Mind the gap: bridging the transversal and transferable skills chasm in a public engineering school

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***Abstract*—*Transversal and transferable skills are the single most important skill gap identified by employers of engineering graduates. This gap can be a very effective chasm in the early careers of otherwise competent graduates. In this paper we address the end-to-end implementation of a transversal and transferable skills training programme in an European public engineering school. The training addresses master and doctoral candidates. The needs assessment, the programme design, delivery and assessment are presented. Relevant stakeholders are involved throughout. They include employers, master and doctoral candidates, faculty, graduate course directors and teaching staff directly involved in the programme. The programme includes methodologies of self-evaluation and course evolution. It is found that the programme is perceived as very important by the trainees and that there is an increasing number of enrolled trainees. The challenges of a sustained delivery of such a growing programme are shortly addressed.*

Keywords— higher education; engineering education; transversal competencies; transferable skills

I. INTRODUCTION

Engineering programs and Schools worldwide have been required to promote the development of specific programme outcomes [1] or competencies, in order to prepare engineers for a myriad of career paths [2,3] to function in a globalized market labour, marked by a rapid and constant changing in cultural, economic, and social environment [4,5].

Such competencies don't relate, specifically, to the particular technical or scientific nature of the engineering field of the programs (hard skills); they are beyond disciplinary knowledge and concern mainly a range of generic, transversal skills. Concerning to the scope of these transversal competences, different frameworks seem to be consistent in agreeing that they are related to areas such as: communication and collaboration, social and/or cultural awareness, creativity, critical thinking and problem-solving, self-discipline [6]. So, by 'transversal competencies', in this paper, we mean those competencies that are beyond disciplinary knowledge, not related to the particular technical or scientific nature of the engineering field of the programs, but that can be developed through formal education [7]. They enhance the graduates' personal development and professional abilities [6] when transferred to a different context (e.g. future employment be it research, business, teaching, etc.). [8, 6, 9] or used in a wide variety of situations and work settings [10].

However, transversal and transferable skills are still not addressed seriously enough in higher education [11, 7] and are known to be often forgotten in the engineering studies plans or relegated to the will of the professors [12].

In Portugal, DL 74/2006 defined the profiles of master and doctoral graduates in the form of reference skills for those degrees, promoting the paradigmatic shift to a pedagogical model that, instead of emphasizing the teaching of knowledge, emphasizes the development of competencies, be those of a specific nature (scientific and technical) associated to the area the student is enrolled in, be those of a global, generic nature (transversal skills). Despite the regulations that frame this educational paradigmatic change, several reports evaluating engineering programs and various employers surveys have pointed out the mismatch between the required competencies an engineer must have to perform in this field, and the competencies delivered by Academia (particularly in what concerns the lack of provision of transversal competences in areas such as entrepreneurship, promotion of scientific production, ethics and responsibility, management, career coaching, etc.) Documents of the European Commission [13,14] and other institutions of reference, also point out that the promotion of the development of transversal competences is one of the principles of quality of higher education, recommending its implementation in HEIs that want to be competitive and internally recognized as a reference in their fields.

Aware of these challenges, the School (FEUP - Faculdade de Engenharia da U.Porto) has made efforts to facilitate and promote transversal competencies development for its students.

This paper intends to present the transversal and transferable competencies programme (T&TC programme), developed by the School, to foster such competencies in their students. The paper will describe the programs' main features, explain how the pedagogical decisions have enhanced the strategy and will discuss the programs' effects and impact on the improvement of the quality of the students' educational experience.

II. METHOD

The transversal and transferable skills programme at the School consisted in 4 stages, namely: context analysis, planning, delivery and evaluation, yearly revised and updated.

A. Needs assessment

We analysed the School's prior existing experience of 4 existing courses on soft skills (Leadership and Team Management; Assertiveness Communication and Public Presentation Techniques; Time Management and Personal Goals Setting; Employability Skills), addressed specifically to undergraduate students. These themes were prioritized on the basis of a long experience of working with students developed by the internal 'Orientation and Integration Office (GOI)'. As a part of its work to improve students' academic experience, GOI developed some workshops where these topics were addressed. On the other hand, the satisfaction evaluation form of these workshops contemplated a field for suggestions of other themes. There, we could regularly find suggestions to develop skills such as 'leadership' or 'public communication'. Trying to meet the students requests and expectations, these competencies also integrated the institutional offer of such skills, being each, accredited centrally with 1,5 ECTS (that corresponds to 10h-14h of contact and around 40h total).

We later on collected data from the Institutional Survey (SENSOR project) to the employers of our alumni (engineering graduates/former students), in order to understand their perspectives on our graduates' performance, particularly regarding the competencies mismatch (required and lacking).

We also collected qualitative data, through meetings with the School's several engineering Programme Directors to promote a better understanding of this mismatch and inform on the needs of the employment market. We then prioritized which - of the list of gathered competencies - could be developed through formal training, considering available resources.

The data collected and the existing experience and feedback reported, provided us with guidelines in terms of competencies to be developed first, at the School, and how could they be enhanced and/or delivered. This enabled the creation of the transversal and transferable skills programme.

B. Programme design

In the second stage, we began to design the programme. We intended for a programme that consisted in the creation of a series of short courses of 1,5 ECTS (10h-14h of contact and around 40h total), each addressing specific competency. Short courses can focus, intensively, on the development of a single competency allowing theory to be addressed and practice to be trained; it also allows the student to develop, in a short period of time, a set of competencies that they perceive they're lacking.

In this scope:

- The four courses, referred above, continued to be addressed specifically to undergraduate students.
- Eight more courses were created and offered to graduate students (doctoral students and doctoral candidates).

The courses were able to be:

- credited in the curricula, substituting, for instance, optional/elective curricular units (integrating approach to the development of transversal competencies) [7] and thus, became a part of the formal curriculum.

  or

- able to be attended extracurricularly by those students who intend to develop further theses competencies (bolting-on approach to the development of transversal competencies) [7] without crediting them to their study plans. In this later case, since all the courses were accredited by the University of Porto, the students would receive a certificate for their CV and/or place the course in their Diploma Supplement.

These courses were offered to all of the Schools' students, independently of the Master or Doctoral programme they were registered in. This means that, for instance, in an 'Assertive Communication' course we can have students from the Master in Civil Engineering programme and students of the Master in Mechanical Engineering program.

C. Programme delivery, teaching methods and learning assessment

In the next stage we've set the programme in motion. The courses were created and submitted for institutional accreditation. Afterwards, they were publicised, internally, through email to all the student community. Candidates for each course where then selected according to criteria, in the following order: students wishing to credit the course in their curricular studies, students wishing to register in the course extracurricularly.

There was a course responsible person for each one and all the pedagogical decisions (selecting the students, defining teaching methods, planning assessment, etc.) were made by this person and its teaching staff. So, each course had a different teaching-staff group and the teaching methods were adapted to the intended learning objectives and the specific competency(ies) to be addressed in that course.

All the courses' participants had to be assessed regarding the competencies acquired/developed. For instance, in the 'assertive communication and presentation techniques' courses (initial and advanced modules), each participant was asked to do a simulation of a presentation to show evidence of the use of assertive communication good practices in a real presentation. In the 'scientific publishing and writing' course, the participant has to simulate the submission of a paper to show evidence if he has, indeed, used the good practices covered during the course.

D. Programme assessment

An online survey was created, based on the pre-existing survey that is implemented in other training courses, but also included questions that aimed at collecting data:

- on the participants' satisfaction with the courses attended,
- to see if their expectations on the courses they attended were met and
- to assess further needs on transversal skills.

The survey is aimed only to course participant and it is done in googleforms. It has multiple-choice questions that provide us quantitative data and short-open questions for participants to leave their comments on the course (qualitative data).

Each time a course ends, its participants receive an email asking them to fill out the survey.

Our objective, with this survey, was not to ascertain the students' perception on the level of competence they possess in the list of competencies offered, but to: analyse the students' perceptions on the importance of transversal skills development, besides the employers and the Programme Commissions perspectives; and their satisfaction with the School's strategy to help them develop their transversal competencies.

All the data is gathered in a course report and sent back to the Course Responsible person and its teaching staff; so their perceptions are also collected, as well as their intentions to address the participants' comments.

III. Results and Discussion

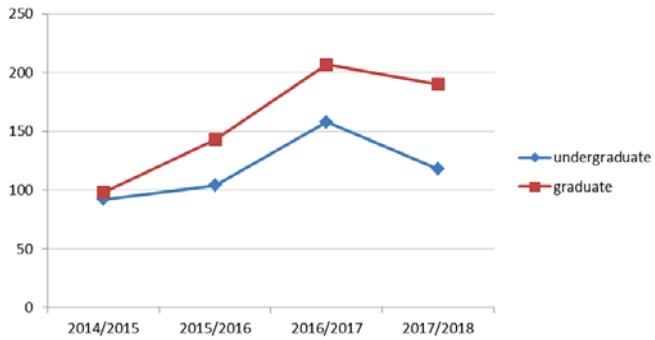
The results of the Surveys to the employers of our students provided a list of competencies that needed to be developed in academia and transferred to the workplace. That list was later on discussed with the Schools' Programme Directors and resulted in a list of priorities, namely:

- Intra and Interpersonal skills (leadership, team management, assertive communication, presentation skills, time management, science communication, pedagogy and teaching skills)
- Career management skills (employability, entrepreneurship, intellectual property, business creation)
- Research skills (scientific research methods, scientific writing, publication, LaTex)

The priorities were also classified by group target: i) undergraduate students and ii) doctoral students and candidates.

- 4 courses were delivered specifically to undergraduate students (master students) that developed the following skills: Time management and personal organization, Assertive communication and presentation techniques, Employability, Leadership and team management.
- and 8 courses able to be attended by graduate students (doctoral students/candidates) that developed the following skills: Assertive communication and Presentation techniques (advanced module), Science communication to non-specialized audiences, Intellectual Property and Business Creation, Basic skills to teach in higher education, Time management and personal organization (advanced module), LaTeX, Scientific research methods, Scientific publishing and writing.

The applications revealed a huge adhesion to the courses



Graph I – Enrolled students in all courses, per curricular year

The courses' evaluation data allowed us to perceive that participants have pointed out several benefits of attending these courses. 'Skills enhanced' and 'Effectiveness improved' (see table I) were the most chosen options. 'Contacts formed' as well as 'collaborations initiated' were the least chosen option, which may indicate that the courses are structured around autonomous/personal work and not collaborative learning methods. Thus, networking is not being developed.

Table I – Personnal benefits of attending the course

Skills enhanced	75%
Effectiveness improved	43%
Confidence increased	38%
Ideas birthed	36%
Options expanded	34%
Enthusiasm refreshed	32%
Contacts formed	18%
Collaborations initiated	7%

Still regarding the benefits of attending such courses, 87,6% of the participants have stated that what they've learned will be useful for the development of their curricular studies and 76,7% indicated that what they've learned in the courses will enrich their CVs in a way that will make them stand out.

Regarding satisfaction, 92,4% of the courses participants have specified that they were satisfied with the courses they attended and that they fulfilled their expectations. 91,9% of them indicated that they would even recommend the attendance of these courses to other colleagues.

In terms of future needs:

- the PhD candidates have been pointing out the following competencies: "Critical thinking & Design thinking", "Scientific-academic English" (see table II)
- while IM students highlight topics such as "Conflict management", "Negotiation", "Software engineering" and "Training of trainers" (see table II).

The School is revising this list annually to discuss which of these are able to be offered to the students, thus increasing the transversal competencies offer.

TABLE II – NEEDS ASSESSMENT ON COMPETENCIES TO BE ADRESSED

	Competency	N
Life and Career management	Career planning and coaching - from research to industry	**51**
	Patenting	**39**
	Self-presentation and project pitch	**80**
	Ethics and deontology	**28**
Intra and Interpersonal	Critical thinking & Design thinking	**115**
	Effective negotiation	**37**
	Effective Networking	**57**
	Teamwork and leadership	**90**
	Making scientific posters and presentations	**44**
	Marketing	**25**
Media, Information, TEC and Research	Grant-writing	**35**
	MatLab	**52**
	Qualitative research in Engineering Nvivo, QDA, Atlas	**49**
	SPSS statistical program	**39**
	Scientific-academic english	**180**
	Scientific event organization and management	**30**

IV. CONCLUSIONS

The list of priority competencies provided us with guidelines to start the Transversal and &Transferable Competencies programme. This list is yearly discussed and revised with the data collected from the final survey to course participants, where they explicitly mention which competencies they'd like to have training on. Our intention is to provide competencies formal training opportunities in several domains of the transversal competencies group. On the one hand, this allows the Programme Directors to integrate, in their programs, those courses that best suit their programme aims. On the other hand, it provides the students a broader range of choices, so they can choose those competencies that best suit their career goals and personal interests.

When deciding on the different approaches to deliver the Schools' 'Transversal and & Transferable Competencies' programme to students, we were aware that literature shows greater support for integration of skills into the curriculum [11,15 ap 7]. However, our proposal was to offer an 'integrating approach', complemented with a 'bolting-on approach' [7]. The Programme Directors, along with the students, can choose which approach they'd like to have, considering the student's/candidates academic expectations, motivations and career choices. On the one hand, this strategy provided Programme Directors the option to place, explicitly, in their programs, these competencies and thus, to foster the education of holistic engineers. It also helped to made academia more aware the need to adapt engineering curricula to a competency-based model. On the other hand, this complementary strategy to deliver transversal competencies, also provided students the option to choose which competencies they'd like to develop, according to their personal expectations and motivations, thus enabling them to become authors of their educational path.

The yearly increase in the registration numbers in the courses, as well as the results of the final survey to the courses (items: 'the courses value creation' and 'satisfaction with the courses') reveal that the Transversal and Transferable Competencies programme strategy is being well accepted within the academic community. We believe that it's contributing to the establishment of a culture where transversal skills are perceived as assets that students will profit from during their programs, add value to their employability and make them more effective in the workplace.

Despite this initiatives success, the intrinsic nature of this programmes' features – particularly the teaching and learning methods that require small classes – makes it expensive. The programme isn't scalable to all of the Schools students and extra (maybe external) financing needs to be considered. Industry involvement in such programmes (that aim the development of transversal and transferable competencies) is not new (eg. Project PEP-UP ref 014-1-FR01-KA203-008520) and may add value to the programmes, besides the benefits to both academia and industry.

In terms of future work, in the results of the final survey to each course, students are expressing needs in competencies that concern new ways of thinking to promote innovation and competencies that enhance their research related skills. This is consistent with literature, where is pointed out that engineering graduates value as most important these competencies: teamwork, communication, data analysis, and problem-solving. [16, 3, 16 ap 18]

V. Future work

In terms of future work, the School needs to analyse the initiatives impact and effects in terms of employability increase, performance effectiveness, etc. This needs to be done by collecting not only the participants' satisfaction but also the Supervisors perceptions, employability rates, etc.

We need to discuss ways to increase the participation rate in these courses, either making them mandatory in the engineering programs curricula or by publicizing their positive impact in employability rates and performance effectiveness.

The School also needs to approach the issue of the initiatives' sustainability. We intend to maintain the courses with the same features (small classes to provide more contact with the teaching staff and to provide more support and guidance for the participants, volunteer attendance, exemption of fee payment) and financing issues need to be addressed, since the expenses to provide these courses (particularly in what concerns the human resources) is high.

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