)	5.00 (0)	4.45 (0.71)	5.00 (1)	–2.249*
12. Work organization	4.70 (0.57)	5.00 (1)	4.32 (0.89)	5.00 (1)	–1.882
13. Autonomy	4.95 (0.23)	5.00 (0)	4.31 (0.73)	4.00 (1)	–4.164**
14. Responsibility	5.00 (0.00)	5.00 (0)	4.41 (0.85)	5.00 (1)	–3.459**
15. Goal orientation	4.40 (0.75)	5.00 (1)	4.10 (0.73)	4.00 (1)	–1.749
16. Pressure tolerance	4.60 (0.68)	5.00 (1)	4.15 (0.79)	4.00 (1)	–2.662**
17. Meeting deadlines	4.80 (0.70)	5.00 (0)	4.57 (0.67)	5.00 (1)	–2.046*
18. Problem solving	3.70 (0.80)	4.00 (1)	4.25 (0.77)	4.00 (1)	–3.178**
19. Systemic vision	2.75 (0.55)	3.00 (1)	3.99 (0.74)	4.00 (0)	–6.338**
20. Cost estimation	3.30 (0.87)	3.00 (1)	4.07 (0.83)	4.00 (1)	–3.614**
21. Creativity and innovation	3.35 (0.59)	3.00 (1)	4.23 (0.73)	4.00 (1)	–5.037**
22. Persuasion	2.50 (0.69)	3.00 (1)	3.94 (0.79)	4.00 (1)	–6.378**
23. Adapting to change	4.05 (0.83)	4.00 (2)	4.20 (0.80)	4.00 (1)	–0.922
24. Proactivity and initiative	4.10 (0.79)	4.00 (2)	4.14 (0.76)	4.00 (1)	–0.283
25. Attention to detail	3.65 (0.81)	4.00 (1)	4.10 (0.73)	4.00 (1)	–2.467*
26. Continuous learning	4.20 (0.77)	4.00 (1)	4.26 (0.76)	4.00 (1)	–0.416
27. Flexibility	4.05 (0.51)	4.00 (0)	4.18 (0.67)	4.00 (1)	–1.011
28. Decision-making	3.60 (0.75)	4.00 (1)	4.05 (0.81)	4.00 (1)	–2.662*
29. Leadership	3.05 (0.76)	3.00 (0)	4.07 (0.80)	4.00 (1)	–5.229**

Notes: IR = interquartile range; * $p < 0.05$, ** $p < 0.01$.

experience in teamwork and project development during the years of their master thesis preparation, in comparison with first cycle students. In line with these findings, first cycle engineering programs should offer more opportunities for students' involvement in cooperative projects similar to those undertaken during second cycle studies.

In comparison with the companies' representatives, students valued the generality of the transversal skills. The companies' representatives presented a more differentiated perception of the importance of transversal skills for their business practices. Future research should take into account the evaluation of the teachers' perceptions.

This study was based on self-assessment data, and with this type of methodology, combined with a strong interaction with the companies of the sector, students become more aware of their potential individual strengths and weaknesses and can improve their skills' gaps and prepare themselves for companies' demands.

5. Conclusion

Engineering students need to become actively involved in the management of their own careers as early as possible in order to be prepared to face an extremely competitive context. Through assessment methodologies, awareness can be promoted among students about the importance of transversal skills for their future employment, and personal strategies can be found in order to overcome possible skills' gaps. Although not exhaustive, the studied transversal skills are important to every engineering career. Findings suggest that students identified deficiencies in the quality of skills they considered important for future work, and presented a less differentiated perception of the importance of transversal skills in comparison with companies' representatives. These results underline the importance of the identification of employers' needs and the incorporation of transversal skills into curriculum design and development.

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