STUDENTS' PERCEPTIONS OF MASTER PROGRAMMES: READY FOR WORK IN 2021?

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ABSTRACT

Educating engineering graduates to confidently tackle issues in their future jobs demands a well-balanced curriculum that integrates development of essential conceptual knowledge, professional skills and attitudes for ethical conduct. Often, it is the case that priority is given to developing a strong knowledge base, with an expectation that other professional elements will gradually emerge in the course of students' engagement with either project-related work or other collaborative tasks. Designing a comprehensive Master programme requires careful balancing of technical and professional skills, hence in this paper we expose the results of a study that looks at the strengths and weaknesses of five Master courses of our institution, from the students' point of view. Data gathered through a survey that contains quantitative scales and open-ended qualitative questions provides the perceptions of students on their gains in terms of both conceptual knowledge and professional skills. Results indicate strong student outcomes in theoretical knowledge across several disciplines, but a clear request for a more practical and real-life based approach. Moreover according to the students' opinions, there is an expectation for more learning experiences regarding project management skills, use of IT tools and understanding on some ethical, legal and environmental aspects of engineering.

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Observations and conclusions of this study also include reflections on the extent to which the COVID-19 lockdown impacted the overall student experience of the Master courses.

1 INTRODUCTION

1.1 Background

By the end of the last century, a significant volume of academic literature pointing to the need of reorienting teaching and learning to better respond to 21st century challenges had been produced [1]. There is an existing need to include more complex critical thinking skills, an interdisciplinary understanding of problems, and reflections on solutions that encompass ethics and equity. This is particularly applicable to engineering education [2], which has been criticised for its significant shortfalls in teaching transversal skills within its main curriculum [1][3][4]. The demand for a more holistic engineering education [3] with versatile workviews and the capacity to understand different dimensions of problems is completely justifiable when looking at the first 20 years of this century, culminating with the current challenges brought on by the ongoing pandemic.

However, are engineering graduates prepared for these challenges? As a result of a global lockdown of higher education institutions, the generation graduating in academic year 2020/2021 is the first to finish their education under these unprecedented circumstances. We examined five Master programmes of our university, a higher education institution that offers Bachelor, Master and Doctoral degrees in engineering and architecture. By collecting quantitative and qualitative answers from students, we aimed to understand how prepared for work the students felt at the time of their graduation. This paper presents the main results and invites a discussion on positive and negative aspects of current engineering programmes and how to move forward.

1.2 Literature overview

There is an overall agreement that the “purpose of engineering education is to provide the learning required by students to become successful engineers - technical expertise, social awareness, and a bias toward innovation”[5, p.1]. The combination of adequate knowledge, skills and attitudes necessary for successfully engaging in the engineering profession has been a driving force for change. Yet, the change is slow-paced and at many institutions tectonic pedagogic changes are needed in order to arrive at a well-balanced curriculum[6]. Additionally, the future trends of engineering education shows shifts “towards socially-relevant and outward-facing engineering curricula”, one that is based on interdisciplinarity and examples outside the classroom with close examination of its social impacts [7].

While there is a strong need for interdisciplinarity and social skills in the engineering curriculum, much of the engineering curriculum is based on a single discipline [8]. Current studies show that graduates often lack some of the core skills that can help them in the transition from university to work [9].

Adapted from a European Commission’s document, Torres et al (2018) [1] sketched a structure of skills profiles specifying the job specific “hard” skills as one small part, sitting on top of a wide spectrum of “soft” transversal skills, including legislative and regulation awareness, economic awareness, basic skills in science and technology, environmental awareness, ICT skills and foreign language skills. The bottom layer of

this skills pyramid are components that are closely related to project management and self-esteem, including personal effectiveness, relationship and impact and influence skill clusters. Additionally, as a response to some of the issues in the current engineering education curriculum, a Conceive-Design-Implement-Operate (CDIO) approach was developed [5]. The CDIO approach emphasises on mastering the four components of conceiving, designing, implementing and operating "complex, value-added engineering products, processes, and systems in a modern, team-based environment" [5, p.7] and embeds learning in a cultural environment to enhance learning within a context.

1.3 Context of the study

Our study focused on the perception that students have towards the achievement that they reached at the end of their training regarding both disciplinary and professional Learning Outcomes. The main question was:

> How prepared do students feel for working effectively in engineering after finishing their Master programme?

In order to break down and properly answer this complex question, we designed three sub-questions that provide specific dimensions for our evaluation:

1. What is the students' evaluation of their knowledge and skills?
2. What do students perceive as strengths and weaknesses of the programmes?
3. How did COVID-19 impact their studies?

Our intention through this paper is to provide empirical evidence on the three sub-questions and evoke a discussion around our leading question that will stem from the analysis of the answers to the three sub-questions.

2 METHODOLOGY

2.1 Instrument

An evaluation of the Bachelor's and Master's programmes was implemented in our institution in 2017, following accreditation requirements. A questionnaire containing quantitative and qualitative aspects and targeting students at the end of the Master's programme is one of the instruments of this evaluation. This paper is based on 181 answers across 5 Master programmes, from the 2020 survey.

Data was collected between May and December 2020, with a response rate between 21% and 84% among the respective Master programmes. The sample included 29% of female students, 69% male and 2% of those that did not identify with either.

The quantitative part of the questionnaire was implemented in a format of four-grade scales (including the options excellent, adequate, insufficient and none, but not missing[2]). The surveys differed slightly since the implementation of the programme

[2] Category « None, but not missing » refers to students not learning a skill/knowledge and perceiving it as not necessary.

evaluation was an on-going process in 2020. For this study, we keep only questions that were the same for at least 3 of the 5 Master programmes. These included:

Q1:“How do you assess your level of competence in these core areas at the end of the Master in XXX?” (5 programmes)

Q2 “How important do you perceive the development of the following skills at the end of your Master training?” (3 programmes).

The qualitative side of the survey included the following open-ended questions:

- What should be added concerning the contents of the Master?
- In your opinion, what are the strengths of the Master programme?
- Please, give us your comments and suggestions for improvement
- How has the COVID-19 situation affected your internship or Master Project?
- How has the COVID-19 situation affected your studies?

Additional questions were asked in Masters A, B and C, as following:

- Master A and B: In your opinion, what are the weaknesses of the Master programme?
- Master C: In your opinion, are there any areas/domains in this Master programme that may be underrepresented or absent (courses offered). If yes, please tell us which ones.

2.2 Procedures

The quantitative data was analysed using descriptive statistics. After combining extracts from the five Master files, we constructed a table for each question, and we presented the responses in the form of bar charts. The percentage for each of the four-grade scale was calculated on the number of effective answers. In the bar chart, each bar is attached to a sub-question. Sub-questions were grouped according to the categories from the CDIO competences framework [5] as far as possible.

The qualititative questions were analysed following deductive and open coding techniques. The names of the five Masters’ programmes have been anonymised and replaced in respondents answers by the letters A-E before the coding phase. We used the framework provided by CDIO to start with the procedure, and the initial coding included codes ranging from teamwork, professional skills, personal skills, communication and foreign language. The first iteration of coding involved the same segment of data, coded by three independent researchers. During the first round, we realised that some data did not fit the pre-existing categories of CDIO, so for the second iteration we used open coding techniques to add codes that better described the data. The added open codes included self-esteem, emotions, remote work and impact of COVID-19, assessment and flexibility of the programme. We observed that some of the aspects missing from the CDIO framework were specifically related to students’ personal feelings, as well as the more technical characteristics of the programme which seemed to influence students’ opinions. The open codes were

strictly defined and discussed among the three researchers, therefore the final codebook included a mix of CDIO and agreed open codes that were then used for the final third iteration.

3 RESULTS

Across all data, the most interesting finding, which is equally represented in quantitative and qualitative answers, is the way students regard the quality of the Master programme, both from the perspective of strong disciplinary knowledge and the choice of subjects they were provided with. In a similar fashion, we notice that overall, students perceived that during their Master education there had been missed opportunities to gain professional transversal skills and hands-on experience.

3.1 Knowledge and skills

In more detail, the first such discrepancy is noticeable with how students assessed scientific knowledge and professional skills, presented in Fig. 1.

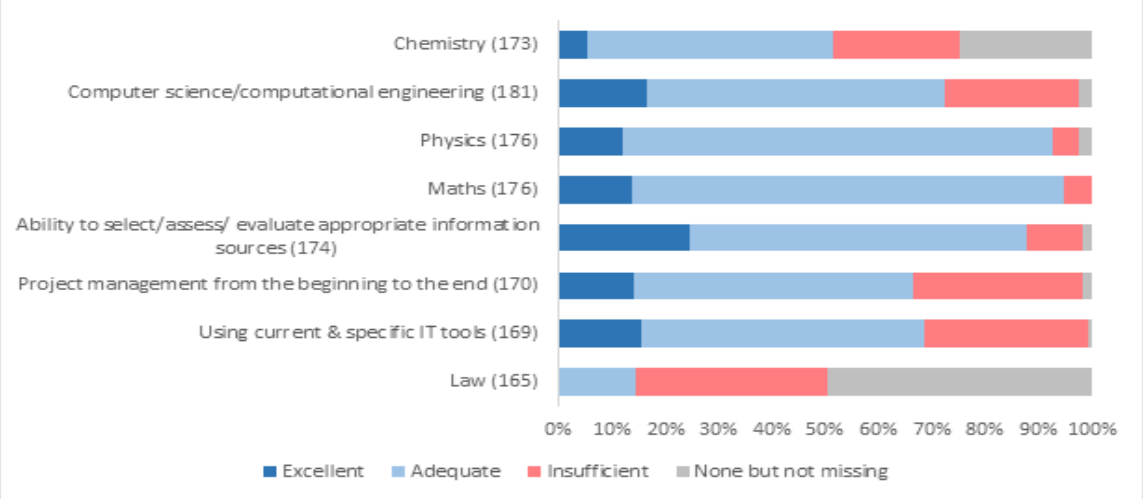

Fig. 1. Self-assessment of knowledge and professional skills – Five Master programmes.

In reading these results we can see that:

- A majority of respondents are satisfied with the level of knowledge in mathematics, physics and computer science, and about half in chemistry
- However, 24% of respondents found their level of knowledge insufficient in Computer sciences / computational engineering
- In chemistry, 23% of respondents found their level of knowledge insufficient, while 24% believe they do not have the adequate knowledge but it is not missing

In comparison to professional skills:

- Most students feel they have the ability to select / assess / evaluate appropriate information sources

- However, 32% of respondents found their ability level insufficient in project management, and about the same proportion noted this for using current and specific IT tools
- Strikingly, when it comes to law, only 15% of students assessed their skill level as adequate, while 35% of students rated it insufficient and half of the population as something they do not miss.

These results go hand in hand with the qualitative answers where overall, students seem to be satisfied with the level of knowledge, however in some cases they do suggest specific subject related courses, some transversal skills and better balance between theoretical and experiential learning. Some of the student quotes confirm this:

"We obtain an excellent level in maths and this is very appreciated worldwide." (169)

"Great theoretical set of courses, especially the ones that are taken in the 3rd semester (which are in fact from the doctoral school)." (165)

"Extremely good education in my field, compared with world top universities. Great teachers." (151)

On the side of professional skills, however, students' answers indicate that even though our institution offers the opportunity to carry out interesting and challenging projects, there are aspects of professional skills that could be improved. The participants (70 comments out of 208) show their willingness to apply the theory in a more practical way and more contextualised in a real world situation. Some of the most repeated examples are:

- Project management: experience all the process and phases.
- Foster interdisciplinary projects.
- Practise: build robots, lab immersion.
- Collaborate with real companies, face real challenges

Opinions of several students showed that the programme should be more balanced.

"[We should be] focusing on soft skills which are often MORE important than technical / hard skills" (134)

"Not enough practical and real life applications. I know that it is hard to implement. But I learn so much during association project rather than master courses" (26)

This is also examined in the following section, which looks specifically at strengths and weaknesses of the programmes.

3.2 Strengths and weaknesses of the programmes

A very high proportion of respondents (97%) considered their capacity for critical thinking to be a strength of their training. Most of them (95%) also considered as other strengths of their training the development of their oral and written communication skills, their capacity to keep/acquire new knowledge, their ability to communicate and collaborate with others, and, to a lesser extent (90%), their ability to use an appropriate work methodology and to give/receive feedback.

The main identified weaknesses are related to the responsibility skills. More than 40% of respondents perceived their ability to take responsibility for the environmental impact of their actions and decisions to be weak, and 25% their ability to respect ethical codes for their profession. Lastly, the ability to use both general and specific IT resources and tools is perceived as weak by 19% of respondents.

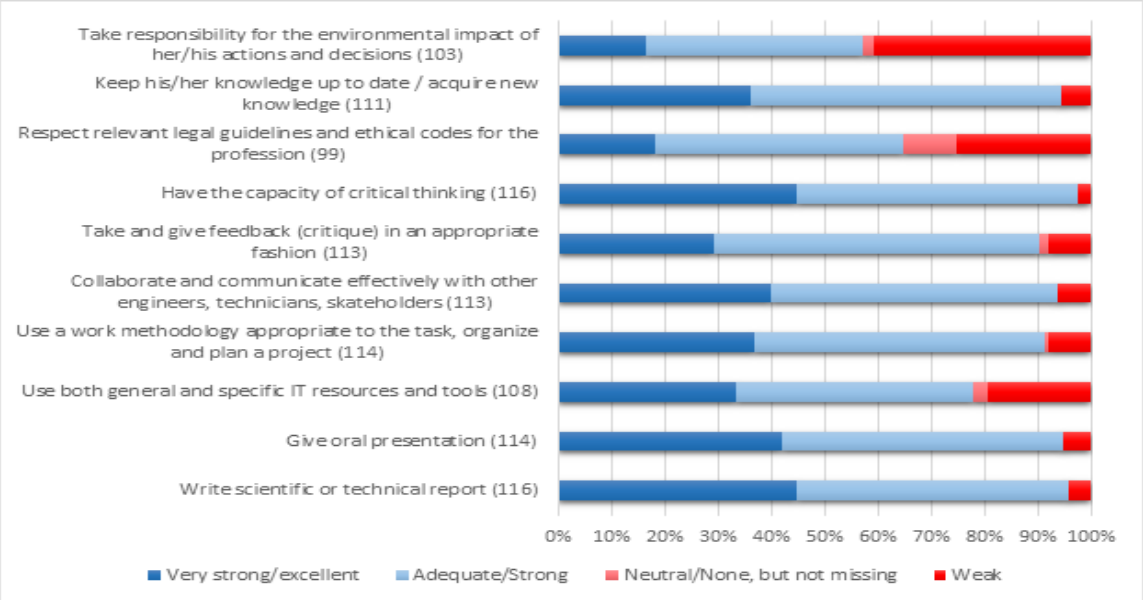

Fig.2. Respondents' perception of strengths and weaknesses - Three Master programmes.

In their qualitative replies, students offered further insights into what they felt were the strengths and the weaknesses of their education. Interestingly, several replies related to well designed programmes that provide an interdisciplinary overview of the field, as portrayed in these examples:

> *"The mix of possible courses from various different fields create the possibility to move in many different directions." (42)*

> *"I think [institution] is a superb place to grow as an adult, even more than as an engineer. I would encourage the intersection collaborations between sections uncompatible at first sight, about subject that matters for all." (110)*

Alongside the interdisciplinarity, the answers indicate that students highly value and appreciate internships and collaborations with real companies.

"I think it could be a very nice idea to push for more semester projects in collaboration with enterprises and more interventions from industrial experts to create awareness for the industrial challenges ahead. The mandatory internship is excellent to gain experience, but I think this advantage of gathering experience already as a student could be further enhanced and would make the [B] master even better." (76)

Several opinions have pointed towards the value of the programme content that offers transversal skills, like those provided by the Social Sciences and Humanities Section (SHS), as given in this excerpt:

"How the real world works: to know what is 'maitre d'ouvrage, mandat, appel d'offre, etc...' SHS focuses on soft skills which are often MORE important than technical / hard skills, depending on the company we work at. Working as a consultant, my level in french / english, presentation, social competenties, teamwork are more important than the technical stuff…" (134)

Assessing the proportion of coded qualitative answers given by students, we noticed that most frequently they mentioned autonomy (45.9%), which was often regarded as a strength of the programme. Opposite to this, sustainability, ethics (each with a proportion of 18%), and law (13%) were often mentioned in a negative way, as something missing from the programme, as these examples show:

"More environnemental, ethical and legal knowledge." (101)

"Environmental concerns, impact of the civil engineering industry, how to minimize environmental impacts, what to be careful with. I suggest not to add a course, as student could just not take it but to add this topic in the various courses" (131)

3.3 Students' self-perceptions and impacts of COVID-19

Most of the comments related to how students experienced COVID-19 lockdown were neutral. There was a large proportion of answers (132) indicating that there was minimal or no effect of the lockdown with respect to their studies, and in some there were notions of how students adapted to the situation, reflecting on greater independence and autonomy. This was present in 28 comments, including this one:

"I had very little contact with my professors and it was sometimes difficult to be isolated in a foreign country alone. I had to rely on independence to complete the project. "(139)

However, outside of the knowledge and skills frameworks, there was a lot of content in qualitative answers related to students' emotions. These comments were often related to the COVID-19 situation. Many of the perceived difficulties were connected to students' stress related to finishing their studies, having to leave to their home countries, as well as having experienced negative consequences for their Master

project, such as impossibility to do prototyping or being away from hardware. Some respondents reflected on different levels of teamwork quality in the COVID situation during their internship. They observed that zoom remote teamwork was more difficult than face-to-face (difficulty to speak simultaneously, more time consuming, less efficient, reduced interaction and collaboration with teammates), as well as hardship due to the lack of interaction and isolation during COVID.

Emotional aspects were coded in about a quarter of all the open-ended answers. In these comments, students described their difficulties of staying motivated and efficient during remote working, the lack of social contact, the feeling of loneliness (even depression in one comment). One respondent pointed with bitterness the impossibility of carrying out their PDM abroad, whereas another that was abroad for PDM described a feeling of being very isolated. One respondent described the sadness of ending the Master without celebration of this moment.

"I felt like nobody followed what I did, I was working alone on my project" (170)

Also, in 22 answers we found references to "self-esteem". In these comments, respondents often expressed doubts about their own ability to adapt to the professional world. These were not always strictly connected to the COVID-19 situation, but they reflected the ambivalence of their training, balanced between broadness of knowledge and specialization.

"It is difficult to express what I think of the master. It is great because on one hand, I have studied many different fields and that was very interesting. On the other hand I do not have the feeling to be fully prepared to work in any of those fields, even in my specialization in which I feel I have too broad and not specific enough knowledge." (105)

There were two other contributions in which students specifically suggested adding activities in the curriculum that would reinforce students' self-confidence, which could possibly improve their capacity to evaluate their own knowledge and skills, and feel more self-secure.

3.4 Discussion: how prepared do students feel?

Results showed that respondents feel well prepared in theoretical scientific fields such as Maths and Physics, and to less extent in Computer sciences/computational engineering and use of IT tools. Studying within the context of COVID may have reinforced the perception of need in this later domain. Opinions were divided regarding Chemistry, that may be explained by the various Master programmes that were included in the study. They perceived their ability for critical thinking and communication as strengths of their training.

On the other hand, results also showed that respondents seek mere preparation/experience in personal and professional skills, such as what participants call "real life work". Respondents are demanding for even more practice and interdisciplinarity in their training, and more preparation for teamwork. Results also

showed that respondents felt less prepared regarding law and that responsibility skills are perceived as weaknesses of the training.

So, in answer to the initial question “How prepared do students feel for working effectively in engineering after finishing their Master programme?”, we could state that from a theoretical perspective, they feel ready, but they feel they are lacking personal and professional skills that are essential in the industry.

This brings up the discussion: is the curriculum sufficiently up to date to face 21st century needs? Engineers have to be educated for facing challenges of sustainability and climate change, of automation technologies, and be trained for innovation, entrepreneurship and design thinking. They are expected to have both a systemic and interdisciplinary approach for dealing with ill-defined and complex interactions between technologies, integrating human and societal values, and designing innovative solutions in fast changing contexts. The engineering programmes of this study embraced some trends of emerging curriculum models, as described by Hadgraft and Kolmos, such as active-learning, integration of practice through internships and projects, and personalized learning through the choice of courses within the programme [10]. However, for dealing with complexity, the present study tends to confirm the students’ expectations of more integrated project work within the curriculum. This is coherent with emerging trends towards more integrated curricula, such as the CDIO approach [5]. Hence, further explorations, including Alumni surveys, are much needed in order to understand how teachers and curriculum developers can enhance opportunities for students to gain adequate work-related skills adapted to the 21st century context.

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