# Teachers' and Students' Perspectives about Curriculum Development in Engineering Education: Implications for academic work

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## INTRODUCTION

The educational changes under the Bologna Process have challenged, amongst other issues, the teaching practice in Higher Education (HE). Particularly regarding to curriculum development [1], the referred challenges relates to implementing active learning strategies [2, 3], planning different ways to assess students [4] and also defining learning outcomes considering the competences that students must be able to develop [5, 6]. Furthermore, Higher Education institutions are often criticized for the lack of preparation of graduates to solve real problems [7], and several studies highlight the gap of competences identified in graduates regarding to their professional context [8, 9]. The teaching approaches influence the way that students become engaged in their own learning process. In other words, the teacher is a key element to create meaningful learning experiences to benefit of students, allowing them to develop a wide range of competences related to their professional practice [10].

All over the world, engineering programs have been innovating the teaching and learning approaches [11, 12]. A recent report developed by the New Engineering Education Transformation (NEET) initiative from the Massachusetts Institute of Technology (MIT) provides a worldwide picture of successful innovation in engineering education [13]. Three important engineering education trends were identified in this report, namely: “a tilting of the global axis of leadership in the field; a move towards socially-relevant and outward-facing curricula; and the emergence of university leaders that deliver an integrated and world-class curriculum at scale” (p.47). Thus, the MIT report and current research emphasise the importance of curriculum development in the future of engineering education, as well as the role played by teachers, students, leaders and other stakeholders in this context.

With this in mind, this work focuses on the teachers’ and students’ perspectives about curriculum development in Engineering Education (EE). This implies to look at different dimensions such as: planning the learning process (including the learning outcomes), defining the strategies to present contents to students, as well as defining and planning the delivery of innovative teaching methodologies, creating learning environments to promote interaction between students, developing tools and materials for student support, and finally manage the assessment and evaluation processes. These dimensions are some of the criteria for the quality of teaching in HE identified by Zabalza [14]. Understand them in a specific context helps to understand how it is possible to contribute for the quality of an engineering program, in terms of practices, processes and stakeholders.

Based on the need to improve engineering programs, this paper aims to analyse the perspectives of the teachers and students on curriculum development in Engineering Education, using a case study approach, focusing on three dimensions: 1) planning the learning process; 2) implementation of an interdisciplinary approach; 3) engagement of teachers in collaboration.

## 1 METHODOLOGY

The Industrial Engineering and Management Integrated Master program (IEM-IM) at the University of Minho was analysed as a case study, considering the innovative curriculum context, in which several semesters are organized in interdisciplinary project-based learning (PBL) approaches. In these approaches, group of students develop a project during a semester, to solve an open-end problem related to the professional practice and to the courses of that semester [15, 16]. The perspectives, experiences and beliefs of teachers and students of IEM-IM program were taken into account. Implications for academic work will be discussed, as a contribution for the definition and improvement of the quality of teachers' professional development in engineering programs.

Based on a case study approach, this work seeks to address the following research questions: What are the perspectives, experiences and beliefs of teachers and students regarding curriculum development in the IEM-IM program? What are the implications of curriculum development for academic work in Engineering Education? In regard to data collection and analysis, a qualitative approach was considered, in order to get an in-depth understanding about the several issues related to curriculum development. Four focus groups were conducted with a total of 14 teachers with engineering, science and technology background. Teachers were selected in terms of diversity of management experience (e.g. program director), teaching experience (e.g. years of teaching in the IEM program) and experience with curriculum innovation (e.g. implementation of project-based learning). Regarding to students, eight focus groups were carried out, totalising 30 students from the 1$^{st}$ to 4$^{th}$ year of the IEM-IM program (two focus groups per year). The participants were encouraged to share their opinions, beliefs and perspectives, highlighting the challenges, the difficulties and the suggestions for improvement. All focus groups were recorded with the participants' permission and transcribed *verbatim*. Data analysis was based on the dimensions of quality of teaching in HE identified by Zabalza [14], and referred on the section of introduction. These dimensions allowed using a structured approach to get an in-depth understanding about curriculum development in Engineering Education.

## 2 FINDINGS

In the context of this work, the data were organized in three dimensions, namely: 1) planning the learning process; 2) using an interdisciplinary approach; 3) engaging teachers in collaboration. The dimensions can be considered challenges for teaching practice.

### 2.1 Planning the Learning Process

Biggs [10] argues that the learning objectives are the central dimension of the curriculum, providing inputs for the others dimensions related to the teaching and learning process. This purpose is supported by other authors, whom claims for the relevance of the definition of the learning objectives in engineering programs [17-19].

The complexity of planning the learning process goes beyond the definition of the learning objectives. Implies making decisions regarding to the content, strategies, and resources, as mentioned by this teacher.

> « (…) sometimes, the teacher' difficult is the selection of the content, particularly in an "Introduction" course in which we can talk about everything and anything related to IEM! » (Focus Group Teachers – Participant 11)

Furthermore, the teachers recognized how difficult it is to keep the alignment between all the dimensions of the curriculum, particularly between teaching strategies and assessment:

> «I use examples to help them [students] to understand the content, but then, in the exam, they will reproduce that content in an abstract way, without any meaning, without thinking. So, I use examples and so on, but then when I am going to assess is completely against my original purpose… it is very hard» (Focus Group Teachers – Participant 9)

From the students' point of view, the objectives are important in order to understand what is expected. The following quote illustrates this purpose:

> « (…) I need support, I need some orientation, I need clear objectives and, in this case, were not clear at all (…) I think the minimum of planning from the teacher is essential. » (Focus Group 4th year Students - Participant 27)

Furthermore, students' point out that linking theory and practice is a key-issue and, for that reason, must be considered in curriculum planning.

> « (…) having the lecture and see where that content can be applied, see where that makes sense and where it will help us, that's important. We never know where some content is going to be applied, if we are going to need them in the future or not… If we know all this, I think our motivation increases. » (Focus Group 1st year Students – Participant 3)

In this sense, using an active learning approach is crucial to enhance students' motivation and engagement in the learning process. The teachers also highlight this idea, considering the impact of the project-based learning approach in the curriculum:

### 2.2 Using an Interdisciplinary Approach

Considering the value of linking theory and practice, students highlight the project-based learning approaches as their most meaningful experience.

> «I think it is the best way to apply theory into practice; and it is not the theory that we had before, but the theory that we are having at that moment. This turns everything that we are learning much more powerful» (Focus Group 3rd year Students – Participant 21)

PBL model in IEM-IM program at the University of Minho started in 2004/2005 in the 1st and 4th semesters. Teams of students need to develop a project considering the content of the different courses of each semester [15, 16].

Interdisciplinary projects challenge teaching practice. Teachers involved in this study identified some of them, such as the difficulties of communication and cooperation between teachers, the complexity of planning and management of the project (e.g. organizing milestones, defining the problem, etc.), heavy workload when comparing with traditional approaches, amongst others. This can be noted in the following quote:

> «The project also brings additional difficulties in order to foster the link between the courses and the integration that is needed. In fact, with the project we are in a different level, it is more complex and demanding for teachers, because everything needs to be coordinated and everybody needs to be engaged and committed. » (Focus Group Teachers - Participant 8)

Despite the difficulties, teachers involved in this study also recognized the advantages of the interdisciplinary projects, in which students are able to solve engineering problems.

> «The courses are organized in “lockers” and we know that this is not what the students find out when they go outside. But we can link some courses with each other and the IEM-IM shows that this can happen with the projects. » (Focus Group Teachers - Participant 10)

### 2.3 Engaging Teachers in Collaboration

Planning the learning process is one of the pedagogical competences for a teacher in Higher Education. However, considering the importance of the interdisciplinary approaches within the curriculum, other competences are also relevant, such as collaboration and teamwork. In fact, teachers’ collaboration is a key-dimension to innovative curriculum development in engineering education [20].

According to the teachers’ participating in this study, collaboration might be the most challenging dimension in curriculum development and also the most important to innovative teaching and learning environments:

> «I think that more communication is needed. Between Mathematicians, Physicist, Engineers… we need to know what each one is going to need, what is possible to do, and so on. Nobody talks, so everything stills the same. Even if you look at an engineering program, basic sciences for one side, engineering sciences for another side… seems that are different things, but in fact they are closely related. And then, we expect that the student be able to link everything…» (Focus Group Teachers - Participant 2)

## 3 CONCLUDING REMARKS

The results reinforce the role of teachers in curriculum innovation. It is clear some of the difficulties identified by the teachers concerning their teaching practice: in the alignment between the curriculum dimensions, in the implementation of interdisciplinary contexts to foster a meaningful learning process, in practices of collaboration. The most surprised finding is the need to paid more attention to these

and other criteria in terms of teachers' professional development contexts in HE. In other words, teachers might be better prepared for needs demanded by students learning processes, by developing competences that might transform teaching and learning into a more effective and sustainable process. The teacher is a key-person to transform engineering education by creating meaningful experiences for students, innovating the curriculum and preparing them for the challenges of the world, defined by the 2030 Agenda for Sustainable Development [21]. Nevertheless, other dimensions in regard to academic work might be also considered in teachers' professional development, such as the impact of research, management and cooperation with the society in teaching practice. The findings of this study suggests that the complexity of academic work can have impact on the decisions to introduce innovative approaches in the curriculum. Particularly, the teachers' collaboration is a dimension that need to be considered: What is possible to do to foster collaboration amongst teachers? There are spaces and opportunities to develop teachers' collaboration? As an example, the focus on research activities and results often affects the time available to introduce innovative practices. Recent studies point out the relevance of developing research related to teachers' professional development in HE [22-24]. Different approaches can be used for teachers' professional development, such as training, coaching and mentoring, amongst other [25]. The lack of studies regarding to this topic provides opportunities for further research in Engineering Education.

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