STUDENTS’ PERCEPTIONS OF A MAJOR ENGINEERING CURRICULUM REFORM

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ABSTRACT

As the demands of industry are evolving and new generations of students are entering universities, many engineering faculties invest time in curriculum reforms based on inspirational innovations, underpinned by engineering education research. The Faculty of Engineering Technology (FET) of KU Leuven had an additional argument to implement a huge programme reform: this faculty, hosting more than 6000 students spread across seven campuses in Flanders (Belgium), was an amalgam of different traditions and visions. Their merger into one faculty in 2013 aimed to optimize the organisation of research, education and community service.

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The goal of the programme reform in 2020-2021 was fourteenfold: enhancing our typical profile of (1) hands-on engineering in (2) strong interaction with the labour market and setting up (3) a technology hub with more attention to (4) multidisciplinarity, (5) professional competencies, (6) personal development & support, (7) lifelong learning and (8) challenges including (9) complex problem solving. The reform also aims to increase the (10) attractiveness and (11) social relevance of the programmes. By strengthening the internal coherence in the faculty, we can exploit the (12) multicampus narrative to offer students more choices and develop their (13) future disciplinary self, supported by (14) choice guidance.

This paper describes how the curriculum was adapted in order to achieve these goals and presents the results of perception measurements organised among freshmen who followed the old programme in 2019-2020 and freshmen registered in the new programme in 2020-2021. Of foremost importance is the increased feeling that the professional competencies are essential for an engineer.

1 INTRODUCTION

All sectors of society are witnessing great changes. Higher Education in general, and engineering faculties more specifically, play an important role as leaders in teaching and learning of the future engineer. The actual engineering student should be prepared for the challenges of tomorrow. It is the task of the engineering faculties to empower engineering students by helping them to achieve the relevant competencies needed in their future professional life.

Van Damme [1] states “Universities are doing reasonably well in translating changes in scientific knowledge into course contents but do not identify similarly important changes in skill demand in the external world and transform their education programmes accordingly.“ Indeed, engineering education research confirms that the skill set demand in the field of engineering is broad [2], role-specific [3] and in constant evolution (e.g. responding to the challenges of the Sustainable Development Goals [4]). Engineering faculties are responding to these social and technological developments in different ways. Hadgraft and Kolmos [5] list some responses they have detected in new types of engineering programmes: “These responses are student-centred learning, integration of theory and practice, digital and online learning, and the definition of professional competencies.” In her ‘Global state of the art in engineering education’ Graham [6] has identified the ‘current’ and ‘emerging’ leaders in engineering education and she concludes with the following list of features of this new generation of engineering programmes: “Distinctive educational features of the ‘emerging leaders’ include work-based learning, multidisciplinary programs and a dual emphasis on engineering design and student self-reflection.”.

This paper explores how engineering students have perceived a major engineering curriculum reform in the Faculty of Engineering Technology (FET) of KU Leuven. It was developed from a blank slate, based on 14 goals which were established through a collaborative process. The research question of this paper is formulated as follows:

"To what extent have the students experienced our 14 objectives?".

The context and the 14 goals of this collaborative curriculum design process are described in section 2. This is followed by a description of the implemented methodology to monitor the students' perceptions. And in the two last sections, the results of this monitoring process are given and discussed.

2 CONTEXT AND GOALS

KU Leuven is a comprehensive, research-intensive university, active at different campuses. The university is highly ranked (most innovative university of Europe) and counts more than 60000 students.

The new Faculty of Engineering Technology is a multicampus faculty spread over seven campuses in Flanders (Belgium) and is established in 2013 after a merger of the engineering departments of six different University Colleges of Applied Sciences. The faculty has a total student cohort of over 6000 students, of which more than 1000 are in the first year of the Bachelor's programme at the time of the curriculum change. These first-year students do not have to select their major or discipline when registering at university. The selection of one of the four the disciplines (civil engineering, chemical engineering, electromechanical engineering or electronics & ICT engineering) is made at the beginning of the second year. By consequence all first-year students take the same courses.

The curriculum development process started in 2017. Three years later, in September 2020, the first cohort of students started in the new three-year Bachelor's programme. This cohort will start the new one-year Master's program in 2023-2024. This paper only focuses on the experiences of the first-year students of the first cohort.

Since this faculty is the result of a merger of six institutions with different traditions, the curriculum development process started with an in-depth review of the faculty-wide goals. This collaborative process at different levels of the faculty resulted in 14 goals for the revision of the curriculum across the whole faculty. We discuss them one by one in a logical sequence, not influenced by relative importance.

2.1 Multicampus education

In order to exploit the multicampus context, the programme of the first year of the Bachelors is *identical on all campuses*. This allows (1) to reduce the number of majors/disciplines on some campuses without limiting the choice of a student since they can move from one campus to another, and (2) to intensify cooperation among the teaching staff in faculty-wide teaching teams.

The curricula of the Masters on the other hand are on purpose very diverse across the campuses and based on the research activities performed on each campus. By consequence, a graduated Bachelor's student has a huge choice of possible specialisations if the student is willing to move from one campus to another.

This supports the idea of a student-centred learning environment that emphasizes 'student choice', our second goal discussed in 2.2.

2.2 Choice guidance

Students have to make several important decisions while studying, such as 'pick a major', 'select a specialization in the Masters' and 'choose a job'. Starting from day one of the Bachelor's programme we support our students in these decision-making processes by intra- and extracurricular activities and clear communication (e.g., a first-year project covering the four disciplines, orientation days, job shadowing, etc.).

2.3 Supportive programme

Higher Education in Belgium has an open admission policy, resulting in a very diverse population of incoming students in terms of prior knowledge. We support our first-year students with extracurricular activities before the start of the academic year (e.g., MOOC basis mathematics, on-campus summer course, etc.) and during the first year (e.g., online tools, on-campus private or group sessions, etc.).

2.4 Challenging programme

This diversity requires support for some students and extra challenges for others. In general, the faculty engages in initiatives to motivate students to push their limits (e.g., a project with a bonus for those who go the extra mile, international experiences, etc.). This is in line with our focus on a student-centred learning environment that is attractive for potential engineering students.

2.5 Technology from day one

At KU Leuven three types of engineering curricula are organised: engineering technology, bio-engineering sciences and engineering sciences. The programmes within the Faculty of Engineering Technology are more applied, technology from day one is an important element to distinguish us stronger from the other programmes. Basic sciences and technical knowledge remain important, but the programme is broadened. The new curriculum sequence 'engineering experiences (EE)' in the Bachelors (EE1 in year 1, EE2 in year 2 and EE3 in year 3) offers students the chance to operate as engineers from day one. 'Integration' is the key word.

2.6 Professional competencies

The new programme emphasizes the increased importance of professional competencies. Experts in professional competencies organize seminars about these professional competencies, integrated in the EE-curriculum sequence. Moreover, these professional competencies such as communication, leadership, project management, team dynamics, etc., are not only 'teached' in colleges, but are also 'trained' and 'evaluated' during the regular courses such as laboratories and projects. This integration is essential since this is also the way it will be applied in the professional context.

2.7 Multidisciplinarity

Engineering problems are becoming increasingly multidisciplinary. Students have to learn to think and work across disciplines. At least during EE the students have to work multidisciplinarily, but also other activities support multidisciplinarity. This starts simple in EE1 where they have to integrate the content of different general courses in the integrated lab/project and it becomes a real multidisciplinary project in EE3.

2.8 Practice in the programme

The focus on practical engineering underlines our specific profile. It is not only realised in EE, but in almost every course since most courses are split in three parts: colleges (theory), exercises and laboratories. These laboratories are expensive learning environments, but essential to understand the theory in an applied way. This profile enhancing focus is moreover for many students an attractive feature.

2.9 New technology

Technology evolution speeds up. We invest a lot of money to give students the opportunity to have hands-on experiences with new technology in projects and laboratories. But we also focus on introducing new technology through lectures and contacts with industry (e.g., company visits, Master’s theses in collaboration with industry, etc.).

2.10 Interaction with the labour market

The Faculty of Engineering Technology has a long tradition of cooperating with the labour market. This programme reform wants to reinforce it by implementing e.g., job shadowing during the first year, intensified company visits, guest lectures, partnerships with some companies, etc.

2.11 Disciplinary future self (DFS)

Freshmen are usually still figuring out who they are and what they want to become in the future. We support students by developing a learning environment in which they can reflect on who they are and want to be (e.g., PREFER-explore and -match test, personal development plan, etc.).

2.12 Complex problem solving

Engineering problems are becoming increasingly complex. It is important to learn students how to deal with this complexity by building in progressively more and more complexity throughout the curriculum. The way we approach this is very similar to the way we ‘teach’ multidisciplinarity. It starts very simple with for example with the training of the ability to solve exercises combining topics from different chapters within one course and it ends in the Masters with dealing with authentic engineering problems which are by definition complex.

2.13 Lifelong learning

Lifelong learning is the buzzword of the moment, but not without reason. This is essential when it is our goal to empower our students to be ready for the future. Self-regulation is for example an essential competency of lifelong learners..

2.14 Socially relevant programme

We want to educate social responsible engineers, ready to tackle the Grand Challenges for Engineering. We want to stimulate this responsibility and awareness by giving them the opportunity to take part in for example community-based social projects, student competitions with a focus on sustainability, etc.

3 METHODOLOGY

A multidisciplinary team has translated each of the 14 goals ('scales' called from now on) into 3 to 4 targeted questions to measure the perceptions of the students. The questions can be answered with a 6 point Likert scale (from 'totally disagree' to 'totally agree'). This resulted in an online survey of 54 questions given to 943 first-year students in May 2020. This was at the end of the academic year 2019-2020, the last year the former programme was organised for first-year students (old cohort). The response rate was 48% or 450 students completed the questionnaire. In May 2021, at the end of the academic year 2020-2021 in which the new programme was initiated, 798 first-year students were invited to complete the questionnaire and 267 effectively did (new cohort). This resulted in a response rate of 33%. Normality of the distributions of the scales was checked using the Shapiro-Wilk tests. Since they were not normal distributed, the perceptions of the old and the new cohort were compared with Wilcoxon rank sum tests.

The reliability and validity of the survey with 14 scales was measured with Cronbach's Alpha and an exploratory factor analysis. A confirmatory factor analysis confirmed a necessary reduction of the scales.

4 RESULTS

The validity of the survey is discussed first, followed by the results of the perception measurements. A discussion of the (non)significant changes in perceptions between the old and new cohorts constitutes the conclusion of this paper.

4.1 Reliability and validity of the survey

The internal consistency of the scales of the survey is given in Table 1.

Table 1. Cronbach's alpha of the 14 scales ordered in sequence of Cronbach's alpha.

Scale (goal)	Cronbach's alpha	Scale (goal)	Cronbach's alpha
Interact with labour market	0.78	Choice guidance	0.67
Supportive programme	0.77	Socially relevant programme	0.58
Challenging programme	0.74	Disciplinary future self (DFS)	0.56
Complex problem solving	0.73	New technology	0.52
Practice in the programme	0.7	Multicampus education	0.51
Professional Competencies	0.69	Lifelong learning	0.49
Technology from day 1	0.68	Multidisciplinarity	0.46

Cronbach's alpha's of less than 0.7 are in principle not acceptable. The exploratory factor analysis also did not confirm the 14-factor model. Implementing a promax rotation and a cut-off of 0.3 for the factor loadings, 5 items of the survey were rejected, and 7 factors selected. This was confirmed with the scree plot and a confirmatory factor analysis (CFI=0.86; RMSEA=0.051). Five original scales remained, and two new scales were developed (see Table 2). The new scales are shown in italic in Table 2. 'Lifelong learning', 'multidisciplinarity', 'Disciplinary future self' and 'socially relevant programme' are not withheld.

Table 2. Cronbach's alpha of the final 7 scales

Scale (goal)	**Cronbach's alpha**
Challenging programme with complex problem solving	*0.82*
Interact with labour market	0.78
Supportive programme	0.77
Student centred programme (multicampus, choice guidance and DFS)	*0.76*
Practice in the programme	0.7
Professional Competencies	0.69
Technology from day 1	0.68

4.2 Changes in perceptions between the old and new cohorts

The results of the Wilcoxon rank sum tests are given in Table 3. The perceptions of the students of the two cohorts can be compared. Only for three scales (or goals) a significant change is measured: 'interact with labour market', 'supportive programme' and ' professional competencies'. Unfortunately, only for 'professional competencies' the students have experienced an increase so far.

Table 3. two-sample t-tests for the two cohorts in the 7-factor model.

Scale (goal)	**Old cohort M (SD)**	**New cohort M (SD)**	**p-value**
Challenging programme with complex problem solving	4.51 (0.58)	4.41 (0.68)	n.s.
Interact with labour market	3.96 (1.02)	3.12 (1.03)	<.001
Supportive programme	4.58 (0.78)	4.37 (0.85)	<.01
Student centred programme (multicampus, choice guidance and DFS)	4.03 (0.70)	4.12 (0.75)	n.s.
Practice in the programme	4.34 (0.71)	4.12 (0.75)	n.s
Professional Competencies	4.27 (0.83)	4.46 (0.76)	<.01
Technology from day 1	4.58 (0.64)	4.62 (0.65)	n.s.

5 DISCUSSION

The answer to the research question can be short: the first-year students of the first cohort who have followed the new curriculum do not have the impression that the interaction with the labour market has improved, neither they have an increased feeling of support yet. But they have fortunately experienced that the professional competencies are an essential part of the broad skill set. For the other four goals no conclusions can be made at this point.

This limited result is understandable considering the following contextual factors:

1. The focus was only on the first year of the programme. Not all 14 goals are achievable in the first fourth of the new curriculum. On the other hand, a first basis can certainly be laid for the 7 corrected goals. For example, we invested quite some time in a new initiative of job shadowing. This seems not to have effect, on the contrary, the interaction with the labour market was appreciated less. There is clearly something else going on.
2. Starting from March 2020 Covid-19 had a major impact on education. The old cohort was partly hindered. The new cohort started at university during the pandemic. Laboratories (practice in the program) were less frequently organised, job shadowing (interact with the labour market) and supporting workshops (supportive program) were online, etc. This puts this work in perspective.
3. And last but not least, during the first year of a huge programme reform not all that you would like to do has been achieved yet. We have the intention for example to implement in near future a personal development plan and a more intensive support programme.

As we are now only reporting on the first step of a longitudinal study, it is important to have a critical look at the survey the coming years. Not necessarily all validation recommendations of this paper should be considered in near future. After all, we have validated the survey only with first-year students. 30% of them drop-out after the first year, so they are not a representative sample of our population. A new validation should be done the coming years.

Concluding, this study proves that it is possible to make students aware of the importance of professional competencies. Since we are not the only faculty integrating professional competencies into the core of the curriculum [7-10], this is hopeful information for many curriculum reforms. Improvements are still possible, such as a stronger integration of the professional competencies in the engineering courses and not only in EE. Also, the development of a supported framework to track and evaluate the professional competencies might be helpful.

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