Introduction of a career planning system for Aerospace Engineering students

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Many engineering programmes have hardly changed over the past 30 to 40 years. We can no longer stick our heads in the sand and refuse to see that both technology and society are fundamentally reshaping the engineering profession.

Aldert Kamp, 2016
Acknowledgments

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Resumo

O mundo atual tem sido frequentemente descrito como volátil, incerto, complexo e ambíguo (VICA). A realidade do trabalho está a mudar a um ritmo mais rápido do que nunca e o acesso livre a informação nunca foi tão generalizado. De forma a preparar os estudantes para um futuro cada vez mais complexo e para os qualificar para carreiras de sucesso, as instituições de ensino precisam de se reimaginar e garantir o acesso dos seus alunos a informação e ferramentas curadas e relevantes, para lá do conhecimento técnico tradicional. Nos últimos anos, o Técnico tomou um passo importante neste sentido ao desenvolver o novo modelo de ensino Técnico 2122. Este trabalho tem como objetivo apoiar a implementação deste novo modelo focando-se num aspeto crítico da educação em engenharia no século XXI: desenvolvimento de carreira.

Várias abordagens diferentes ao planeamento de carreira são possíveis e válidas. Ao longo deste trabalho, são apresentadas diversas iniciativas de outras universidades líderes, são analisados os sistemas atuais do Técnico e é feita uma revisão das principais teorias de psicologia vocacional. As perspectivas das principais partes envolvidas no desenvolvimento de carreira de estudantes de Engenharia Aeroespacial (alunos, alumni, órgãos da universidade e empresas da indústria Aeroespacial) são analisadas de forma a identificar os principais problemas e possíveis soluções. Por fim, é proposto um conjunto de sugestões para contribuir para um sistema de planeamento de carreira mais coerente, através da adaptação ou desenvolvimento das práticas atuais ou da introdução de novas iniciativas.

Palavras-chave: engenharia aeroespacial, planeamento de carreira, educação em engenharia, competências transversais, psicologia vocacional
Abstract

Today’s world has been frequently described as volatile, uncertain, complex and ambiguous (VUCA). Changes in the world of work are taking place at a faster pace than ever before and access to information has never been greater. In order to prepare their students for this increasingly complex future and to qualify them for successful careers, education institutions need to reimagine themselves and provide curated access to information and relevant tools beyond the traditional technical knowledge. In recent years, Tecnico took a great step in this direction by developing the Tecnico 2122 model. The present work aims to support the implementation of this new teaching model by focusing on one critical aspect of 21st-century engineering education: career development learning.

Several different approaches to career planning are possible and valid. The present work presents various initiatives from other leading universities, analyses the systems currently in place in Tecnico and gives an overview of vocational psychology theories that typically inform this kind of interventions. The views of the main stakeholders of the career development process of Aerospace Engineering graduates (students, alumni, university bodies and Aerospace companies) are analysed in order to identify the main problems and possible solutions. Finally, a set of suggestions is proposed to contribute to a more coherent career planning system by adapting or developing current practices and introducing new ones.

Keywords: aerospace engineering, career planning, engineering education, transversal skills, vocational psychology
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List of Abbreviations

ABET  Accreditation Board for Engineering and Technology.
AEDCP  Aeronautics, Space and Defense Cluster Portugal.
AEIST  Students’ Association of Tecnico.
AGUPP  Airbus Global University Partner Programme.
ASEE  American Society for Engineering Education.
BEST  Board of European Students of Technology.
CDIO  Conceive Design Implement Operate Initiative.
CP  Pedagogical Council.
ECTS  European Credit Transfer and Accumulation System.
ENAEE  European Network for Accreditation of Engineering Education.
ESA  European Space Agency.
EUR-ACE  European Accredited Engineer.
FEANI  European Federation of National Engineering Associations.
GCRP  Public Relations and Media Office.
GDP  Gross Domestic Product.
HE  Higher Education.
IFEES  International Federation of Engineering Education Societies.
ILS  Index of Learning Styles.
IoT  Internet of Things.
MBTI  Myers–Briggs Type Indicator.
**MEAer**  Master's Degree in Aerospace Engineering.

**MOOC**  Massive Open Online Course.

**NAPE**  Student Support Unit.

**NDA**  Academic Development Unit.

**NGO**  Non-Governmental Organisation.

**OEIST**  Graduate Employability Observatory.

**PREFER**  Professional Roles and Employability of Future EngineeRs Project.

**SEFI**  European Society for Engineering Education.

**STEM**  Science, Technology, Engineering and Mathematics.

**TT**  Technology Transfer Office.

**UAV**  Unmanned Aerial Vehicle.

**VUCA**  Volatile, Uncertain, Complex and Ambiguous.
Chapter 1

Introduction

As many authors point out, a good engineer, particularly the one of the future, is not just someone who possesses a lot of knowledge about several technical and specialist disciplines. The ability to synthesise, to think creatively, to develop different types of thought, to address socially-relevant problems, and to integrate and connect seemingly unrelated topics, will be much more relevant in the 21st century [1–3].

The roles of engineers in the industry and in society in general are increasingly diverse and students need support and guidance in understanding the type of engineer they want to become and developing the necessary skills for their professional life.

The present work does not concern a particular Engineering discipline, but is rather an attempt to systematise and improve the career support offer in Tecnico, which will potentially have a positive impact in the development of several engineers in the university. It embodies an analysis of best-practices regarding career support in Europe, input and feedback from students, industries, educators and relevant university bodies, and an implementation plan based on the insights gathered.

The motivation behind pursuing a topic that was far from the conventional type of Master’s thesis was to create something that would have a real impact in the lives of people. The original proposal for the thesis was more focused on understanding the key competencies and skills sought by the industry and how they could be integrated in the Aerospace Engineering curricula. This issue has been widely explored in the works of several authors and institutions and its implementation in the Tecnico curricula has been outlined in the Tecnico 2122 model (section 1.1.2).

At the beginning of this project, the idea of creating a decision support system for Aerospace Engineers to either choose courses or career paths was also explored. The idea was dropped due to the fact that there was a lack of literature in the area, the data available to develop the system was poor and difficult to collect, the discovery of a career path is an exploratory process and not a simple decision, and, finally, the implementation of the results in any form was very remote.

Finally, the decision was made to focus the scope of the work in the field of career planning as it was a less explored topic in the context of the Tecnico 2122 model and one that the author felt as one of the main issues as a student.
1.1 Motivation and Context

In a world that is rapidly changing and where there are great uncertainties regarding the world of work, the idea of mass production of professionals for predefined jobs is outdated. The relevance of a student-centred Education is bigger than ever. Therefore, it is urgent to introduce the concept of career planning, give students access to a wide range of relevant information and opportunities, and defy them to think critically about their aspirations and goals as individuals [4].

Airbus identifies some of the key areas that are not traditionally tackled in Engineering curricula but are essential to the future engineers, in the White Paper “The Engineer of the Future”, by the Airbus Global University Partner Programme [5]:

“Enterprise education, commercial awareness, intercultural awareness and career development learning are not traditionally seen as core or mandatory aspects of engineering and STEM degree programmes more generally yet they are absolutely key to an employer and graduate employee.”

To design a system that gives Aerospace Engineering students the opportunity to learn about career development and develop some of the key skills needed to thrive in their careers, which could be extrapolated to other degrees in Tecnico and eventually outside of the faculty, is the main goal of this work.

1.1.1 Personal Interest and Experience

The personal interest in the topic of Education stems mainly from the author’s learning experiences in the Portuguese educational system. Even with all its excellence features and diverse optional paths, in most classes or degrees the idea of a “one size fits all” Education is still very present and there is little institutional support for making informed career decisions.

Another factor that contributed to this motivation is the involvement in the Board of European Students of Technology (BEST), specifically in the field of Educational Involvement. The author took part in several projects and events with the goal of raising students’ awareness about educational matters, gathering their opinions about Higher Education (HE) and disseminating these results to European HE stakeholders. This was a unique opportunity to contact and work with diverse important players in Higher STEM Education, such as thought leaders, policy-makers and researchers. The experience motivated the author to take action and keep working towards an Engineering Education system which is inclusive, socially-responsible and capable of facing the demands of the Volatile, Uncertain, Complex and Ambiguous (VUCA) world.

Additionally, the author studied Models and Interventions in Vocational Psychology, from the Faculty of Psychology, as an elective course, featuring several important concepts and models related to career development and the underlying psychology theories. This experience, besides giving the opportunity to contact with different teaching and learning approaches, also had a very important role in the motivation to develop further work in the area.
1.1.2 Tecnico 2122 Model

Following international expert recommendations and its strategic alignment, Tecnico is invested in reviewing and updating its teaching methods and curricular structures in order to keep up with current trends and best practices in Engineering Education worldwide. With this in mind a commission was created in the beginning of 2018 to analyse and reflect upon the current situation and possible improvements to the educational offer for undergraduate and graduate programmes.

The result of this work was a final report (Portuguese only), published in February 2019, after consultation from the school, from relevant stakeholders and from external experts [6]. This report includes a proposal of a new model for the faculty, Tecnico 2122, and an implementation strategy, aiming at applying the model in the academic year 2021/2022.

This model proposal includes several actions divided in 3 main fields:

- Curricular structure, organization and philosophy;
- Pedagogical practices;
- Human and material resources and teaching staff management.

The present work aims at finding ways to support the implementation of some of these changes, in particular, one critical measure that still lacks specific actions to be taken: introduction of a career planning concept. This measure is included in the Curricular structure, organization and philosophy bundle and is tightly related to another measure of the same group: increase in curricular flexibility.

The implementation of the latter measure has drastic implications in the curricular structure of all the degrees in Tecnico. Students will have more flexibility regarding the courses they take and will have to make choices earlier in their careers in Tecnico. There will be a wider range of disciplines and minors to choose from and these options will be made more often by students.

These changes will put more responsibility in students which will need to be better informed about their options and about the implications that such choices can have in their careers inside and outside the university.

The rationale for the measure about introducing a career planning concept, is to give students the tools to make mid to long term plans for their careers, allowing them to make informed decisions regarding their career options and alternative curricular paths. This can be achieved by introducing, early in the students paths, career planning sessions and activities, as well as promoting their participation in career discovery initiatives and in extracurricular activities.

It is expected that these changes will give students more autonomy and promote their pro-activity.

Initiatives with the goal of supporting students already exist in Tecnico, such as the Mentor Programme from the Student Support Unit (NAPE), the Tutoring Programme from the Academic Development Unit (NDA) and the Career Discovery Programme from the Technology Transfer Office (TT). These initiatives and the resources available in each of their responsible bodies will be discussed in section 2.1.2.
The present work analyses strengths and weaknesses of these existing programmes, explores different possible solutions and suggests a set of actions to be implemented to support the Tecnico 2122 model.

1.2 Objectives

Career planning and curricular flexibility are very important for several reasons, such as allowing students to focus on fields that are better aligned with their personal goals and aspirations, which is shown to increase their motivation and positive attitude towards learning [7]. Students’ ideas and beliefs about the nature of the engineering profession and about their career goals, can have a very positive impact in their learning process as well [8].

The development of career education and career planning practices has had many faces, highly dependent on contextual factors and with different approaches for each application. Nevertheless, four main general goals can be identified [9]:

• Developing employability and adaptability skills;

• Encouraging the personal development of the individual;

• Helping students choose between educational options;

• Encouraging societal integration.

With these general goals in mind, the main objective of the present work is to develop a system to support Aerospace Engineering students in Tecnico in acquiring some important knowledge and skills for their careers, having a more positive approach towards learning, making better decisions regarding their curricular and extra-curricular options and developing career goals which are relevant for society and aligned with the school position.

In particular, the systems currently in place both in Tecnico and other reference institutions were studied and the views of students, alumni, companies and university bodies were gathered. Based on these insights, a set of suggestions was developed in order to improve the current programmes and systems or to create new ones.

1.3 Research and analysis methods

The methods used in the present work are partially derived from social sciences studies, but the biggest focus was put on the applicability of the outcomes rather than on the procedural rigour that often characterizes sociology studies, for example. Some concepts from the grounded theory were applied, such as the balance between objectivity and sensitivity when analysing data, as well as an effort to gather data from various sources and be in close contact with the real world when inductively developing a theory [10]. The original research design was mostly inspired by mixed methods research since it includes the collection and analysis of both qualitative and quantitative data in response to the research questions,
but defining it as a convergent parallel mixed methods research is not completely accurate since not all the procedures inherent to this type of research design were followed [11].

The research process conducted was emergent, as it is typically the case for qualitative studies, meaning that the specific objectives and processes used were changed or shifted after the beginning of the research, as new data was gathered and integrated into the project.

The main research question being addressed is “How can Aerospace Engineering students have better career planning support?”. In particular, the goal is to understand what can be changed or added in the current activities, programmes and curricula in Tecnico to better support these students in their career planning process. To address this issue, five subquestions were tackled:

- How do Aerospace Engineering students plan their careers?
- How do current bodies and programmes in Tecnico support students?
- What are the best practices in terms of career support in European universities?
- What is the state of the art in vocational psychology?
- What are the needs and expectations of the Aerospace industry?

To answer these questions, in addition to an extensive literature review in the fields of vocational psychology, career development, engineering education and future trends in engineering and employment, there was an effort to understand the views of students, alumni, Aerospace companies and representatives from different university bodies. These insights were gathered through a combination of questionnaires and semi-structured interviews by video call with some of the stakeholders.

In total four questionnaires were created, disseminated and analysed: one for European engineering students (N=32, results in section 2.1.1), one for Aerospace Engineering students from Tecnico (N=203, results in appendix A), one for Aerospace Engineering alumni from Tecnico (N=39, results in appendix B) and another one for Aerospace companies in Portugal (N=14, results in appendix C).

The semi-structured interviews conducted can be divided into two groups based on their relation to the project being developed. Let’s call them external interviews and internal interviews. External interviews involved individuals not currently connected to Tecnico or to the possible implementation of the suggestions being presented. These interviews were designed to understand best practices in other universities and gather ideas for possible implementations in Tecnico. Internal interviews involved the stakeholders of the career planning system being introduced. They were designed to understand the functioning of current systems in Tecnico, gather feedback to refine the suggestions being presented and, at the same time, raise the interviewees’ awareness of the problems being tackled and involve them in the discussion. The interviews did not have a common script and the questions asked were prepared for each of them independently subject to the context of the interviewee and the information sought at each stage of the research. The interviews were also complemented with information shared through email and text messages with the people involved.

In terms of external interviews, there were nine calls in total, which supported the information gathered online from public sources. These calls were mostly with individual students of the universities
being studied, except for the cases of UCL Engineering (there were two calls, one with a degree co-
ordinator and another with the careers office team), ISAE-Supaero (the call was with three students)
and KU Leuven (the call was with a researcher from the PREFER Project and it was mostly related to
this project and its implementation). It is also worth noting that the students contacted from TU Delft,
ISAE-Supaero and NOVA SBE were former Aerospace Engineering students in Tecnico, so they were
able to draw valuable comparisons.

When it comes to internal interviews, they were quite diverse in terms of scope and content, but
generally there were two phases, one exploratory and another confirmatory. The former, which took
place between April and July 2020, had the goal of connecting information previously gathered and
developing hypothesis for the solutions. The latter, which took place between September and October
2020, had the main goal of confirming and gathering feedback about the proposed suggestions.

The university bodies that were reached were the MEAer coordination, the Pedagogical Council
(CP), the NDA), the NAPE, the TT and the Graduate Employability Observatory (OEIST). Outside of
Tecnico, a Human Resources professional, specialized in Aerospace industries, and the coordinator of
an Aerospace industry cluster were contacted.

1.4 Thesis Outline

The present work is divided in five main chapters: Introduction, Career Planning and Mentoring, Career
Paths for Aerospace Engineers, Career Planning System and Conclusions. The second and third aim at
introducing concepts and analysing different aspects of career planning, while the fourth proposes some
suggestions for improving the career support for Aerospace Engineering students. The suggestions
proposed are supported by the research presented in the other chapters and by the results of three
surveys, presented in the appendices. The Conclusions chapter summarises the main outcomes of the
work.

The chapter Career Planning and Mentoring explores different career planning and mentoring prac-
tices in Tecnico and in other relevant institutions. Without diving into many technical details, an overview
of Vocational Psychology literature is also done to contextualise some of the practices with the relevant
theories and psychology research.

In the chapter Career Paths for Aerospace Engineers, the curricular changes being implemented in
Tecnico are mentioned, with an emphasis on the impact they have on the curricular options for future
Aerospace Engineering students. Some ideas and concepts related to engineering roles are discussed,
in particular, the PREFER Project is explained in some detail. Lastly, there is a brief overview of the main
current trends in education and the labour market, as well a short analysis of the Aerospace industry
and expected future developments.

The chapter Career Planning System draws ideas presented in the other chapters to contextualise
and support the insights presented in the form of actionable items. Not only the desired outcomes are
presented, but also some specific recommendations about the possibilities of implementation, which
have been created with the opinions of some members from the bodies involved being taken into ac-
count.

The *Conclusions* lay out the expected impact of this project and highlights some considerations regarding future work in the field, based on the information gathered, which do not fit into a specific suggestion.

Finally, the appendices summarise the insights gathered from the questionnaires done.
Chapter 2

Career planning and mentoring

Career planning can be defined as the ongoing process of matching career goals and objectives with the individual's aptitudes, personal preferences and career choices. The process of exploring different possibilities for the student's career and learning about the job market will be referred to as career exploration. All the activities and initiatives that aim for preparing the student for their integration in the job market (such as workshops about job interviews or courses on career-related skills) will be referred to as career training. Career support refers to all the activities that generally contribute to the students' career planning process, in which career training and career exploration initiatives are included. The term career development and career planning will be used interchangeably in the context of this work.

The term mentoring can have several different meanings and connotations. Throughout this work, it will be defined as a general process in which someone perceived as more experienced or knowledgeable (mentor) supports someone perceived as less experienced (in this context, a student) in achieving predefined goals. Mentoring programmes can be a powerful tool to support career planning in general and career exploration, and many different existing systems will be explored in this chapter.

In the context of this work, the desired outcome of the career planning process is making decisions about alternative curricular paths and extracurricular opportunities that improve students' motivation and confidence in their careers.

In view of the changes proposed by the Tecnico 2122 model, the underlying idea is that students should develop a personalized training plan aligned with their career goals, with the objectives and learning goals of their degree, and with their personal needs and interests. This plan should be developed throughout their path in the university and revised on a regular basis. In order to do so, the students should be supported by the school and its bodies.

There are currently several initiatives aimed at supporting students in learning more about their possible training and learning paths and exploring different possibilities regarding their careers. Such initiatives are developed and promoted by different bodies, such as the Pedagogical Council, NDA (Academic Development Unit), NAPE (Student Support Unit), TT (Technology Transfer Office), AEIST (Students' Association of IST), BEST Lisbon (Board of European Students of Technology) and other students' nuclei. Some of these initiatives and their objectives will be highlighted in the following section while the
main problems and constraints will be further explored in chapter 4.

2.1 Review of Best Practices

2.1.1 External Practices

Examples from leading institutions have been studied by reviewing existing literature, analysing the results of a short survey and conducting unstructured interviews, as described in the section 1.3. This benchmark is particularly relevant considering the principle of imitating best practices in leading institutions that is present since the genesis of Tecnico and highlighted by its founder as a recommendation for the future developments of the institution [12].

In an exploratory step, a survey was created to get a broad overview of the situation in European universities regarding career planning and mentoring systems, and was disseminated in the author’s personal network. The survey, disseminated between the 10th and 15th of April, collected 32 answers from students from 27 different European technology universities (no Portuguese university was considered).

One interesting observation from the survey is that only 3 out of 32 students “agree” or “strongly agree” with the sentence “In my university, I feel supported in making decisions regarding my career”. Also interesting to note that 13 out of 32 students answered that there was no mentoring system in their universities; even if it is possible that such a system exists, it is not very encouraging to notice that so many students don’t know about any mentoring system. Since the number of answers and questions of this survey is very low, no major conclusions can be drawn. Only one university with very good practices has been identified and was subsequently studied further: ETH Zurich (Switzerland).

The universities were chosen to ensure a diverse sample of top universities with some particularly relevant features in terms of career planning, based on the author’s knowledge and research about top universities. In particular, ETH Zurich and UCL Engineering were included for their outstanding prestige; TU Delft and ISAE-Supaero were included for their relation with Tecnico and for being particularly recognised in the field of Aerospace Engineering; and NOVA University of Lisbon for being present in the same city as Tecnico.

Before getting into details about the highlights from each university, it is relevant to point out that these are only some features and practices in place in the universities considered and are not a fully comprehensive review of all the systems taking place.

ETH Zurich

The Swiss Federal Institute of Technology in Zurich (ETH Zurich) is a public research university dating back to 1855 and currently with over 21,000 students. The university is focused in STEM fields and it is ranked 6th (2nd in Europe) in the QS World University Ranking 2020 [13].

An interesting service worth highlighting is the free-of-charge and on-demand individual advice on choosing a study programme. This is aimed at potential students even before they apply for any programme at ETH.
A similar on-demand advisory service/coaching is also available for all students throughout their path in ETH and up to one year after graduation. This service aims at supporting the students in different career-related topics such as personal assessment, application strategy, interview preparation and support in career decisions. Additionally, several guidelines and online tools to support students in these topics are available on the university website.

Another very interesting feature is that every Master's Programme is tutor-driven. This means that each student is assigned a tutor (professor) that helps them create an individualised curriculum, aligned with their interests and strengths. The tutor discusses with the student the choice of courses and approves the choices. This individual study plan is formalised in a Learning Agreement and accessible online. The students have the possibility to select and change their tutor.

Regarding support in the job search, ETH uses a platform called ETH Get Hired which is managed by ETH Career Center and a non-profit organization of ETH Zurich. The platform is also available for job seekers in general, not only to ETH students.

**UCL Engineering**

University College London (UCL) was founded in 1826 and is ranked 8th (4th in Europe) in the QS World University Ranking 2020 [13]. UCL Engineering is one of its 11 faculties and it comprises 11 departments. In 2014, the Integrated Engineering Programme (IEP) was launched and it has been one of the most interesting case studies in the field of innovation in Engineering Education, being featured in *The Global State of the Art in Engineering Education* report [14].

In terms of Career Planning and Training, UCL Engineering has an approach that can be considered counter-intuitive. While many programmes strive to find the weaknesses of the students in terms of career-related skills and try to strengthen these areas, the IEP is focused in finding students strengths, applying them in team projects and developing them further. Each student is given access to the StrengthsFinder 2.0 online assessment tool in the beginning of their studies [4]. This model identifies the student’s “strong talents” in 34 themes (such as adaptability, communication or ideation) and suggests “ideas for action” for the people with “strong talents” in each theme, as well as recommendations on how to work with others with said characteristics [15].

Throughout the 3 to 4 years of the programme, the students take part in several multidisciplinary intensive projects in which they have the chance to apply their strengths to solve real-life engineering problems and learn how to work in a team of colleagues with a diverse set of strengths. During these projects, the teams are supported by a mentor/teaching assistant who helps the team solve possible conflicts and use the members’ strengths in the best way possible. The underlying idea is that, by the end of the programme, the students have a very clear understanding of their strengths, the added value they can bring to a team and how they have applied those characteristics to solve problems in the context of a project.

In terms of career support systems for students, there is a careers team dedicated to UCL Engineering which is part of the UCL Careers. This team is the central body for career planning, exploration and training, helping students align their career goals with their personal characteristics, providing infor-
mation about career-related and recruitment opportunities and also carrying out some workshops and events. There is also an on-demand one-to-one consulting/coaching service for students, handled by the careers team, which is composed of career consultants from diverse backgrounds.

Regarding platforms, there is an Engineering Careers Moodle page and all the career services, including job opportunities, are accessible through the myUCLCareers platform by TARGETconnect.

**TU Delft**

The Delft University of Technology (TU Delft) is a public university founded in 1842, currently with over 19000 students. The university is ranked 50th in the QS World University Ranking 2020, being the 15th in the field of Engineering and Technology [13], and is known for its innovativeness especially in the field of Engineering Education, being also featured as one of the 4 case studies in *The Global State of the Art in Engineering Education report*. TU Delft is one of the mobility options for Aerospace Engineering students in Tecnico.

Similarly to the previously discussed cases, TU Delft provides one-to-one appointments with a career counsellor or with a psychologist. For more specific counselling, regarding the choice of subjects, for example, there are dedicated academic counsellors in each faculty. There are also walk-in hours for each of these services for clarifications that don’t require a specific appointment.

Another interesting feature provided by TU Delft is the Career Toolkit which is an online tool that makes all the services related to careers more accessible to students. It comprises resources of different units inside the university as well as external complementary sources that support students in all areas related to their careers. This section of TU Delft website, “Managing your career” is also connected to other related pages with the goals of helping students make study choices, improve study skills, work with others and develop self-awareness and self-management.

The Faculty of Aerospace Engineering is one of the 8 faculties of the university and is one of the most prestigious in the field worldwide. In 2016, a Mentor Alumni Programme (MAP) was launched to connect Aerospace Engineering alumni as mentors to Aerospace Engineering students, and has supported over 600 students. Mentors use their experience to advise students and support decisions regarding their study paths, ambitions and future careers. This programme is still growing and currently is only available for Aerospace Engineering students.

**ISAE-Supaero**

ISAE-Supaero is one of the most prestigious French engineering schools, created in 2007 by the merging of ENSICA and SUPAERO. The university is focused on Aerospace Engineering and currently has 1700 students, 34% of which are international. Supaero has very strong connections to the Aeronautic industry, partly because of the geographical location in Toulouse. Supaero is one of the mobility options for Aerospace Engineering students in Tecnico.

Some of the most important factors contributing to excellent career support, according to students who completed the first cycle in Tecnico and then moved to Supaero, are presented below and supported
by data from the annual report of the university [16].

- Strong connection with industry (support from 250 companies; formal partnerships with more than 30 firms).
- Lectures from industry experts on different topics (pool of 1800 lecturers from high-tech companies and academia).
- Professors are more aware of the most important skills, knowledge and software required by the industry. Additionally, they provide real life examples of application of technical knowledge in industrial context.
- Some projects in the courses are proposed by companies and the students are provided real life data to work with. It is also relevant to note that all projects are team projects.
- Professors are more approachable and work as informal mentors. This is possible due to the high ratio between professors and students.
- Many job and internship opportunities available through the JobTeaser platform.
- There are career related workshops and activities delivered by external entities which are included in the students’ schedule. The career centre, which organises these workshops and manages the job opportunities, has an open office policy to support students in any career related issues, including follow-up from the workshops.
- Access to an updated database with information from alumni with their curricular paths, current professional positions and with the contacts from some of them.

One astonishing difference between Supaero and Tecnico, which makes some of these things possible, is the amount of funding per student, which is more than four times higher for Supaero [16, 17].

It was also mentioned that there are informal peer-tutoring initiatives organised between students, but mostly for local students. Even without a formal tutoring or mentoring system for all students, the strong connection with the industry and the availability of lecturers, allow for extremely valuable opportunities for students to get advice and support for their curricular and career decisions.

**NOVA University of Lisbon**

As a final example of best practices in the field of career support, we will discuss the systems in place at the School of Business and Economics and the School of Science and Technology of the NOVA University of Lisbon. NOVA was founded in 1973, and is the youngest of Lisbon’s three public Universities. The University adopted a model that stresses interdisciplinary approaches, technological developments while, at the same time, safeguarding offerings in traditional academic domains including medicine, sciences and humanities. Currently, NOVA FCT has around 8000 students and NOVA SBE has around 2500.
School of Business and Economics (SBE)  Business schools typically put a stronger emphasis on career support systems than engineering schools and NOVA SBE is a good example of it. The school provides a career development programme embedded in the curricula. The Building your career programme is focused in helping students improve their self-awareness, gain knowledge about the job market, develop a career plan and engage in recruitment processes, with the final goal of deploying a meaningful career.

This programme is presented to Master’s students as a mandatory course without any ECTS, meaning that there are some mandatory activities but the depth of involvement depends on the student’s interest. The students have to participate in some of the workshops provided, covering topics such as CV creation or job interview practice.

From the point of view of a student that changed from Tecnico to this school, the fact that participation is mandatory is a great feature because only after engaging in such activities did they realise the importance and value of career planning.

There are also several online tools available to help students learn about the market and job hunting. Examples of such platforms are Goinglobal, Vault, PrepLounge, Graduate First, Fitch Learning, Big Interview and VMock. In order to access job and internship opportunities, as well as the events, counselling, and other career-related resources, students have the Nova SBE Career Center platform by JobTeaser. This is a central platform that connects all the career-related services and opportunities for students.

Included in the Building your career programme, there is also a mentoring programme in which students are paired with alumni to receive insights on entering the job market, based on the know-how and experience from the alumni. Additionally, the careers office provides an opportunity for students to consult with experienced counsellors to get career advice or feedback.

School of Science and Technology (FCT)  Regarding FCT, the main point to highlight in this context of best practices is not the career support system but rather the innovative curricular profile which emphasises many career-related knowledge and skills. The FCT Curricular Profile includes five-week activities between the first and second semesters of each year for all Bachelor and Master’s degrees. The structure of the curricular profile is presented in figure 2.1.

From the first year of university, students get support for developing transversal skills that are relevant for their subsequent work in the degree and also important for developing their careers. All these courses and activities contribute for students to get a better understanding of the job market and awareness of different professional roles. This element is a distinctive feature of FCT graduates, contributing for their employability and professional success, in particular in their first job.

Similarly to SBE, FCT uses the JobTeaser platform. From the perspective of a student, the university does not promote it enough and some students end up missing what is published there.
Main outcomes

One of the things that stand out from this analysis of best practices is that all the universities discussed have a central platform that incorporates all the information and tools related to careers. This is done to different extents and using different tools. Some use a custom created platform while others use software provided by a third party. It is difficult to identify which would be the ideal option since there are pros and cons to all of them and the differentiating factor is not the platform itself, but rather its implementation (as we can see from the differences between NOVA SBE and FCT).

Another important feature is the offering of individual advice or coaching, either in the format of walk-in hours or scheduled appointments. This is useful to function as follow-up to the workshops or career events to support students implementing their learnings, for example in the construction of their CV. It is also important that the students are aware that they can use this service for free and clarify how they can make use of it.

As we will discuss later, it is crucial that students develop their self-awareness, increase their understanding of the job market and that they develop some career-related skills that will not only increase their employability but also help them make better career decisions. These can be achieved in many
different ways and from the examples analysed, we can gather some ideas:

- Provide tools (such as strengths or interests assessments) and activities (such as counselling sessions or workshops) that promote self-awareness;

- Integrate collaborations with the industry in the curriculum (such as lectures given by industry experts or projects in collaboration with companies);

- Provide workshops or courses on transversal skills (such as leadership training or interview practice).

There is no ideal way for a university to provide career support because the process is too complex and is dependent on several variables, such as the engagement of the involved parties as well as the resources available. The practices presented here have had a positive impact in a large number of students but are obviously not universally effective. We will now focus on the current practices in Tecnico trying to identify what is working well and what can potentially be improved.

### 2.1.2 Internal Practices

Since its foundation, Tecnico has always been a reference on the national and European panorama of Higher Education. There have been several initiatives developed to support students in their academic life and in their transition to the job market, which have contributed to the establishment of Tecnico as a leading institution in Portugal. Such initiatives have been developed by different bodies of the faculty and have been constantly improving since their implementation based on feedback and evaluations.

With the goal of improving the relationship of the students with the school, NAPE was created in 1990/91, with a former structure and denomination. The Mentoring Programme was launched in the academic year of 1996/97, as a pilot experience with LEEC students, and it formally became a responsibility of NAPE in 1998/99. This programme has been a great success with very high satisfaction rates and reaching almost all Tecnico students.

In parallel, the Tutoring Programme in Tecnico has been a pioneer of its kind, being for some time the only in Portugal and having clear differences from the typical Anglo-Saxon conception of Tutoring [18]. With its beginnings dating back to 1999 and with a more structured and comprehensive implementation in 2003/04, the Tutoring Programme has had an impact on thousands of students. Currently, this programme is coordinated by the Pedagogical Council and the NDA. [19]

In 2009, Tecnico was restructured and TT was created. This body is responsible for managing Tecnico intellectual property, establishing and maintaining relations with companies and promoting entrepreneurship among students, researchers and professors. This office has developed several initiatives to support students in career planning, exploration and training, helping them in their transition to the job market. Most of these activities have been incorporated in the Career Discovery programme.

In the strategic plan for Tecnico, created in 2015, there are 2 goals connected with these areas: improve Tecnico career services and improve academic success. Many of the actions performed by the bodies mentioned above in recent years, were empowered by and are in line with this strategic vision.
The first goal is strongly related to TT and to the Career Discovery programme, the second is strongly connected to the Tutoring programme from NDA.

In order to better understand the system currently in place in Tecnico, we will look at three of the main programmes related to academic and career development available for all Aerospace Engineering students. Each of these programmes is coordinated by a different unit inside the university, so we will also look at some complementary activities that each of these unities have. We will discuss the Tutoring Programme from NDA, the Mentoring Programme from NAPE and the Career Discovery Programme from TT.

Tutoring Programme (NDA)

As it was mentioned before, the first structured and comprehensive implementation of the Tutoring Programme dates back to 2003/04. This programme was born as an effort from Tecnico to fight the high levels of academic failure and dropout, as well as to promote the necessary support for all students that show difficulties fitting in with the demanding level required by the school.

The programme has been evolving since its creation based in a culture of experimentation with particular degrees and subsequent implementation on a school level. Even though the coordination and evaluation of the programme is done by the NDA, each degree coordination has a certain level of freedom to experiment and implement slightly different models. Throughout the present work, the particular case of Aerospace Engineering will be analysed and some suggestions for experimentations will be presented.

Personal tutoring can have different objectives and areas of application. Some of the general objectives of personal tutoring in Higher Education are facilitating the progress of students in the educational system, contributing for the personal and social development of students, efficiently articulating needs and available resources, and promoting an effective transition from High School to Higher Education and/or from Higher Education to the job market. Despite these general objectives, many different formats are possible for a tutoring system and these can be categorised in diverse ways. For instance, the Mentoring Programme from NAPE can be seen as a system of peer tutoring and the informal tutoring implemented in the Architecture degree is an example of tutoring embedded in the instruction process. [19]

Even though the tutoring system should be adapted to the reality of each degree, there are some general goals that are transversal to all of them. The main goals of the Tutoring Programme in Tecnico are to:

- Keep up with the academic path of students;
- Support the transition from High School to Higher Education;
- Help students practice transversal skills;
- Identify academic failure situations in an early stage;
- Guide students with high academic performance;
• Support activities connected to the Coordination of each degree;
• Promote pedagogical competencies of teachers;
• Contribute to the improvement of the teaching quality in Tecnico.

There are two distinct versions of the Tutoring Programme in place in Tecnico: the tutoring for first and second year students and the “tutoring by request”. The first is the most common, and it aims at serving all the first year students. The main goals are to help the students integrate in the Higher Education system and to identify and allow for early interventions in case of academic failure. The latter is available for all the students from third year or from the second cycle who request it via email to the NDA. It is mostly used by students who complete the first cycle outside of Tecnico.

Most of the tutoring work is performed by the tutors through individual or group meetings with their students throughout the academic year. This work is then monitored by the NDA through semestral surveys to the tutors and through phone calls.

For the “typical” tutoring programme, the students are randomly assigned a tutor in their first week in Tecnico. This tutor is a professor from the same degree as the student and is expected to contact the student to schedule a first meeting. After this, the tutor and the student can define when they will meet and establish personal objectives for the programme. Even though the tutoring relationship is supposed to last for the first two years of the student in Tecnico, in most cases it does not last longer than this first meeting (figure A.7).

Data from the yearly evaluations of the programme [20] and from a survey conducted with Aerospace Engineering students show that not all the objectives of the programme are being achieved and that there are some constraints related to the structure of the tutoring programme. It has been highlighted in the evaluation reports that the main problems for the recipients of the tutoring are a lack of motivation and engagement from the tutors, unclear role of the tutor, unclear goals for the meetings and lack of regular and structured meetings, which are in line with the data collected from Aerospace Engineering students presented in figure A.8. The fact that the tutors are attributed randomly without taking into consideration the areas of interest of students and tutors, may partially explain the difficulties students report in empathising with the tutors.

These problems as well as suggestions for experimental changes will be further discussed in chapter 4.

As a final comment regarding tutoring in general, here are seven “golden rules” for tutoring programmes, highlighted in the book about tutoring programme in Tecnico [19]:

• Define clear objectives so that the students’ expectations can be assessed;
• Clearly define roles and responsibilities of the participants;
• Offer some kind of training to tutors, particularly about how to deal with students successes, failures and behaviours;
• Structure the relevant contents whenever possible, particularly by creating materials for both students and tutors;
• Support tutors, giving regular feedback and creating sharing opportunities among them;

• Ensure that logistic and bureaucratic aspects are as simple as possible and define time commitment expectations a priori;

• Regularly evaluate the programme without overloading the participants.

Mentoring Programme (NAPE)

Since 1998, NAPE has been coordinating the mentoring programme which aims at supporting new students in their reception and integration in Tecnico, provide mentors and mentees with personal and professional development opportunities and to promote networking between all participants of the programme.

As it is explained in the NAPE website:

The Mentoring Programme counts with the support of older students (Mentors) who, on a voluntary basis, with their academic experiences, accompany new students (Mentees) in order to facilitate their integration and adaptation. Mentees can be 1st year students or international students.

During the Welcome Week, Mentors receive new 1st year students on the day of their degree and new mobility students on one (or more) of the Reception Days of their choice. At the Alameda campus, Mentors are assigned on the day of each course at the time of the enrollment. New students will be accompanied throughout the enrollment process by their Mentors.

During the school year, regular monitoring is carried out and activities of a playful nature and personal and professional development take place. Mentees may participate in some activities in which they may meet other new students and Mentors from other courses, the Tecnico and its surroundings and the city of Lisbon.

This programme has a very big reach since most students make use of it at least during the registrations day. Unfortunately it is not useful for all students, especially when at least one of the parts of the mentoring does not take the programme seriously enough. The goal of developing professional skills of the participants as well as promoting networking between all participants is achieved with a reduced number of participants, as these activities are not mandatory and some students do not engage in them. It is relevant to highlight that the mentors have a series of four workshops to prepare them for the mentor role and that throughout the year they have the exclusive opportunity to participate in some workshops for personal development, some of which are focused on career development.

On the other hand, the goal of helping new students integrate in Tecnico and in Higher Education in general, which is the main goal of the programme, is achieved or partially achieved for most participants. It is also relevant to point out that this goal is overlapping with the goals of the Tutoring programme.
Career Discovery programme (TT)

The most comprehensive institutional programme at Tecnico connected to career exploration and job search is the Career Discovery programme, coordinated by TT. This programme comprises several activities and projects that strive to provide students with opportunities to explore different career options as well as to connect with possible future employers.

Not all the activities of the programme are organized by the TT but all of them are promoted by this body and aim at serving students from all the degrees in Tecnico. Apart from the activities organized by TT, the programme includes projects from NAPE, Spark Agency, BEST Lisbon and other students’ nuclei, and it is constantly updating and improving its portfolio. Not all the activities will be explained in detail, but we will look at them for a general overview.

To start with, the Tecnico Career Sessions are a series of 90 minutes presentations aimed at Master’s students taking place throughout the year. These presentations include a time for discussion or clarifying doubts at the end and tackle topics such as the importance of professional career planning and recruitment processes in technical companies.

In the Career Discovery website there is also a page (only available in Portuguese) tackling career management best practices, guidelines about CV creation and information about internships provided by external entities available for Tecnico students. This page does not tackle all aspects of career exploration but is a great first step to giving students an overview of the whole process and some relevant recommendations.

Then, there are the Tecnico Career Workshops, which are available for second cycle students for a fee or for free through the Tecnico Career Scholarships. Each of these workshops has the duration of three hours and is delivered by a professional to groups of 12 to 15 students. The goal of these workshops are to help students navigate career exploration and prepare for job search and application.

Another initiative, which can be considered a programme by itself is the Tecnico Career Weeks. This is a series of one- to five-days events organised by the students nucleus of each degree in the faculty. Even though not all degrees have a dedicated event, the overall offer is quite comprehensive and diverse in terms of industries and companies represented, since the events are generally open to all students. The format and content of each event is the responsibility of the organising group, being the role of TT focused in promotion and facilitation.

The Tecnico Business Cards initiative aims at providing students with professional personalised business cards that they can use in their job search and application process. These cards are provided for free as long as the students fulfill the requirements and follow the application process.

One of the initiatives included in the Career Discovery programme which is co-organised by another unit is the Alumni Talks. This initiative is organised by NAPE together with the TT. It consists of a series of breakfasts held at Tecnico with Alumni and students, where networking and sharing of experiences is promoted in an informal setting. Some of these sessions have specific underlying themes, such as the Consulting Edition or the Women Edition.

The Pitch Bootcamp@Tecnico is a two-days event organised by the Spark Agency and integrated in the Career Discovery programme, available for a fee. This project is a career accelerator which connects...
students and companies and is present in several schools in Portugal. During the event, participants are encouraged and guided to understand their competencies and skills, to realise how the recruitment processes are executed by companies and to pitch themselves to potential employers.

The BEST Inside View is a project organised by the students’ group BEST Lisbon since 2012. It is a job shadowing event where students have the opportunity to follow a professional in their everyday work during one day at the offices of the company. There is also an opening ceremony where students can get to know some of the partner companies in a networking environment.

Going back to the projects organised directly by the TT, another relevant initiative is the Tecnico Summer Internships. These are opportunities for students to experience working in a company between July and September. The duration and type of internship vary from company to company, and the bureaucratic process is handled mostly between Tecnico and the partner companies. The initiative started in 2012 and is currently growing at a fast pace, having had 80% of the internships happening in the last 4 years. The application for these internships is done through the Tecnico Job Bank, which is the penultimate initiative from the Career Discovery programme we will discuss.

In order to provide students with opportunities from partner companies, the TT created the Tecnico Job Bank by Simplicity. In this platform, students can view opportunities for internships, part-time or full-time jobs, specifically directed to Tecnico students. The student can personalise the personal profile with information about their skills and experiences, integrating their CV and LinkedIn profile, so that they can be contacted by recruiters. They can also follow companies and job opportunities in which they are interested. The platform includes a tool called Career Finder, which uses the RIASEC model (further explained in section 2.2) and information from O*NET Web Services. This tool is obviously very limited and does not provide much relevant information for a student or recent graduate, but is a good starting point to emphasise the importance of career exploration and discovery.

Similarly to other universities already mentioned, Tecnico Job Bank is powered by a third party software, in this case the software is called Simplicity. Simplicity serves several universities around the world, mostly American. The Career Services Management solution has much more potential to provide career services to students than the simple posting of job offers, such as a recruiting toolkit or appointment scheduling.

Last but not least, we will mention the Tecnico Alumni Mentoring Program. This program had its first edition in 2017 with a small cohort of students and had the second edition in the current academic year (2019/2020). Interested students are matched with alumni of the school to get support and mentoring for their careers. This programme differs from the Mentor Alumni Programme for Aerospace Engineering students from TU Delft mainly because it is not exclusive for students of a specific degree.

Other initiatives

One other very important organisation working for the extracurricular development and representation of students is AEIST. This association is responsible for several activities and projects as well as for supporting and promoting other students’ nuclei initiatives. In terms of career support, most of the activities are organised in partnership with companies and the main tree are courses and workshops on
career related skills, the AEIST Job Portal and the Jobshop.

The courses vary in length and format, but tackle topics such as public speaking or emotional intelligence. AEIST also provides several language courses. These courses usually have a monetary cost for the students with a discount for AEIST members. There are also workshops on career related topics provided during one week in what is called the Weekshop. The Weekshop has a similar structure to some of the Tecnico Career Weeks from the Career Discovery programme but instead of focusing in one area/industry, tackles topics from recruitment processes to entrepreneurship.

The AEIST Job Portal aims at providing students with job opportunities and is also quite similar to the Tecnico Job Bank from TT. It is tightly connected to the Jobshop, which is a three-day event where companies from all technology fields gather to showcase their opportunities to Tecnico students. It can also be argued that this event has a similar structure to some of the Career Weeks, but again, is not focused in a specific field.

Revisiting the offers by NDA, which is responsible for the Tutoring Programme, it is relevant to highlight in this context:

- The transversal competencies training, provided in partnership with some curricular units;
- An extensive compilation of support materials regarding topics such as ethics or time management, available in their website;
- The coaching sessions, personalised for each student and covering topics such as academic performance, goal setting or study plans;
- And, more recently, the online study rooms, still in a pilot phase.

Most of these activities and projects have little engagement from the students as they are not known to the majority of them. Also the access to these opportunities is not very intuitive. For instance, the request to get coaching support should be done by sending an email to NDA and the support materials are provided as a lengthy list of links which is only accessible through the NDA website.

Another important body in Tecnico is the Institutional Studies, Planning and Quality Area (AEPQ) which collects and analyses large sets of data and information which can be relevant for students in many different contexts. When discussing career exploration and planning it is relevant to highlight the work of the OEIST, which provides relevant statistics for all students on their website. These statistics include general employability data, average first salaries and main employers, both for the whole school and filtered by degree.

Apart from these, there are other career-related activities and tools provided by the several student groups in Tecnico, such as engineering or consulting competitions, exchange opportunities or CV databases shared with companies. Unfortunately, there is no common platform for the promotion of such activities and tracking all of them becomes extremely difficult. It is hard for Tecnico to promote them effectively and it is hard for students who are interested to find them.

Finally, it is pertinent to point out that volunteering in the various student groups available in Tecnico is also a great opportunity to develop career-related skills and to get insights about the professional
world. The type of activity varies greatly but in all of them there are several learning opportunities, from some groups that develop extracurricular projects in partnership with companies to others that organise cultural and social events for students. It is possible to develop some non-technical skills, such as communication or teamwork, as well as to gain knowledge about how organisations function and about how recruitment processes look like.

Main outcomes

When looking at the offer in terms of career-related opportunities in Tecnico it is clear that there is a wide variety of affordable and accessible opportunities for students. On the other hand, the reach of such activities and the engagement levels of students is relatively low.

What has been noticed by the TT as well as by the students’ nuclei is that the promotion of these types of extracurricular activities is quite difficult among Tecnico students as they do not feel the need to engage in them to achieve professional success. There is a strong belief among the student community that in order to achieve career success the only requirement is to complete the degree, so a large portion of students prefer to focus on this objective and not to “waste time” with complementary activities.

As mentioned earlier, the approach in other universities, such as the ISAE/Supaero and the NOVA SBE, is to make some of the career-related activities mandatory (with zero ECTS) in order to make all students experience them. From the feedback from students that have been in Tecnico and changed to those universities, this was a positive feature because it led them to take part in valuable activities in which they would not have participated otherwise.

On another note, there are clear overlaps between the goals and content of some of the activities. Considering that not all students participate in all activities, this is not a very critical issue, but having a better harmonization between all the activities and providing the students with clear information about said goals and content, can have a positive impact in the engagement of students and in the added value that the initiatives provide.

With all this in mind, it becomes clear that some adjustments to the way different career-related activities are planned, promoted and executed, in particular to the way they connect with each other, can produce positive results in the overall outcomes of said initiatives.

2.2 Vocational psychology theories

Interest in vocational guidance can be traced to the fifteenth century but the origin of career development theory is in the 20th century, being the work of Frank Parsons one of the first to tackle this issue [21]. The recent and expected developments in the job market and in the role of professions in society pose a huge challenge to some of the traditional views about career development and vocational psychology.

Since the beginning of the 21st century, career development has been included in a broader approach to personal development, which means that there is an approximation between vocational counselling and counselling in general. In line with this, there is a smaller emphasis on the content of the decisions themselves and bigger attention is drawn to the development of the individual, to equip them
with the right tools to adapt and make decisions that are aligned with their goals. The increased uncertainty about the careers makes the development of adaptability, resilience and coping, as well as a continuous update of skills and knowledge, an integral part of career development [22].

Before getting into details in this chapter, the author wants to point out that this does not aim to be an extensive literature review or a summary of the work developed by several researchers on the topic of Vocational Psychology. The goal of the present section is to give a broad overview of the field to non-experts, by referencing some relevant authors for further readings, and to present some important concepts that influence the rest of the work.

There are several theories and authors that shape the study of career guidance and counselling. Different authors have identified different theories as the most influential ones. We are not concerned about ranking them or choosing one over another, so we will simply do an overview of these main theories. For instance, Leung identifies five big theories[23]:

- Theory of Work-Adjustment (René V. Dawis and Lloyd H. Lofquist);
- Theory of Vocational Personalities and Work Environments (John L. Holland);
- The Self-concept Theory of Career Development (Donald Super and Mark L. Savickas);
- Theory of Circumscription and Compromise (Linda Gottfredson);

These theories share some common ideas but the main differences among them are in their focus and the type of intervention that stem from them. These theories can be divided in three big groups. In very broad terms, the first two theories use the concepts of matching and fit to establish a relation between the characteristics of the individual and the characteristics of a certain job or occupation (trait-and-factor theories). The following two are based on the assumption that the individual and the environment are constantly changing and, therefore, the career development process is never complete (developmental models). The last theory emphasises the dynamic relationship between the individual and the environment, in particular, how the concepts of self-efficacy beliefs, outcome expectations and personal goals of the individual influence and are influenced by the environment (anchored in Learning Theory).

Apart from the concepts and ideas stemming from these three groups of theories (in which some other relevant theories fit), the Social Learning Theory of Career Decision Making and the Planned Happenstance theory will also be discussed, as important models deriving from Albert Bandura’s Social Learning Theory. With that being said, we will be looking at four distinct groups of theories:

- Trait-and-factor theories (concepts of matching and fit);
- Developmental models and theories;
- Social Cognitive Career Theory (concepts of self-efficacy, outcome expectations and goals);
- Social Learning and Planned Happenstance theories.
Despite being tackled separately, the last two groups mentioned stem from the same theoretical background: the Social Learning Theory from Albert Bandura. It is also relevant to note that most of the work and research done in these fields have been conducted in the USA.

2.2.1 Matching and fit

The classical approach to career counselling, systematised by Frank Parsons in 1909, is that every young person needs to make “the greatest decision of (their) life” to make the transition between their education and the job market. There are three broad factors affecting this decision: a clear understanding of oneself (aptitudes, abilities, interests, ambitions, resources, limitations, and their causes), knowledge about different lines of work (requirements and conditions of success, advantages and disadvantages, compensation, opportunities, and prospects) and true reasoning on the relations between the first two [24].

This approach is based on some assumptions which are very questionable nowadays, such as the stability of the individual’s traits, characteristics and preferences, as well as the stability of the job market. Additionally, the interventions aligned with this approach are implied to be a one-time event performed when a transition occurs, while developmental models take into account the fact that the individual is constantly changing.

Several theories, models, tests and inventories have been developed based on this basic concept of matching, also referred to as trait-and-factor theory and correspondence models. Even though most of these tests and inventories are a useful component of career planning and counselling, it is now clear that they are not a solution by themselves.

One of the most notable psychologists in this field was John L. Holland, who extended the trait-and-factor model and developed the Theory of Vocational Personalities and Work Environments and multiple tests that can be self-administered. This theory assumes that people have different interests and traits that can be organised in six personality subtypes: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (RIASEC). Both the individual and the work environment can be described in terms of these six types, based on typological tests or expert observation. With access to the relevant tools and inventories, the individual can evaluate their own characteristics and find out which occupations better fit these characteristics, with minimal counsellor intervention. Being easily-used cheap practical devices, Holland’s instruments became very popular tools and revolutionised the provision of vocational assistance worldwide. Apart from this tremendous impact on practice, Holland’s work also provided the impetus for hundreds of research studies. [21, 25]

2.2.2 Developmental models

Trait-and-factor theory dominated the field for the first half of the 20th century and started being challenged in the 1950s by some ideas related to client-centered approaches and that career development is a lifelong developmental process. [21]
Developmental models stem from the idea that the matching is never complete and is only temporarily achieved when transitions occur, and even then, smaller decisions are still being made. These approaches broaden the study of vocational processes, seeing the vocational decisions as a process being carried out over time. This also opens the way for interventions that are no longer just punctual but assume an educational perspective, in which the emphasis is placed on the development of the individual. [22]

One of the most influential contributions to the field of Vocational Psychology is the developmental model from Donald Super. It includes propositions relating to the trait-and-factor theory, developmental psychology and personal construct theory (from which the self-concept construct derived). This model was developed from the 1950s until the beginning of the 1990s and constitutes the basis for many theoretical developments from other psychologists. [21]

In the core of this theory, there is the life-space concept, which recognises that people play a variety of roles in their lives, most often simultaneously, and that these roles are played in different theatres. Nine major roles are identified (Child, Student, “Leisurite” (no standard term is available to describe the position and role of one engaged in the pursuit of leisure-time activities), Citizen, Worker (including Unemployed Worker and Nonworker as ways of playing the role), Spouse, Homemaker, Parent, and Pensioner) as well as four major theatres (the Home, the Community, the School (including University), and the Workplace). It is important to notice that not all people play all roles, some roles are played simultaneously and that the sequence of initiation and abandoning of roles can be different from individual to individual. Additionally, there is a clear distinction between occupational choice and career, as the first is the process of choosing an occupation and the latter is a much broader concept, which includes the sequence of positions (professional or not) held during the course of a lifetime, some of them simultaneously. [26]

Another important concept from this theory is that the life of an individual can be seen as a maxicycle comprising five different developmental stages (Growth, Exploration, Establishment, Maintenance and Decline). These stages can also be used to describe smaller processes inside each stage, or mini-cycles. Taking into account the changes seen both in the socially acceptable standards of living for each individual and considering that transitions are more diverse and frequent than ever, it may be questioned whether the idea of stages is still relevant.

Also in this theory, to an objective and public perspective of the self, as it is evaluated by psychological tests and by the counsellors, a subjective perspective is added: the self-concept. Self-concept is perceived as a product of complex interactions among several factors, including personal growth and experiences, as well as environmental constraints and stimulation. It is dependent on the individual’s perception of reality and the meanings attributed to their experience.

Just like John Holland, Donald Super also developed several practical tools that became widely used in the field, such as assessment instruments to measure readiness for career decision-making (Career Development Inventory), concern for career development tasks (Adult Career Concerns Inventory), life role salience (Salience Inventory), and values (Values Scale). These assessment instruments became very popular in international research efforts and are the core of the Career Development Assessment
and Counselling (C-DAC) model. C-DAC model combines career assessment and career counselling to help individuals develop career adaptability and to clarify, articulate, and implement their life-role self-concepts. [27]

In short, developmental models introduce the idea of career education and teach us that career development is done throughout the whole life of an individual (life-span) and that it is not only about work-related decisions, but rather about the combination of several distinct roles that the individual plays (life-space). Additionally, developmental models also introduced the concept of adaptability as a critical one in career development and vocational psychology.

2.2.3 Self-efficacy, outcome expectations and goals

Derived from Albert Bandura's general Social Cognitive Theory, Social Cognitive Career Theory (SCCT) was inspired by many other vocational psychology theories, general psychological and counselling domains, as well as the cognitive sciences. One key difference in relation to other theories is how the relationship between the individual and the environment is viewed: while trait-and-factor theories see the characteristics of both as trait-oriented or typological, SCCT emphasises the dynamic relationship between personal attributes and external environment factors. Additionally, while trait- and topology-based theories see the behaviour as a result of the interaction person-environment, in SCCT, the role of the overt behaviour is highlighted as co-determinant of the causal exchange.

This theory uses three key constructs from the general social cognitive theory: self-efficacy, outcome expectations and personal goals, as already mentioned. These can be seen as the building blocks of SCCT, which interact in many ways. The self-efficacy variable is the one that received the most attention in the career literature and it refers to a person's beliefs about their capabilities to organise and execute certain actions required to achieve designated types of performances. Self-efficacy involves a set of self-beliefs that interact in a complex way and can be acquired and modified via four types of learning experiences: personal performance accomplishments, vicarious (observational) learning, social persuasion, and physiological and affective states. Outcome expectations are the individual's beliefs about the consequences of performing a certain action and may be acquired in a similar way as self-efficacy beliefs. Personal goals are defined as one's determination to engage in a specific activity or course of action, or to achieve a particular outcome in the future. [21]

SCCT models how interests are developed, how choices are made and how task performance is influenced by different factors, but what is most relevant to highlight here is that empirical data support the assumption that interests, as well as career choices, are strongly influenced by one's self-efficacy beliefs and outcome expectations. In particular, people are likely to form an enduring interest in a certain activity when they perceive themselves as competent for the task, and performance accomplishments reinforce this interest to the extent that they foster positive self-efficacy beliefs. For instance, it has been shown that the mathematics self-efficacy of students is more predictive of their mathematics interest and choice of math-related courses than either their prior math achievements or math outcome expectation [28]. The opposite is also valid: it is unlikely that an individual will develop an interest in an activity for
which they doubt their competence and expect negative outcomes.

In sum, what is most important to retain from SCCT for the current work is that, in terms of intervention, it is important to expand interests, nurture career aspirations, and facilitate career goal-setting and implementation. Naturally, the interventions that have been proposed or tested have relied heavily on promoting self-efficacy beliefs and outcomes expectations, for example by stimulating exposure to personal mastery experiences and access to accurate information about work conditions and outcomes. Lastly, it is relevant to emphasise that self-efficacy is seen as complementing, and not substituting for, ability, and that large overestimates of self-efficacy can even be self-defeating. [29]

2.2.4 Social Learning and Happenstance

In the 1970s, the Social Learning Theory of Career Decision Making, which derived from Albert Bandura’s Social Learning Theory, was presented by John Krumboltz. Along with the five big theories highlighted by Leung, it is also considered as one of the most influential theories of career development by several authors. By the end of the 20th century, the planned happenstance theory was proposed as an amendment to the learning theory of career counselling, which was an expansion of the social learning theory of career decision-making. The reason for including some reflection about this theory is that it takes into account the role of chance and unpredictability in the career development process, which are increasingly important factors to take into account.

In short, the theory says that individuals are affected by innumerable unpredictable events and that they can also generate events of their own, from which they can capitalise to maximise their learning. Planned happenstance theory sees unplanned events as both inevitable and desirable since they are always learning and growth opportunities. In line with this thought, indecision can be reframed as open-mindedness, which means that the individual should tolerate ambiguity and develop an exploratory attitude. By engaging in this exploratory attitude individuals can discover new possibilities for their careers and develop new interests. [21]

The simple three-step theory proposed by Frank Parsons is insufficient for the 21st century where ambiguity and unpredictability are greater than ever. Therefore, generating, recognizing and encouraging beneficial chance events are a key part of career development. In order to successfully do that, individuals are recommended to develop five important skills: curiosity (exploring new learning opportunities), persistence (exerting effort despite setbacks), flexibility (changing attitudes and circumstances), optimism (viewing new opportunities as possible and attainable) and risk-taking (taking action in the face of uncertain outcomes). [30]

2.2.5 Integrating different models

John Krumboltz said that a good theory is like a well-drawn map which provides a representation of reality that can be very useful in specific situations, despite some inevitable distortions [21]. Even without analysing each theory in detail, we can gather some important concepts and ideas that can be useful in the context of the present work, without deciding which theory is best or whether different career theories
can converge or not.

Taking into account the current trends in the field as well as the expected developments and uncertainty in the world of work and the professions, the interventions must take into account much more than the matching between aptitudes, interests and values of the individual and the characteristics of a certain job. The focus of interventions should be in the subjectivity of one’s beliefs and perceptions, as well as the development of skills and knowledge, to prepare the individual for independent career decision-making throughout life. [22]

Summarising some of the key ideas from different theories which are relevant for the present work:

• Matching one’s aptitudes, abilities, interests, ambitions and resources with the characteristics of certain occupations can be useful to explore and to help narrow down different options but is never sufficient by itself for career planning. The more knowledge and understanding the individual has about the career options and about oneself, the better.

• Understanding that career development is an ongoing complex process and that the development of certain skills and beliefs are more important than the content of individual career decisions is key.

• Understanding the role of self-efficacy and outcomes expectation in career choices allows individuals to work on these beliefs and develop new personal goals.

• Reframing indecision as open-mindedness and having an exploratory approach to career planning can have a great positive impact and make it easier to cope with uncertainty.

• In the process of career development, it is crucial to develop skills such as curiosity, persistence, flexibility, optimism and risk-taking.

• In the construction of one’s career, besides contextual influences, the differentiating success factor is the individual agency and initiative. The way individuals create and explore opportunities and adapt to the circumstances have a great impact in their career.

Taking all these ideas from best practices about career planning and support as well as some key concepts from Vocational Psychology theories, we can now examine the possible career and learning paths for Aerospace Engineering students.
Chapter 3

Career paths for Aerospace Engineers

As many authors, experts and professors point out, many engineering students don’t know what engineering actually is when they join the degree and many of them remain ignorant throughout their studies. In the words of Aldert Kamp, the recently retired Director of Education at TU Delft Faculty of Aerospace Engineering:

“Honestly speaking it sounds quite serious to me that so many engineering students have no clue or whatsoever what engineering actually is. Not understanding that the prime role of engineers is about innovation and designing systems. The students are not aware that those systems actually design society as we know it, are not considering teamwork or communication skills as very important for collaborative design and good engineering. They are not knowing how their future job as an engineering researcher or professional may look like. And even more so, this is not only the case when they enrol in the first year of their Bachelor studies, but even when they are close to graduation of their Master’s five or six years later. These low levels of awareness could be an important cause for low interest in engineering in many countries, and less motivation and poor retention.” [31]

This lack of knowledge and awareness leads some students to have low self-efficacy beliefs and not to develop an interest in engineering practice.

The Aerospace Engineering degree in Tecnico is a particular case because it attracts many students with very high potential that are not necessarily interested in Aerospace a priori (figure A.1). Some students apply for the degree for the fact that it tackles several distinct disciplines (most notably mathematics as well as mechanical, electro-technical and computer engineering), it offers good exchange opportunities and that it has very good employability. For this reason, it is particularly important to offer students alternative curricular paths that enhance their development as future professionals (not necessarily in the Aerospace Industry) and that provide them with opportunities to better understand and develop interests in different areas of the Aerospace Engineering profession.
3.1 Curricular paths in Aerospace Engineering

Aerospace Engineering degree in Tecnico was created in 1991 and the curriculum has been evolving ever since. The last two changes happened in 2014 and 2017, and a new curricular structure, based on the Tecnico 2122 model, was approved in November 2019, to be implemented in the academic year 2021/2022. In this section, we will analyse this new curricular structure, with a special focus on the curricular flexibility and on the improvements introduced since 2014. Both 2014 and 2017 curricular plans consider an “Integrated Master's” format (5 years, 9 “regular” semesters + Master’s thesis), while the Tecnico 2122 model has the first cycle (3 years, 6 semesters) and second cycle (2 years, 3 “regular” semesters + Master’s thesis) separated. The documents explaining the curricular structure in detail can be found on the official website of Tecnico (at the time of writing, the new structure is available in a page dedicated to the new model).

Following best practices in Engineering Education worldwide, there have been efforts in order to increase the flexibility of the curricular paths to better align with each student’s learning goals. In 2017, more flexibility was introduced in the 4th and 5th year as well as a clearer definition of the three specializations/majors: aircrafts, avionics and space. Regarding the first cycle, the only change was in the elective courses options of the third year, which became aligned with the three specializations (pre-majors) and allowed students to experiment the area before choosing their specialization.

Before 2017, the structure and flexibility of the 4th and 5th years was different for each specialization. For instance, the aircrafts branch did not have any electives while the avionics branch had one or two electives per semester. With the curricular plan introduced in 2017, besides the common structure across specializations, the concept of minors was introduced, allowing for students to have a second specialization inside each branch (1 course per semester) and also the “free elective” was introduced, allowing for students to choose one course from any degree in the University of Lisbon, as long as it is approved by the degree coordinator.

Regarding the changes planned for the academic year 2021/2022, one of the most relevant changes is that the 1st and 2nd cycles will be separated, which means that they have to be consistent independently from each other. Additionally, extracurricular activities will be credited up to 6 ECTS in each cycle. Another interesting change is the introduction of 9 ECTS of HASS (Humanities, Arts and Social Sciences) courses, from which 3 are Introduction to Economy or Management and the remaining 6 are for the student to choose from a list of subjects that will be offered by the university.

Another change worth mentioning is the change from Aerospace Seminar I and Aerospace Seminar II (both 1.5 ECTS) to Introduction to Aeronautics and Space (3 ECTS). This new course stays in the first semester of the first cycle, as Aerospace Seminar I was, and Aerospace Seminar II is removed from the fourth semester of the first cycle. The syllabus of the new course is not yet completed but will essentially incorporate the learning objectives of the two Aerospace Seminar courses.

In the final semester of the first cycle, an integrator project will be introduced (“Projeto Integrador de 1º ciclo” - PIC1) where students can work on a project proposed by a company or research unit, on a capstone project (conceptual design of an aerospace vehicle) or on other project-based learning
proposals. This is also the subject in which the 6 ECTS for extracurricular activities can be credited.

With this in mind, students will have to make important decisions regarding their curricular path starting from the first semester of the second year of the first cycle. Typically, the decision points in the first cycle are:

- Year 2, semester 1: choosing HASS courses;
- Year 3, semester 1: choosing the first pre-major and choosing between Introduction to Economy and Management;
- Year 3, semester 2: choosing the second pre-major and choosing an option for PIC1.

Regarding the second cycle, the students will have more flexibility to choose their courses, compared to the current curricular plan. They have the freedom and responsibility of choosing the curricular units for the secondary specialization as well as their minor, whenever they want, depending on the curricular offers in each semester and the limits regarding curricular units and ECTS.

Students have to choose their major (aircrafts, avionics and space), a secondary specialisation inside their major (12 ECTS) and two Aerospace electives (12 ECTS). Then there are 18 ECTS for “free electives” that can be a coherent minor from all the options offered to second cycle students at Tecnico, a “personalised minor” in the context of a personal learning plan (career planning) or another secondary specialisation (adding to the secondary specialisation already mentioned and complemented with a free elective to complete the 18 ECTS).

It is also important to highlight the introduction of the Thesis Project course in the third semester of the second cycle. These 6 ECTS can be used to credit extracurricular activities, to have a course in a topic relevant for the thesis or to start researching for the thesis itself.

Considering all this, the students have to make decisions regarding their studies in the beginning of each semester of the second cycle. In particular the typical decision points in the second cycle are:

- Year 1, semester 1: choosing the major and choosing the first Aerospace elective;
- Year 1, semester 2: choosing the secondary specialisation, choosing the second Aerospace elective and choosing their option for the “free electives” (a minor, a personal learning plan or an extra secondary specialisation);
- Year 2, semester 1: choosing their option for the Thesis Project and choosing the specific subjects inside their secondary specialisation and/or “free electives” (if they did not define them before);
- Year 2, semester 2: choosing their thesis topic.

The Tecnico 2122 model assumes an increase in the curricular flexibility, as well as in the autonomy and co-responsibility of students. Considering this, it is very important to provide the students with all the relevant tools and information, to ensure that they make informed decisions that are aligned with their personal and professional interests and goals.
3.2 Engineering roles

The professional roles of engineering graduates are increasingly diverse. Not only the diversity in the roles and career paths is increasing, but also the diversity of transversal skills required by the labour market, such as entrepreneurship, innovation, communication, teamwork and lifelong learning skills. It is clear that engineers can have very different responsibilities and tasks to perform, which means that the knowledge and transversal skills that they need to employ can vary greatly. Even though these distinct roles are understood and experienced everyday by professionals, students struggle to acknowledge this and to discern which skills (technical or non-technical) they should prioritize in order to become an effective professional [32].

To better understand these different roles, students should be given opportunities to experience them or, at least, to have direct contact with examples from working professionals. Ideally, students would be immersed in different professional profiles that engineers in their field follow in their careers. This, of course, is not feasible due to the virtually infinite possible roles that one can have and to the current structure and content of the curricula. To solve this problem, there has been extensive research aiming at categorising and clustering these diverse roles into a simple model, with a small number of distinct categories students and professionals can identify with. This approach allows experts to design assessment tools that help students better understand which roles are most appealing to them, as well as which roles their skills are mostly aligned with.

Some universities are already incorporating the different professional roles into their curricula by having separate curricular tracks based on these engineering roles and/or by introducing assessment tools to help students understand which roles are most aligned with their interests and skills.

The research on this area includes contributions from many fields, particularly from psychology, education, business and management. We will discuss some of these principles, since relevant ideas are included in different approaches, but we will not be concerned with the coherence of all these different models, since we will focus on a particular model that focuses on professional roles.

3.2.1 Different possible frameworks

From a vocational psychology point of view, there are three main constructs that are typically identified as key for career counseling: interests, needs/values and abilities. Besides these, many other constructs/factors have been identified as important to be considered when thinking about one’s career. We will now look at different possible frameworks and instruments, based on interests, personality types, strengths, learning styles and engineering roles.

Interests

Starting with one of the “big three constructs”, the interests of the individual are a critical factor to evaluate in order to make career decisions. Research has shown that interests are one of the most stable psychological constructs. Especially after age 25 interests are generally very stable. This means
that evaluating interests is an important step to predict and inform career decisions.

The assessment of interests as well as abilities has been done since early applications of the trait-and-factor model and the assessment of needs, values and personality has been incorporated later. Most current models still use the assessment of interests as a key ingredient but fewer models emphasize the importance of measuring abilities, values and personality.

Career exploration that includes interests assessment can be valuable throughout the lifespan. In particular, it has been shown that students who take an interest test and receive a basic interest inventory interpretation are more likely to participate in career exploration activities than the students who did not take an interest inventory test. Therefore, including interests assessment in career planning activities proved to be beneficial by providing important information for the student to develop their potential. [33]

Several interest inventories and tests have been developed and validated throughout the years, but the most popular and widely used interest assessment is the one developed by John Holland included in his theory of occupational themes. This test, also known as Holland Codes or RIASEC, have already been briefly described in section 2.2 and is currently integrated in Tecnico Job Bank through the O*NET Interest Profiler.

Another widely used interests assessment is the Strong Interest Inventory, developed in the 1920s by the psychologist Edward Strong and revisited by other psychologists and researchers in more recent years.

**Personality**

Personality is a very complex and interesting construct to look into as it can be relevant to understand how an individual makes decisions but also to inform or predict the content of such decisions, in addition to the “big three constructs”. Personality influences how people behave, think and react in different situations and throughout time, becoming an important process-oriented construct to be taken into account. There are also other traits that are influenced by or overlapping with personality such as the learning or communication styles.

The most widely used tool to measure personality, both in the context of career counselling and in general, is the Myers–Briggs Type Indicator (MBTI). This indicator allows to score people according to four dimensions which are based on the types identified by Carl Jung. The four dimensions evaluated are extroversion-introversion, sensing-intuition, thinking-feeling, and judging-perceiving. The attractiveness of this model lies on the practicality of the test, the amount of fields that the results can be applied to and also in the extensive research that has been developed using the model.

MBTI is also available in combination with assessments for other constructs, providing a more comprehensive overview to inform personal career decisions. For example, a package including Strong Interest Inventory and MBTI has been developed and widely used in career counseling. By extending the analysis of the MBTI results it is possible to interpret information about the individual's decision-making and project management styles, in addition to communication and learning styles, already mentioned. [33]
**Strengths**

The traditional view in society regarding strengths and weaknesses is that one should focus on their weaknesses in order to improve them and consequently become a better student, professional or citizen in general. Another alternative view, developed by Donald Clifton and other scientists at Gallup, is to put the focus on identifying the strengths and working on them, which has proved to have several advantages in terms of engagement and potential for growth.

One simple way to explain this principle is to reject the traditional view that “you can be anything you want, if you try hard enough”, which despite being inspirational is quite unrealistic, and replace it with the idea that “you cannot be anything you want to be—but you can be a lot more of who you already are”. And by placing the focus and efforts in understanding one’s abilities and in “strengthening the strengths”, the individual will be able to perform better in some specific roles.

Gallup is a “global analytics and advice firm that helps leaders and organizations solve their most pressing problems” and it has developed extensive research in the field of psychology and other topics related to the workplace. Based on its 40-year study of human strengths, a description of the 34 most common talents was created as well as a test to help people understand their unique strengths - the Clifton StrengthsFinder. This test later developed into the StrengthsFinder 2.0 which provides a more extensive and detailed analysis about how the main themes of each person interact and influence one’s life. These results are accompanied by several “ideas for action” for each strength. [15]

The assessment of strengths is quite connected to the assessment of ability, which is one of the main constructs for career counselling. StrengthsFinder 2.0 is a powerful tool with real world applications in the field of engineering curricula such as the Integrated Engineering Programme from UCL Engineering, already mentioned in section 2.1.1. The insights from the assessment are used by the students to better understand and adapt their role in team projects and assignments. These experiences can provide the students with insights about which roles they are more likely to play effectively when they get to the job market.

**Learning styles**

Different roles are also quite connected to different ways of taking in and processing information, which can be defined as learning styles. Effective professionals work well in all learning styles but depending on their role they will inevitably use some modes more than others. Understanding one’s strongest learning styles allows the individual to take advantage of that style to learn and work effectively as well as to develop the less dominant learning styles in order to become a more complete student and, ultimately, a more complete professional. In the same way, educators taking some of these models into account can foster their students’ learning as well as create the environment for them to develop different modes, by teaching in a varied manner.

According to James Keefe, learning styles can be defined as “characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment” [34]. The reason why we are discussing learning styles is
because these are tightly connected to personality types and to the way students process and interact with information which inevitably connects to the way they make decisions, the way they work and the role they will have in their future jobs.

Different students learn better in different ways. For instance, some are very good with abstractions and theoretical concepts, while others prefer facts and empiric observations. The goal of the school should be to equip students with as many tools as possible to operate in different learning styles, since one is not better than another and they will all be useful and necessary to work efficiently as professionals.

Examples of learning styles models include the already mentioned personality MBTI model, the Kolb Model, the Herrmann Brain Dominance Instrument and the Felder-Silverman Model. The latter is the basis of a free online tool called the Index of Learning Styles (ILS) and it classifies learners according to five dimensions: sensing-intuitive, visual-verbal, active-reflective and sequential-global [35].

Richard Felder identifies some strategies to ensure that educators present information in a way that appeals to a range of learning styles, based on the Felder-Silverman model [36].

- Teach theoretical material by first presenting phenomena and problems that relate to the theory (sensing, global).
- Balance conceptual information (intuitive) with concrete information (sensing).
- Make extensive use of sketches, plots, schematics, vector diagrams, computer graphics, and physical demonstrations (visual) in addition to oral and written explanations and derivations (verbal) in lectures and readings.
- To illustrate an abstract concept or problem-solving algorithm, use at least one numerical example (sensing) to supplement the usual algebraic example (intuitive).
- Use physical analogies and demonstrations to illustrate the magnitudes of calculated quantities (sensing, global).
- Occasionally give some experimental observations before presenting the general principle, and have the students (preferably working in groups) see how far they can get toward inferring the latter (sequential).
- Provide class time for students to think about the material being presented (reflective) and for active student participation (active).
- Encourage or mandate cooperation on homework (every style category).
- Demonstrate the logical flow of individual course topics (sequential), but also point out connections between the current material and other relevant material in the same course, in other courses in the same discipline, in other disciplines, and in everyday experience (global).

By being taught in a way that addresses all learning styles, more students can effectively assimilate the knowledge and each student becomes more capable of operating in different modes.
It is also relevant to point out that the concept of learning styles is not universally accepted, as some psychologists believe that there aren’t enough theoretical basis and the instruments used to measure them are not properly validated. [37]

Engineering roles

Moving further away from the psychological models and focusing more in the engineering field, students can be grouped according to engineering roles. Different professional roles presuppose different interests, personality types and strengths, so even though there is not a direct correlation between these constructs, it is relevant to understand and assess some of them to better align students with each role.

There are different models that describe engineering roles. For example, following a study of three hundred job vacancies and validation from engineering recruitment agencies, eight distinct profiles were identified: product, process and automation engineer; maintenance engineering; quality, prevention, environment and safety engineer; project engineer; research and development engineer; planning and work preparation engineer; method engineer; and the commercial engineer. For each of these profiles, different competencies are identified. [38]

As another example, the CDIO syllabus identifies five different roles: the researcher, the system designer/engineer, the device designer/developer, the product support engineer/operator and the entrepreneurial engineer/manager. The syllabus not only defines and details a large set of skills applicable to all roles, but also identifies specific skills (both technical and non-technical) for each of the five roles. It is also specified that graduating engineers are not expected to be experts in all of these roles and that it is even reasonable that they are not experts in any of them. What is crucial is that these students understand the importance of different roles, that they are able to effectively work with individuals in each of the five tracks and that they are prepared to follow a career in any one or combination of these roles. [39]

Conclusion

It is important for students to self-assess and better understand that there are different roles both in academic settings and in the job market. It is also important for educators to recognize that their students have different personalities, interests, strengths and learning styles, and that they will likely have different roles in their professional lives. With these concepts in mind, educators can better understand their students and better provide the opportunities for different students to learn effectively and to develop themselves in alignment with their career and personal goals.

As it has just been discussed, students can be categorized using several distinct frameworks and instruments focused on interests, personality types, strengths, learning styles or engineering roles. The choice of such a framework is arguably immaterial [36], since between the several possible frameworks to work with what is most important is to have a common language to work with. In the context of this work, we will use the Professional Roles model developed by the PREFER Project.
3.2.2 PREFER Project

The Professional Roles and Employability of Future EngineeRs Project (PREFER) is a European Knowledge Alliance co-funded by the European Union. It involves researchers from three European leading technical universities as well as professionals and representatives from companies and European Non-Governmental Organisations (NGOs). The end goal of the project is to reduce the skills mismatch in the field of engineering. As stated in the website of the project, “young engineering graduates often display a lack of self-awareness of who they are as an engineer. The PREFER project aims to help engineering students/graduates with identifying their strengths and weaknesses.” Since 2016, the project has achieved several milestones and is currently in the implementation phase.

Additionally, the project aims at providing students with opportunities to explore a wide variety of engineering roles in the labor market as well as to develop non-technical competencies that are relevant for different roles. With that in mind, some recommendations have been created for students, instructors and organisations.

In order to help students identify their preferred and strongest roles as engineers, the researchers have developed two tests: the PREFER Explore and the PREFER Match. The first can be administered early in the students academic path and is mostly based on the personality traits and interests of the individual. It allows for the student to understand to which extent they align with each of the three roles identified and validated by the project research. The latter requires some understanding of the engineering field and is actually divided in three separate tests, one for each role. It helps students understand how their strengths and weaknesses align with each of the three roles. Both tests are available online for free and are easy to incorporate in any website.

![Professional Roles Model / PREFER Framework](image)

The PREFER project uses the Treacy and Wiersema model, which distinguishes three value disciplines: operational excellence, product leadership and customer intimacy [40]. This model proved to be adequate to describe different engineering roles, both by industries and students [41].

Figure 3.1: Professional Roles Model / PREFER Framework
3.2.3 Professional Roles Model

Based on an extensive literature review, the researchers evaluated two possible models, one with eight profiles and one with three distinct profiles. The threefold model, originally proposed as a value discipline model, proved to be more easily recognised by Human Resources experts. Most participants in the study were able to recognise the three roles in their companies and in the process of recruiting engineers. Some participants pointed out that a job often contains a combination of the three roles. [8]

After refining the framework, three main engineering roles have been identified: operational excellence (focus on process optimization and increasing efficiency), product leadership (focus on radical innovation and research and development) and customer intimacy (focus on tailored solutions for individual clients). The model also proved to be quite flexible, allowing for a combination of the different roles within one job. [42]

A later study with industry expert panels identified the most important professional competencies for each role, resulting in three competency profiles made up of up to nine key competencies, which are presented in the table 3.1 [43].

<table>
<thead>
<tr>
<th>Operational Excellence</th>
<th>Product Leadership</th>
<th>Customer Intimacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive critical attitude</td>
<td>Creativity</td>
<td>Client focus</td>
</tr>
<tr>
<td>Solution-oriented</td>
<td>Innovation</td>
<td>Networking and relation building</td>
</tr>
<tr>
<td>Focus on results</td>
<td>Client focus</td>
<td>Clear communication</td>
</tr>
<tr>
<td>Planning and organisation</td>
<td>Initiative</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Clear communication</td>
<td>Out of the box thinking</td>
<td>Capacity for empathy</td>
</tr>
<tr>
<td>Initiative</td>
<td>Persuasiveness</td>
<td>Focus on results</td>
</tr>
<tr>
<td>Creativity</td>
<td>Vision</td>
<td>Solution-oriented</td>
</tr>
<tr>
<td>Networking and relation building</td>
<td>Conceptualisation</td>
<td>Stress resistance</td>
</tr>
<tr>
<td>Perseverance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1: Competency profiles

Considering these different possible roles and the main competences required by each, it is clear that the focus on learning outcomes should vary for students that are interested in one specific role. A study analysing the correspondence between the learning outcomes of an engineering faculty and the three models understood that the relevance of the learning outcomes was different for each role, even though some of them were crucial to all the roles.

Looking at some examples, for a student interested in operational excellence, it is particularly crucial to develop problem analysing and solving skills. For another student in product leadership, it is significantly more important to learn design and development skills. For a student interested in customer intimacy, it is more important to develop professionalism, communication, entrepreneurship and ethical responsibility than for a student interested in a product leadership role, while basic scientific knowledge appears to be less important. [8]

It is key to keep in mind that most of the times engineers do not function in a single specific role during their whole professional lives, so it is important not to completely disregard the skills and knowledge required by other roles, even if there is a clear preference towards one of them. Most likely one specific role in a company will fall in the intersection between different roles. In the same way, some students
will have preference towards more than a single role. [44]

### 3.2.4 Practical examples

The outcomes of the PREFER project are being gradually implemented in the partner universities of the project: TU Delft, TU Dublin and KU Leuven. Apart from the tests already mentioned, some modules have been created to train or introduce some professional competencies. Additionally, a set of recommendations and materials to support the implementation have been created and shared in their website.

The first comprehensive implementation of the learnings from the project will be introduced in KU Leuven, where students will learn the Professional Roles Model (or PREFER framework) from day one. Throughout their years at the university they will deepen their self-awareness, learn about labour markets, better understand their fit in a specific future role and develop some of the key competences for their future professional roles.

The depth of the implementation will vary from professor to professor, since the PREFER project will provide guidelines with different levels of commitment. The idea behind this is to avoid situations where the activities are not implemented due to excessive perceived effort by the professor/responsible person.

The first goal is (1) to become aware of the fact that the industry requires different types of engineers. Secondly, (2) the students are expected to understand what each role means by contacting and/or getting introduced to real life examples. Third, (3) students should recognise their strengths and interests in order to better align with possible roles. Finally, the last stage is (4) to train and develop specific skills and competencies that align with their preferred role(s).

For the first year students, the main planned activities are the presentation of the PREFER framework (1), participation in a job shadowing experience (2) and filling in the PREFER Explore test (1 and 3). The PREFER Explore test consists of a 10-minute online questionnaire aimed at understanding the student’s preference towards each role, based on a set of questions where different possible courses of action are presented and the student should identify the most and least preferred. The results of the test tell the student their “level of preference” towards each role.

Starting in the second year there are guest lectures where the expert is introduced in light of the PREFER framework (2). Additionally, students have company visits and are expected to reflect on those to increase their awareness of the diverse roles that exist (1 and 2).

During their third and fourth years, the planned activities focus on applying the roles, increasing self-awareness and developing the necessary skills, given that students are expected to have already internalised the framework by this time. The activities include applying/playing different roles in team projects in the context of their courses (2), doing an internship and reporting the experience (2), labeling the Master’s thesis based on the PREFER framework (2), engage in alumni talks (2), taking the PREFER Match test (3), participating in career sessions (3) and engaging in extracurricular training opportunities (4).

The PREFER Match test consists of three separate situational judgment tests in which students...
responses are compared with the answers from expert engineers in each role. The results tell the students the level of alignment with the role being tested as well as the specific alignment scores with each of the essential competencies for said role. The report includes an explanation of the importance of each skill and tips on how to improve them. Seven skills are evaluated for the Product Leadership role while eight skills are measured for Operational Excellence and Customer Intimacy. Figure 3.2 presents the competencies being tested, which derive from the competencies identified by expert panels and presented in table 3.1.

![Figure 3.2: PREFER Framework competencies](image)

Despite the clear relevance of some of these competencies for several years, the fact that it is critical to focus on them instead of only on the technical competencies partly stems from the rapid developments and increased uncertainty in the world, particularly in technology. We will now shift our focus towards these emerging trends, to better understand what competencies will be critical for an Aerospace Engineer to possess in the years to come and which roles (not necessarily under this framework) are they likely to play.

### 3.3 Fourth Industrial Revolution

As described in the Introduction, the world we live in is volatile, uncertain, complex and ambiguous (VUCA). The rapid developments in artificial intelligence, bioengineering, big data and other critical areas are causing multiple disruptive changes to take place across all sectors. In particular, the worlds of work and education are changing and the pace of development that professional and educational
institutions are used to is not enough.

The definition of Fourth Industrial Revolution or Industry 4.0 is not universally accepted as some argue that it is simply the continuation of the third industrial revolution, powered by the generalised use of computers, the internet and increased connectivity. No matter how we define it, it is clear that the rhythm at which new technology applications are created is faster than ever and it is continuously increasing.

The main goals of the present section are to raise awareness about the main current and future trends that will affect all areas of society and to reflect about the implication they will have in the world of work and education. The ideas summarised here stem mainly, but not exclusively, from The Future of Professions, by Daniel and Richard Susskind [45], The Fourth Industrial Revolution, by Klaus Schwab [46] and Engineering Education in the Rapidly Changing World, by Aldert Kamp [1], as well as reports from Airbus [47] and McKinsey Global Institute [48].

3.3.1 Main trends

Based on research from the World Economic Forum, Klaus Schwab identifies some of the technological megatrends which are likely to have the greatest impact in future years. All these trends are possible because of the increased computational and digital power, but their impact reaches out of the “digital world” impacting the physical and biological realms as well. These trends can be grouped in these three interrelated clusters: digital, biological and physical.

When it comes to the digital sphere, many of the impressive innovations are connected to the Internet of Things (IoT), which allow for products, services, places and human beings to interact through the internet. Sensors and transmitters of information are increasingly small and cheap to produce, allowing its integration virtually in everything, including the human body. Apart from this bridging role between the three realms, digital innovations affect businesses and systems of all kinds. An on-demand economy has been created because of platforms enabled by big data and artificial intelligence such as Uber or Amazon, and radical changes in the way information is shared are being introduced with the use of blockchain technologies.

The second cluster is the biological realm. The innovations in this field, such as genetic sequencing and synthetic biology are extremely disruptive in the fields of medicine and healthcare, but also in agriculture, livestock and the production of biofuels. Despite enabling radical improvements in several areas, these technologies have extreme legal and ethical constraints. In any case, there are not a lot of direct applications expected for the Aerospace industry.

Finally, in terms of the physical cluster, the main trends identified are autonomous vehicles, additive manufacturing (3D printing), advanced robots and new materials. These innovations have more direct implications for the Aerospace industry than the previous two realms. Regarding autonomous vehicles, the developments of highly sophisticated sensors, increasingly powerful batteries and artificial intelligence are catalysing the advancement of drones, aircrafts and other self-driving vehicles, which are slowly becoming commercially available. When it comes to 3D printing, advanced robots and new
materials, all of them have already several applications in the Aerospace industry and their importance is likely to increase in the years to come.

In a broader perspective, we can look at more general sociocultural and economic trends which affect these technological megatrends and the world as a whole. These general megatrends are global forces that influence business, societies, economies, cultures and individual lives. Airbus Global Workforce Forecast identifies six of these trends [47]:

- Economic Globalisation
- Resource Scarcity and Climate Change
- Global Governance
- Demographics and Social Evolution
- Innovation and Technologies
- New consumption patterns

These trends and their evolution have direct and indirect influence in all industries. Employment policies, product development priorities, financing and other key factors are strongly affected by these six megatrends, so it is important to always take them into account when making decisions or plans for the future.

### 3.3.2 Types of work

Similarly to the on-demand economy already mentioned, it is likely that the work relations will become increasingly on-demand. Authors argue that employer-employee relationships are likely to be replaced by independent workers who perform specific tasks for one or several employers. This leads to increased flexibility for the workers but also decreased job and financial security.

Another critical and perhaps the most obvious disruption is due to automation. Automation will likely replace a large portion of labour in the near future. The increasing capabilities of machines are gradually reducing the number of human beings required to perform any given task. This is not only true for unskilled labour but also to highly qualified jobs, such as engineering. The improvements in the software capabilities of all kinds lead to increased efficiency and productivity, requiring less human labour to perform the same tasks.

Automation will force all workers to acquire new skills through retraining, even if they do not change occupations. Even though it is expected that the majority of workers will be able to retain their jobs or change to a similar type of work, a considerable portion of workers will likely need to change occupations. It is also expected that the newly created jobs will require more sophisticated skills, which will still be in shortage. The working-age population in Europe is likely to shrink as well as the average number of weekly working hours, contributing to this shortage of skilled workers. [48]

One trend that is likely to affect many professions and occupations is the shift from face-to-face to online services. These online services can either be provided by individuals with the support of software
or entirely by a computer. Despite being an important and disruptive trend for many professionals, for engineers, it is likely to mean more work opportunities than the loss of them.

Another trend to highlight in terms of the types of work that are likely to become the new normal in the upcoming years is the outsourcing to countries of cheaper labour. With information and practical knowledge readily available online through open-access resources and massive online open courses (MOOC), and with the development of technical education in countries as India and China, technical knowledge is now available to a much wider range of people. With the generalisation of remote work and the decomposition of labour, outsourcing engineering tasks abroad is an increasing reality for many companies in the western world.

The last trend to be mentioned here is the increase in remote work, pushed by the COVID-19 pandemic. Even though this is having a tremendous impact at the time of writing, it is still not clear whether this will become a common practice for companies. This can have an important impact on demographics.

3.3.3 Education

Formal education in general and Engineering Education in particular are changing due to three main driving forces: the needs of the job market, the innovations in education technology and the changes in society. The requirements in terms of technical specific knowledge are changing at a very fast pace with new technologies and systems replacing older ones every day. This progress is also enabling more efficient learning systems to take place, increasing the competitiveness of non-traditional private schools and informal learning communities. Finally, society is changing in all aspects, increasing the importance of education in areas traditionally overlooked, such as ethics, sustainability and diversity.

The university is no longer simply a place where students go in order to have access to information. The information is available online most of the time for free or at a very low cost, curated by reputable institutions or individuals. Automated assessments, learning analytics and peer review systems are making online learning more and more reliable. Universities have therefore to provide the practical expertise and the integrated learning experiences that these online resources lack in order to remain competitive. Professors have to guide students towards the right knowledge, which they typically already have access to, and help them implement this knowledge. As Daniel and Richard Susskind put it, there is a need to change from a paradigm from the “sage on the stage” to the “guide on the side”.

Having one-on-one tuition has extreme benefits in the performance of students as it has been described several years ago by the two sigma problem [18]. The advantages of the personalised support studied by Benjamin Bloom will likely be replicated by technological tools called “adaptive” or “personalised” learning systems, some of which are already in place, both in traditional educational settings and online innovative solutions.

Despite the fact that different authors and initiatives use different words and definitions, there seems to be a general agreement around the increased relevance of transversal skills and competencies that are unique to human nature and are not likely to be performed by machines. One popular framework, called the “Four Cs”, highlights four competencies as the key to 21st century learning: Critical Thinking,
Communication, Collaboration and Creativity. Several schools across the globe are already implementing these ideas, either using this specific framework or using similar concepts.

In terms of the specific case of Engineering Education, there has always been efforts to ensure that it is up-to-date and aligned with world trends and industry needs. Besides independent efforts from professors, universities or companies there have also been several research and development projects carried out by international coalitions (between universities, companies and/or NGOs) and non-profit organisations. Examples of these organisations are the European Society for Engineering Education (SEFI), the European Federation of National Engineering Associations (FEANI), the American Society for Engineering Education (ASEE) and the International Federation of Engineering Education Societies (IFiEES).

For instance, The Attributes of a Global Engineer Project developed by ASEE gathered input throughout several years from globally representative groups of experts from academia and the industry to understand which skills are the most important for a global engineer. The final publications of the project highlight twenty attributes which can be divided into five categories [49]:

- Technical: Engineering-related knowledge, skills, and abilities needed for success;
- Professional: Workplace related competencies for global performance;
- Personal: Individual characteristics needed for global flexibility;
- Interpersonal: Skills and perspectives to work on interdependent global teams;
- Cross-cultural: Society and cultural understanding to embrace diverse viewpoints.

This framework was also highlighted in The Engineer of the Future report by Airbus Global University Partner Programme (AGUPP). This extensive report also highlights other trends already mentioned with a specific emphasis on the impact they will have over Airbus. [5]

These and other competencies, which are typically not the core of Engineering programmes, are already included in learning outcomes in a number of universities and included in quality criteria for some accreditation agencies. Examples of implementations include the Criteria for Accrediting Engineering Programs of the Accreditation Board for Engineering and Technology (ABET) and the EUR-ACE Framework Standards and Guidelines of the European Network for Accreditation of Engineering Education (ENAEE).

Based on the main trends affecting society and the world, particularly the developments in the fields of technology and education, Aldert Kamp summarises his vision for engineering education in 2030 in his book “Engineering Education in the Rapidly Changing World”. Eight key aspects for the education of future engineers are highlighted [1]:

- Rigour of engineering knowledge;
- Critical thinking and unstructured problem solving;
- Interdisciplinary and systems thinking;
• Imagination, creativity, initiative;
• Communication and collaboration;
• Global mind-set: diversity and mobility;
• Ambitious learning culture: student engagement and professional learning community;
• Employability and lifelong learning.

Even though many different frameworks and views are possible, what is key to understand is that the skills required by the workplace and society in general are changing and Education is changing as well. It is key that everyone develops a solid understanding of themselves and understands the importance of commitment to lifelong learning. By always developing new skills, exploring and investing in opportunities and increasing self-awareness, individuals will more likely discover their passions and live meaningful lives.

3.4 Aerospace Industry

The origin of the Aerospace industry dates back to the beginning of the 20th century with the first successful sustained flight experiments by the Wright brothers and other pioneers. It is the industry responsible for the research, development and manufacture of flight vehicles, including airplanes, missiles and spacecrafts, among others. Also the flight vehicle subsystems and support systems, such as propulsion, avionics and maintenance, are part of the industry field. The industry also manufactures products and systems with applications in other areas that use aerospace technology.

Aerospace systems are typically very complex and have a very high value per unit weight, thus making it extremely valuable in economic terms. Its importance for the military and defense sectors also make it extremely important for countries to invest in, resulting in a large portion of the main customers of the Aerospace Industry being military establishments. This also explains the fact that a vast portion of the developments were powered and accelerated by war efforts.

The industry is very complex encompassing several different types of products and processes. Examples of the main final products are general aviation aircraft, commercial heavy aircraft, military aircraft, helicopters, unmanned aerial vehicles (UAVs), missiles, space launchers, spacecraft and airships. Apart from these, there are other very important secondary and tertiary aerospace systems. The main secondary systems are propulsion and avionics, but the number of subsystems a typical aircraft have is too large to be listed. In general they fall into four categories: structural and mechanical, propulsion and power-related, environmental control and communications and navigation. Regarding tertiary systems, the list is equally lengthy but some major groups are simulation devices and telecommunications systems. In terms of processes, these vary from research efforts financed by public and private investment to maintenance performed in aircrafts between flights. [50]

The bottom line is that the Aerospace industry is extremely complex and diverse, including a wide variety of subsystems and processes. Because of this, the skills and knowledge required from an
Aerospace Engineer vary greatly with the specifics of the job. Some Aerospace Engineers work as product managers or telecommunications engineers, while others are researchers or even astronauts.

3.4.1 Aerospace and Defense in Portugal

The Aerospace Industry in Portugal is relatively small. Despite the fact that there are a considerable number of Portuguese companies, these only produce parts or components for bigger Aerospace projects from bigger international companies or government agencies, most notably the European Space Agency (ESA) with more than 40% of the total volume of the Space sector in Portugal. In 2017 the Aeronautic, Space and Defense sectors were responsible for 1.4% of Portuguese GDP, exporting 87% of their production and employing 18,500 skilled workers.

The Aeronautics, Space and Defense Cluster Portugal (AEDCP) is a non-profit organisation connecting over 70 Portuguese entities (companies, institutes and academia), responsible for connecting different players inside the industries to improve their competitiveness. This cluster, established in 2016, aims at increasing the space sector and its role in the national economy based on qualified jobs and collaborations between industry and scientific research. [51]

Despite the fact that these industries are responsible for a considerable amount of the GDP and a considerable number of skilled jobs, around one third of Aerospace Engineering graduates find their first job in other countries and a similar percentage find jobs outside the Aerospace industry (appendix B).

3.4.2 Future

Aerospace industry has experienced a small descent in 2019 after a very strong year in 2018, with a decrease in order backlog of commercial aircraft compared to the 2018 peak. There was a decline in deliveries due to problems in certain models, but the growth of the sector was expected to recover from 2020 onward with the demand for commercial aircraft remaining robust in the long-term.

This was true before the COVID-19 crisis. The commercial aviation sector is experiencing disruption in production and it is likely that there will be considerable long-term effects. Since the companies in the field are capital intensive, short-term effects can also be dramatic in terms of liquidity and employment. Suppliers and specialised providers, such as some aeronautic companies in Portugal may become financially stressed.

On a more positive note, the effects of the pandemic in the space and defense sectors is likely to be smaller, since the budgets are made years in advance and considering that security threats continue to intensify. Regarding the Aerospace industry in general, some of the key trends that are likely to have significant implications in the mid-to-long-term are electric propulsion systems, urban air mobility and automated flight decks. [52]
Chapter 4

Career Planning System

The main goal of this work is to introduce a system that gives Aerospace Engineering students the opportunity to learn about career development and helps them develop key skills for their careers. More specifically, inspired by the goals of the PREFER project, the introduction of such a system aims at impacting students in four distinct ways. If implemented successfully it will help all Aerospace Engineering students:

- understand that there are several different possibilities in terms of career paths for Aerospace engineering graduates;
- get a better understanding of the roles engineers have, particularly in the Aerospace industry;
- increase self-awareness and identify strengths and interests;
- train and develop some transversal skills which are useful for their careers.

Based on the ideas and concepts explored in previous chapters and the results from the questionnaires presented in the annexes, the present chapter outlines a set of suggestions and a corresponding implementation plan. The expected result of the implementation of these outcomes is not a separate new system but rather an optimisation of the current systems in place in Tecnico and an increased coherence and harmony between them.

From the beginning, the most important goal for this thesis was that it would have a real impact in the lives of Aerospace Engineering students. To achieve a successful implementation of the recommendations, it is critical that the stakeholders involved understand the importance of career planning and exploration, as well as the development of non-technical or transversal skills, and actively engage in implementing the changes. Even if the suggestions presented are disregarded, the original objective might still be achieved as long as students, professors and other bodies recognize the importance of such topics and actively take part in changing things around them by organising or simply participating in new activities and projects.

In the implementation sections, it is important to understand that, for most of them, the implementation is not binary, and different levels of implementation are possible depending on the resources
available (monetary, human, or others). The author believes that providing the appropriate tools for career exploration and planning and ultimately ensuring the career success of their students should be one of the key responsibilities of the university and, therefore, investments in this area are generally valuable.

Based on their areas of impact, the suggestions presented are grouped into three areas:

- Access to relevant and up-to-date information and tools;
- Support from a mentor;
- Connections with the industry.

The author hopes that the reader will take these ideas into consideration and contribute to their implementation as much as possible.

The suggestions are a result of an iterative process of brainstorming or gathering suggestions, refining them and cutting irrelevant ones, done through meetings, surveys and literature review. The suggestions are in line with the culture of Tecnico and the available resources.

The focus of these suggestions is the Aerospace Engineering degree, but most of them can (and, from the point of view of the author, should) be expanded to other degrees in Tecnico. This issue will be further discussed in the implementation sections of the present chapter.

In this section each area of suggestions will be explored in more detail, highlighting parts of previous chapters that support or relate to them.

### 4.1 Access to relevant and up-to-date information and tools

From the Vocational Psychology literature (section 2.2), it became clear that having access to relevant information about the job market and career possibilities, as well as access to tools that support individuals’ self-awareness, were relevant factors to provide students with adequate career support. Currently, there is information available online regarding virtually any topic, and career possibilities and self-assessment tools are no exception (the latter are often paid). The challenge is curating said information and making it available to students in an organised way.

When looking at other universities with good career support systems, it was noticed that all the universities considered in the analysis (section 2.1.1) have a central platform aggregating the information and tools related to career planning and typically have one dedicated office responsible for career matters. In the case of Tecnico, the TT is the office responsible for most of the career-related initiatives and the Career Discovery programme page is the page with the most career-related information (section 2.1.2).

Another interesting fact is that most Aerospace Engineering students (figure A.2) are interested in working in the Aeronautics, Space or Defense industries. Taking this into account, it becomes important to provide them with curated information about career possibilities in these particular industries.

In addition to this, less than 25% of both students and alumni agree that they have (or have had) access to information regarding career opportunities (figures A.12 and B.5).
4.1.1 Create a central platform with all career-related information.

Rationale

With these insights in mind, the author suggests that a central page encompassing all the relevant career-related information is created. Ideally, this page would be general for all Tecnico students, with information and opportunities provided by all the nuclei, and would have a dedicated section or version for each degree with specific career opportunities in the main industries related to the degree.

The initial and most obvious idea for the creation of a central page would be to integrate it in the Tecnico website or in the Fenix platform. Nevertheless, the fact that the Job Bank already uses the Career Services Management solution from Simplicity (section 2.1.2), should be taken into account. Ideally, this platform could accommodate much more information and tools, provided by the university, but there are some constraints regarding the costs and the practical details regarding implementation which should be explored further. The current version of the platform does not allow for many extra features. Currently, the TT is considering changing the platform used for the Job Bank, depending on resources allocation. Two other possibilities already mentioned in section 2.1.1 are JobTeaser (used by Supaero, TU Delft and NOVA) and TARGETconnect (used by UCL Engineering).

Another important factor of this possible central page is the way it will be updated, given that information regarding events and job opportunities is constantly changing. To ensure this, a collaboration between different units in Tecnico is important.

Given all these factors, the suggestion presented can be divided into short-term and long-term solutions. In the short-term, the idea would be to improve the current Career Discovery page, making it more user-friendly and encompassing more information from different sources, such as the OEIST, the NDA and other nuclei. In the long-term, the suggestion is to create a robust platform, using third-party software, that encompasses all the offers in Tecnico regarding career exploration and support.

Implementation

Regarding the short-term suggestion, the improvements to the Career Discovery page would require an in-depth evaluation of all the subpages, if possible taking into account analytics regarding current usage. The author suggests that the improvements to this page focus on three distinct topics.

- Align the message with a more holistic view of career planning. Currently, the Career Discovery programme focuses a lot (but not exclusively) on recruitment processes and the transition to the job market for Master’s students. This makes sense, since these students are the ones most actively looking for support, but as it has been shown throughout this work, in particular in section 2.2, career development is an ongoing process that starts even before the student joins Tecnico and developing certain skills and beliefs is more important than the content of individual decisions.

- Include information provided by other groups in Tecnico. Information for students is spread across multiple pages (this will be tackled in the next suggestion) and some other groups in Tecnico have...
information which is relevant for supporting students in their careers. In particular, employability data provided by the OEIST and students support materials provided by NDA should be included, as well as information about career development activities provided by students nuclei, eventually in a calendar format. The opportunities of having a Master’s thesis and, with Tecnico 2122 model, PIC1 in an industry context, should also be mentioned.

- Make the structure more user-friendly. To this aspect, there is not a specific suggestion except that good practices in other universities are taken into consideration and that students are consulted in the process of redesigning the page.

Additionally, the author suggests that the subpage about career management is made available in English and that there is an effort to ensure activities are available for non-Portuguese speaking students, in line with the school’s strategic vision.

Regarding the long-term suggestion, the main recommendations are to ensure that the platform makes sense within the broader structure of Tecnico and to do some benchmarking and detailed analysis of possible tools before committing to any single solution.

4.1.2 Make information for students more accessible.

Rationale

As it has been discussed in section 2.1.2, career development opportunities range from career training workshops to job offers and are provided by many different groups inside the university. This means that, generally, at this moment students need to know who these groups are in order to find their page and the respective opportunities. Even if this problem would be tackled by the previous suggestion, it is part of a broader issue, which is the difficult access to information due to the organizational complexity of Tecnico.

Students that need to find support for a specific issue struggle to find the relevant body to help them and sometimes don’t even know if the information/support they need exists within the university bodies. Throughout their journey in Tecnico students’ needs vary a lot depending on their curricular year, degree, interests and particular circumstances, and no single static page can effectively summarise all the tools available for students.

With this in mind, the author suggests the creation of a dynamic page linking to all the relevant services and tools available for students in Tecnico (not exclusive to career-related issues). The page would show students a collection of relevant initiatives and guide them to the most relevant pages based on their answer to a small set of questions.

This would work as a navigation guide to help students find the most relevant support at specific times. Ideally, the whole organisational map would also be made available to help students understand the broader picture in a visual way. The creation of this page would improve the accessibility of information and provide the student with a better overview of the resources available for their academic and career development.
The implementation of this suggestion will require the collaboration between many different groups which will need the support of the management of Tecnico to work effectively. NAPE has tried creating a similar page called BeTecnico, but the project was abandoned.

Implementation

The key step for the implementation of this suggestion is that a decision to move forward is made by the management bodies of Tecnico. The coordination of such a project would likely fall under the Public Relations and Media Office (GCRP), but in order to ensure an effective implementation other nuclei would need to be involved by providing clear information about all the tools and services they have available.

As soon as there is an agreement to create this “student page”, the first step is to map all the tools and services available for students and categorise them according to their areas, scope and target audiences. Gathering this information from central bodies of Tecnico may be relatively easy, but if the page will be comprehensive of what is offered by all groups in Tecnico (which include research centers and students organisations, among others), this data collection step will likely be more complex. For instance, the TT should be involved to facilitate the communication through the Student Organisations’ Forum.

The details about the technical implementation are outside the scope of this work, but a possible path would be to create a decision tree where the decision nodes represent data points to be collected about the student using the page (either from their Fenix account or through questions) and each end node would represent a set of tags (which would be associated with certain tools or services).

Considering that this page should be comprehensive and up-to-date, an efficient feedback system should also be implemented. This would allow for the groups and individual users to suggest updating the offers presented in the page as well as adding offers that hadn’t been included.

Ideally, the development of this project would take place throughout the academic year of 2020/2021 to be ready for students by the time of the implementation of the Tecnico 2122 model.

4.1.3 Introduce the PREFER Project assessment tools.

Rationale

As discussed in sections 2.1.1 and 3.2.4, other universities provide tools to help students better understand their strengths and interests, such as the StrengthsFinder 2.0 in UCL Engineering and the PREFER Explore and Match tests in KU Leuven. Given the fact that the outcomes of the PREFER Project are quite recent and free to use, the author recommends that the PREFER Explore and Match tests are made available for students in Tecnico. Additionally, the implementation of these resources in one more top engineering school can enhance the impact of the research performed in the context of the PREFER Project.

Currently, a tool called Career Finder which uses the RIASEC (or Holland code) test is integrated in the Job Bank platform, but this test is insufficient and provides very little information for an engineering
student. While the RIASEC test is focused on which general areas is the individual interested (e.g. people vs things), the PREFER test tries to answer the question “what kind of engineer would I like to be”.

Having these two assessment tools being actively used by students will likely improve their self-awareness and help them explore learning and career opportunities in a clearer way.

Implementation

The implementation of the PREFER Project assessment tools would likely fall mostly under TT, who could implement it as a replacement of the Career Explorer in Tecnico Job Bank and/or create a page dedicated to the Professional Roles Model under the Career Discovery page.

The author believes that the best first step for the implementation of this suggestion would be to contact the PREFER Project coordination directly to discuss the best way to implement the tests in practice. The people involved in the project are very open to collaborations and already have some insights about the implementation of the outcomes in KU Leuven.

For the particular case of Aerospace Engineering students, it can be interesting to introduce the concept of different engineering and professional roles early in the degree, particularly in the course Introduction to Aeronautics and Space. Apart from including this topic in the learning objectives, the PREFER Explore test could be suggested to students as a way to start exploring their preferences in terms of professional roles. The PREFER Match test could also be suggested to students at a later stage in the degree.

4.2 Support from a mentor

There is no one universal definition for “mentor” or for “tutor”. According to the online Cambridge Dictionary, a mentor is “a person who gives a younger or less experienced person help and advice over a period of time, especially at work or school”. Being in the form of a career coach, an older student or a professor, it has been a common practice for universities to provide students with support from a mentor.

As discussed in the section 2.1.2, Tecnico already has some of these systems in place, namely the Mentor Programme (NAPE), the Tutoring Programme (NDA), the Alumni Mentoring Programme (TT) and the career coaching provided by NDA. These systems have been analysed and opinions from students and alumni were gathered regarding them, in order to propose some suggestions that would enhance their effectiveness and their impact in the (academic and professional) careers of Tecnico students.

In particular, the suggestion of improving the training for mentors in the context of the Mentoring programme from NAPE was studied in depth but it was concluded that some of the ideas that would be relevant to include are already being taken into account. Overall, the Mentoring programme is constantly improving and already takes into account the career development of students. Hopefully this work can inspire further investment in this area, but no particular issue was identified.
4.2.1 Adjust NDA’s Tutoring programme.

Rationale

One problem identified in section 2.1.2 is that the Tutoring and the Mentoring programmes have some overlapping objectives. Both programmes aim at supporting students in their integration in Tecnico. When asked whether they preferred a Mentor (student) or a Tutor (professor) to support them in the integration in the university, almost all students said they preferred a student. The majority of students also preferred a Mentor to help them make a study plan and understand the functioning of the degree. Students only preferred the support from a Tutor for choosing a master’s specialization. These opinions are presented in figure A.10.

Considering the current format in which the students are supposed to get support from their Tutor in the first and second years (even though only 10% of students met with the tutor more than once), the Tutoring programme is finalised before the students have to decide their master’s specialization or their pre-majors. Based on these insights and on the evaluation of the programme [20], the author suggests that the tutoring programme shifts from first and second years, to second and third years.

As it is summarised in figure A.8, when asked about the reasons for not engaging more in the Tutoring programme, 44% of students identified the lack of clear objectives as a factor, 38% identified being busy with other priorities and 23% identified not feeling comfortable contacting professors.

The main expected benefits of this change are that the students can use the guidance of Tutors to decide some of the elective courses (as detailed in section 3.1, choosing two pre-majors, choosing between Introduction to Economy and Management and choosing their option for PIC1) and that their engagement will likely increase. With this change, there is a clearer objective to the programme and the moment the students will have contact with the Tutor is better for two main reasons: they are likely more comfortable to get in touch with professors and it is a less busy period for them, compared to the beginning of the first year.

Another of the main problems identified in the evaluation of the programme [20] is the ratio between tutors and students, which for Aerospace Engineering was 1 tutor for every 14 students. Adding to this problem, the professors engaged in the programme are doing it voluntarily and the hours invested are not being counted in their schedule. To tackle this, the author suggests that researchers are introduced as tutors, as it is common that they have extra hours they need to “fill”. In addition to this, it is also possible that it will have an extra benefit, which is that the students may feel more comfortable approaching another student (even if they are also a teacher) instead of a professor.

Implementation

While the present work was being developed there have been efforts to improve the tutoring programme and better align it with the Tecnio 2122 model. These efforts are mainly being conducted by NDA, CP and CG. The two suggestions presented above, as well as the insights gathered from the students survey, were delivered to NDA in the form of a short report by the end of October 2020. They were welcomed and taken into account in the discussion.
New guidelines for the Tutoring programme have been developed as a result of those efforts, with the goal of being implemented in the next edition of the programme (academic year 2021/2022). Despite the fact that the suggestions presented above were not fully integrated into the new guidelines, the solutions found are in line with what was suggested.

Instead of shifting the programme from first and second years, to second and third years, the decision was to extend the programme to cover the three years of the first cycle. This allows for the student to turn to their Tutor for support in choosing their elective courses and their Master, while still ensuring the presence of the Tutor to support the integration of the student, particularly in academic terms. The idea is for the Tutor to actively reach out to their students at the beginning of first year and in their third year to support them with important choices and remain available to help on request of the student during the rest of the time.

Regarding the problem with the ratio between tutors and students, the solution found was to limit the maximum number of students per tutor per year to 7 and to introduce assistant professors and assistant researchers as tutors, to increase the amount of tutors available. In addition to this, the system of rewards for tutors have suffered some changes to make it more attractive for professors to engage in the programme.

It is also relevant to mention that there is an interest in working together with Fenix to improve the communication and support tools for tutors and students. Another important change to be mentioned is that there will not be any differences between degrees, as there have been.

Considering that many changes are already taking place which will hopefully lead to a better support for students from the Tutoring programme, the only suggestion left to make is for all the stakeholders, coordination, professors and students, to realise the potential of this programme and actively engage with it to enhance its impact.

### 4.2.2 Increase the usage of the Alumni Mentoring programme.

**Rationale**

If the Mentoring and Tutoring programmes are focused on supporting students in their “academic career”, the Alumni Mentoring programme focuses on helping students gathering insights to better plan their careers after graduation. The feedback about the first edition of this programme is not yet completed and therefore, it was not possible to study possible improvements. This edition had around 100 Alumni mentors for 200 participating students from Tecnico and the matching process already took into account the degrees from the participants.

A relevant insight to point out is that from the Aerospace Engineering students who would like to have an alumni mentor (85% of all students) a slight majority would only be interested in having a mentor from Aerospace Engineering, as it is shown in figure A.16. With all this in mind, the author suggests that the coordination of the degree is involved in recruiting mentors and in the promotion of the programme to students, since it is a recent and not very popular programme that can have a very positive impact in the students career planning process.
One of the main issues with organising an alumni mentor programme is the contact with alumni which can’t be done through existing mailing lists due to GDPR restrictions. From the respondents to the questionnaire for alumni, 20 from the 26 who were interested in being a mentor agreed to share their contacts, which can be a starting point for getting a higher number of Alumni mentors involved.

Implementation

The original idea was to create a dedicated alumni mentoring programme for the degree, similarly to what is done in TU Delft (section 2.1.1), but considering that a more comprehensive programme already exists and is developing further, the suggestion shifted towards supporting the development of the existing Alumni Mentoring programme by TT.

For TT, the organisers of this programme, the suggestion is to reach out to the Aerospace Engineering alumni contacted in the context of the thesis who are interested in being a mentor to increase the number of mentors from the degree. Throughout the present academic year a platform for contacting alumni in an efficient manner is being developed, and despite not having specific suggestions in that regard, the author believes that goal should be pursued further.

For the coordination of the Aerospace Engineering degree, the suggestion is to promote this programme further to students, so that more people will have the chance to get the support from an alumni mentor when planning their careers. It is important to have a reasonable balance between the “supply” of mentors and the interest of students, so the promotion plan should take into account the number of alumni mentors from Aerospace Engineering participating in the programme.

In order to grow the programme further, the informal networks of alumni can be leveraged, for example through a referral campaign, and the reach of the coordination of the degrees can be used to get more students applying to have a mentor.

4.3 Connections with the industry

As previously discussed, it is critical to understand the real career possibilities in order to successfully plan one’s career. Understanding the job market allows for creating a coherent plan and focusing the academic curricular and extracurricular paths in order to maximise the chances of career success. Taking into account that the industry needs and possibilities are constantly changing (section 3.3), it is important that universities are in touch with the industry and that they create opportunities for the students to experience it first hand.

The underlying idea is not that the university subjects itself to the needs of the Aerospace industry since its goal is to develop individuals for the society at large and not only for a specific industry. The idea behind strengthening the connections with the industry is to give students a better understanding of career opportunities in their field of studies and the applicability of the technical knowledge acquired.
4.3.1 Create an Advisory Board with industry experts.

Rationale

Industry leaders are the ones best positioned to help universities understand the current and future needs in terms of skills and competencies. Gathering input from these experts in terms of the content and structure of the curriculum as well as specific curricular units can have a positive impact in the relevance of the subjects taught. Additionally, industry experts can help identify opportunities for collaboration between university and companies, including synergies with active projects and options for financial support.

The author suggests that an Advisory Board is created integrating accomplished and distinguished industry leaders with proven expertise as well as leaders from associations in the sector which by themselves connect several companies, such as the AED Cluster Portugal. In the creation and management of such a group, the coordination of the degree should be careful to avoid conflict of interests between the university and companies.

The creation of such a group would help the coordination making even more informed decisions about the degree and reaching companies in a more efficient manner. It would also facilitate the implementation of the succeeding suggestions since the connection between the coordination of the degree and the Aerospace industry would be strengthened.

Implementation

This suggestion is addressed exclusively to the coordination of the Aerospace Engineering degree. The first step for implementing this idea is to clearly define the structure, scope and objectives of the Advisory Board. Typically this kind of group does not have formal membership or structure, but defining the objectives and expectations from all stakeholders involved beforehand can avoid possible conflicts. That being said, the author believes that creating a small document outlining some guidelines could be beneficial.

The next step would be to investigate possible members and agree on a list of individuals to be invited to the Advisory Board. These individuals would ideally have a vast experience in the Aerospace industry and have connections to various companies. Having a diverse group can also be very positive to ensure that different views are taken into consideration and it would be ideal to have at least some Tecnico alumni, who would have a better understanding of the reality of the university. Additionally, the list of companies who showed interest through the companies survey can be shared with the coordination.

After agreeing on a prioritized list of relevant people for the role, the coordination could address the invitations and clarify the expected commitment. The extent of involvement of the Advisory Board would be totally up to the coordination to manage.
4.3.2 Have PIC1 proposals by companies.

Rationale

As explained in section 3.1, an integrator project will be introduced at the end of the first cycle for all degrees in Tecnico. The document describing the new structure of the first cycle of the Aerospace Engineering degree explains that the curricular unit can be done through work in a company or in a research unit, through a capstone project, by crediting extracurricular activities or through an offer of project-based learning projects. Despite the fact that these possibilities are available for students that take the initiative to propose a project (dependent on the approval of the coordination of the degree) the "standard" project for Aerospace Engineering students will be the capstone project (conceptual design of an aerospace vehicle).

Based on the research presented, the author believes that the option of having project proposals by companies can be extremely beneficial for the students to improve their understanding of the applicability of the concepts learned and to get in touch with a new reality. In addition to this, most companies answering the survey showed interest in proposing projects for 3rd year students and supporting those students during one semester (appendix C), which indicates that there is some interest from the companies’ side.

With this in mind, the suggestion is to ensure that there is a reasonable amount of project proposals for PIC1 made by companies. To accomplish this, it is important to have good communication and relationships with companies in the sector. Companies need to clearly understand the goals of the project and also to perceive value creation for their side, being it in the form of employer brand awareness or actual project output. In order to make the proposals of companies a reality, the coordination should actively invite companies to submit proposals and communicate with professors to ensure that they are aligned (every project should be overviewed by a professor).

Implementation

The first issue to tackle is to clarify what possibilities will be presented for students regarding the PIC1. Despite the fact that a standard capstone project consisting of the conceptual design of an aerospace vehicle would be easier to implement, the author believes that the benefits of providing a variety of options for the development of students outweighs the efforts of implementation.

In order to have proposals from companies it is important to clearly communicate what are the expectations and objectives of the project to potentially interested companies. This could be done in the form of a call for proposals in a timeframe which allows for the companies to develop the proposals and for the coordination to review the proposals before presenting them to students. To make this process effective, some concise and clear guidelines should be developed and provided to companies, as well as a template for submitting the proposals.

This call could be sent to the companies who are part of the Aerospace industry in Portugal, eventually with the help of the Advisory Board to identify companies potentially interested and who could develop project proposals which are interesting and valuable for the students. The companies identified
In the context of this work can be a starting point to be contacted for the PIC1 of the academic year 2021/2022.

In terms of future developments, it is important to keep track of the quality of proposals and the support provided by the companies participating, to ensure that the projects completed in collaboration with the industry match the quality standards of Tecnico. Potential constraints and issues related to Intellectual Property should also be revised beforehand together with TT.

4.3.3 Introduce guest lecturers for specific subjects inside various courses.

Rationale

Another powerful way to learn technical subjects is to have lecturers from the industry, who can give a better insight into the applicability of the knowledge in industrial settings. As shown in figure A.11, only about 25% of students from the 2nd to 5th years understand the applicability of theoretical knowledge. This measure, if implemented successfully, may have a positive impact in this number.

This is not a new approach and it is already done in a limited number of curricular units in Tecnico. In the Aerospace Engineering degree, two curricular units are taught by professors with a strong connection to the industry: *Performance* (2nd year) and *Air Traffic Management* (4th year - Avionics). Student feedback indicates that the *Performance* course does not provide an increased understanding of the career opportunities in the area or of the applicability of the knowledge acquired, while the *Air Traffic Management* course appears to typically allow students to have contact with multiple professionals throughout the year and better understand the applicability of knowledge.

As discussed in section 2.1.1, having guest lecturers from the industry is a very common practice in Supaero with positive feedback from students. According to students that did the first cycle in Tecnico and the second in Supaero, it makes it easier to understand the applicability of the theory while also allowing for a better understanding of the companies and their opportunities. Additionally, it ensures that the specific subjects inside the curricular units have real-world applicability and are up-to-date with industry trends.

Implementation

Ultimately, the implementation of this suggestion is totally up to the professors responsible for each curricular unit. The degree of implementation can vary from having one guest lecturer presenting a single implementation of the theory learned at the end of the semester to a variety of guests tackling different topics throughout the semester. Despite this fact, the call for action is not only for individual professors to start considering this option more often but also for the coordination of the degree to support this and encourage professors to do so.

One way to make this happen is to make a list of professionals, preferably with some connection to the Aerospace Engineering degree or to Tecnico, detailing their fields of expertise and connections to specific curricular units. Professors should be invited to add names to this list, eventually of former students with whom they have worked closely.
Having access to this list would not only make it easier to contact potential professionals to give lectures but also remind the professors to keep this option in mind when preparing the work for their curricular units.

4.3.4 Promote job-shadowing experiences for 1st-year students.

Rationale

One activity recommended by the PREFER project for first-year students is a job shadowing experience, in which students are encouraged to find a company that would allow them to follow the work of a professional to better understand the day-to-day work of an engineer.

Since 2012/2013, BEST Lisbon has organised the BEST Inside View with the support from Tecnico. This initiative gives students the opportunity to visit a company of their interest during one day (Inside Day) in which they get direct contact with employees working there to develop a better understanding of the daily work performed by engineers in the company. The main problems with the organisation of the event are connected with the lack of involvement of companies from specific industries (being most of the partners from the fields of consulting and IT) and, connected to that, low amount of students interested in participating.

The author suggests that the coordination of the degree cooperates with BEST Lisbon in order to ensure that there is a good number of companies from the Aerospace industry taking part in the initiative so that most students get the opportunity of getting to know a company from their field. By collaborating with this initiative, contacting companies from the Aerospace industry and promoting the initiative to Aerospace Engineering first-year students, it is likely that more students will have a better understanding of the job reality in the Aerospace industry since the beginning of their path in the degree.

The goal of the BEST Inside View is to provide the job-shadowing opportunity for all Tecnico students, so the collaboration with the coordination of MEAer can be done as a pilot experience and, if successfully executed, this collaboration can be extended to other degrees so that more first-year students in Tecnico have a job-shadowing experience with a company of their field of studies.

Implementation

The suggestions here are mostly addressed to BEST Lisbon to improve the way it collaborates with companies to receive students and to improve the reach of the event, which can add a lot of value for students. In terms of getting companies to participate, it is important to ensure that the barriers for participation are minimal (financial, timeline-related or in terms of human resources) as well as to put effort in the quality and variety of the companies rather than quantity.

Connecting with the different degrees in Tecnico, in particular with their coordination, can help reach companies from different industries more effectively and also reach more students from all the fields of studies. Considering that this work was developed in the context of the Aerospace Engineering degree, it may be easier to try this approach with this degree first, in case connecting with all the degrees can be too overwhelming.
For the coordination of the degree, the only recommendation is to recognise the potential value of this opportunity for students and try to support the organisation in order to ensure its relevance for Aerospace Engineering students.
Chapter 5

Conclusions

Getting the knowledge and skills necessary for a successful career, be it in the Aerospace industry, research or other fields is the main reason for students getting a degree. Preparing students for their careers should be one of the main concerns of universities. This work emphasizes the importance of career exploration and career planning, in the hope that the system currently in place can be improved to increase the chances of Aerospace Engineering students attaining a successful and fulfilling career.

The suggestions presented are aimed at specific bodies inside the university, but all the readers can take something from this work, being it for their own careers or for the ones around them. Actively exploring different possible career paths that align with personal interests and personality traits is important for all current or future professionals. Getting to know success stories in the areas one is interested and networking with peers and more experienced people in those fields is another important part of the process. Hopefully, this work will not only inspire the bodies who are directly addressed to create systems which help students thrive but also inspire individuals (you included!) and Aerospace Engineering students, in particular, to think critically and creatively about what they want to do with their careers and take action to achieve those goals.

The introduction of a career planning concept is expected to instigate students to be more autonomous, proactive and responsible regarding their curricular and career paths [6]. This means that not only the system should evolve but also the students’ attitude must change. The present work is an example of an effort to align the curricular work with personal interests and passions as much as possible, and for this reason, the author hopes it may inspire some other colleagues to do similarly unconventional choices that align with their inner motivations.

5.1 Contributions

The present work collects opinions from students, alumni, companies and university bodies regarding career planning which can inform future decisions and projects. The research done regarding best practices in career development and in the fields of vocational psychology, professional roles and future trends can be useful to help students think about their careers in a different way and also help professors
and university bodies providing a better support for students.

In chapter 4 specific suggestions are presented on how to improve the career planning system for Aerospace Engineering students. These suggestions presented are informed by the information collected and the opinions gathered from the various stakeholders consulted.

Another important contribution is that the methods used, while being radically different from a typical thesis in Aerospace Engineering, implied a direct contact with the stakeholders of the system, either through questionnaires or interviews. This involvement led to an increased awareness of the problems and deficiencies in terms of career planning, which will hopefully lead to an easier implementation of changes. The bodies involved in the implementation of the suggestions were contacted and their input was taken into account when proposing a solution.

The hardest part of this project is the actual implementation of the changes in the career development offer for students. It is great to see the example of NDA that took some of the insights of the present work to shape the changes to be implemented in the upcoming year. Hopefully this work can support other stakeholders involved in the transition to the Tecnico 2122 model.

5.2 Future work

In terms of future work, as mentioned, the implementation of the suggestions is now up to a lot of different bodies and will require some efforts from the stakeholders involved. Hopefully, the present work will contribute to a smooth implementation and the author will be available to provide clarifications or further information, if necessary.

One very important thing for future engineers (and professionals at large) is the ability to take initiative and think creatively. That being said, it is important that the people and the systems in place in the university welcome diverse ideas and actively support projects that can have a positive impact on others. One example of such a project currently being developed by Aerotec is a podcast with Aerospace Engineering alumni, to help students understand their career possibilities. It is important that not only this type of work is supported but also made known for students that can be interested.

There are some ideas that have been gathered from the stakeholders contacted during the work on this project but don’t fall under any of the main recommendations presented (some are mentioned in the appendix). There were a lot of opinions gathered from students, from the importance of making classes more practical and attractive to keeping the recordings of classes online for students to study from. The most recurring ideas are presented below:

- Better integrating companies in the curricular units and their projects;
- Introducing a (mandatory) internship, ideally a paid one;
- Promoting a closer contact with alumni, as well as an providing access to a database with their information;
- Creating a dedicated office of the university with available professionals to individually support in career planning and job search;
• Improving the Master’s curriculum in Space.

Apart from improvements in the Space major, there were also some specific suggestions for improving the courses on Performance, Algebra and Programming.

The last thing left to do is for each and every student to keep working on their careers to have a fulfilling life and a positive impact in the world.
Bibliography


Appendix A

Aerospace Engineering students survey

The responses on this survey have been gathered between the 9th and 31st of August of 2020. The questionnaire was sent to all current students by email and shared in a group on social media. A total of 203 current students submitted valid responses to the questionnaire.

<table>
<thead>
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<th>Enrolment year</th>
<th>Respondents</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019/20</td>
<td>37</td>
<td>18.23%</td>
</tr>
<tr>
<td>2018/19</td>
<td>31</td>
<td>15.27%</td>
</tr>
<tr>
<td>2017/18</td>
<td>37</td>
<td>18.23%</td>
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<td>7.88%</td>
</tr>
<tr>
<td>Before 2014</td>
<td>12</td>
<td>5.91%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>203</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>

Table A.1: Methodological information

Even though the number of answers and the distribution of answers per enrolment year, it must be taken into account that the sample was not randomly selected from the population.
Figure A.1: "How important was each factor when choosing your degree?"

Figure A.1 shows that the most important factors for students when choosing Aerospace Engineering as their degree were interest in engineering and mathematics, the good employability and the breadth of the degree. 17% of students considered that family influence was an important or very important factor. The reputation and popularity of the degree (associated with a competitive and proactive environment and a high GPA required) were also mentioned by some students as an important factor.

Figure A.2: "In which industries would you like to work? (choose all that apply)"

The vast majority of students are interested in working in the Aeronautics, Space and/or Defense industries (72%) or in other engineering fields (14%). Only 4% of students admit being interested in working in specifically non-engineering fields.
Figure A.3: "Which skills acquired in Tecnico do you believe will be most important in your future job?"

As shown in figure A.3, around 74% of students identified problem-solving as one of the three most important skills for their careers and around 65% put autonomous learning in the top-three. Less than 25% of students included software experience in the most important skills and only around 15% included maths knowledge in the list.

Figure A.4: "Which skills acquired in Tecnico do you believe will be most important in your future job?" (plotted by year of studies)

Figure A.4 represents the differences in the perceptions of students regarding the three most important skills for their careers as a function of the years in the degree. The plotted lines are simple linear regressions of the data.

It is interesting to notice the different perceptions of students regarding the most important skills throughout the years. The sample is not big enough to draw significant conclusions but it is interesting to note that:

• problem-solving and autonomous learning are most often perceived as the most important by
students independent of their academic year;

• programming is more often perceived as part of the most important group by students after their third year of studies;

• the perceived importance of project management and specific technical knowledge decreases for students in the 4th and 5th years.

The results presented in figure A.5 should be analysed considering that this question is done some years in retrospective, meaning some respondents may have participated and not remember. In any case, the analysis is relevant for a comparative study.

Figure A.5: “Which activities/tools did you make use of?”

Figure A.6 illustrates the impact perceived by the students that participated in each activity. Despite being implicit by the section and the possible responses that the question referred to career impact, it
was not specified in the question whether it was impact in their careers or impact in general, meaning that some students may have perceived the question differently.

The answer to this question shows that the activities with the most perceived impact are the ones that allow them to have direct contact with companies. The coaching sessions from NDA had the least perceived impact, but the beneficiaries of this type of service are a small number (30 out of 211) and a particular kind of student that doesn’t necessarily represent the student population.

![Participation in the Tutoring Programme (NDA)](image)

Figure A.7: “Did you participate in the Tutoring programme?”

As shown in figure A.7, only one student reported having a close relationship with the tutor beyond the first year of studies. 90% of students reported never meeting or having only one meeting with the tutor, which means that the objectives of the programme were not fully met for the vast majority of students.

From the students that contacted the Tutor whenever needed, some of the reasons for contacting the Tutor were to get support regarding:

- managing time, schedules and study;
- mental health and other personal issues;
- adaptation to the university;
- choosing master’s specialization.

The main “selling point” pointed out by these students regarding the Tutoring programme were that the Tutor is someone with a vast life and academic experiences, able to provide informed support and suggestions about how to deal with the personal and academic challenges and how to learn more about certain topics. It was also mentioned that the Tutor can be a link to other bodies inside the university.
From the students that only had one meeting or never met their tutor, the main reasons for not actively engaging with the programme were the lack of involvement/effort from the Tutor, the lack of clear objectives and not considering it a priority and eventually forgetting about it, as presented in figure A.8. It is also interesting to note that 5% of students admitted usually not participating in non-mandatory activities.

Only 6% of students disagree or strongly disagree that the mentors of the Mentor Programme (NAPE) have the necessary knowledge to help new students make decisions regarding the degree. The vast majority of students (72%) agree or strongly agree that Mentors, who are typically 2nd and 3rd year students, have the necessary knowledge.
Figure A.10: "Would you rather get the support from a Mentor (student) or from a Tutor (professor)?"

Figure A.10 shows that almost all students prefer the support of a fellow student for the integration in the university. It also shows that the vast majority of students (77%) prefer a fellow student to help them make a study plan. The only topic for which most students would prefer the support of a Tutor (professor) is choosing the master’s specialization. It is worth noting that this is not an option in the current Tutoring programme that is in place for 1st and 2nd year students.

This question was initially analysed separately for students that actively participated in the Tutoring Programme and the ones that didn’t, but not significant difference was found, despite some small differences in the percentages (the sample size of students that actively participated in the Tutoring Programme was only 19).

Figure A.11: Understanding of the applicability of theoretical knowledge

Only the majority of first-year students agree that they understand the applicability of the theoretical knowledge learned, as it is represented in figure A.11. From the second year onwards, only around 25%
of students agree or strongly agree with this statement.

From figure A.12 it is reassuring to realise that the majority of students agree or strongly agree that they have access to information regarding curricular units. In terms of information regarding career opportunities, less than 25% of students agree or strongly agree that they have access to information. Objectively, students have access to some relevant information regarding the curricular units and also regarding career opportunities, meaning that these results can be indicative of lack of quality/quantity in the information provided and/or in its accessibility.

Figure A.12: Perceptions of students regarding access to information

Figure A.13 shows that only 15% of students agreed or strongly agreed that they felt supported in making career decisions and 46% disagreed or strongly disagreed with the statement.

Figure A.13: Perceptions of students regarding support in career decisions
Figure A.14: Factors influencing curricular unit decisions

Figure A.14 illustrates the importance of three factors in the students’ decision of their elective courses. The fact that only 10% of students admit not taking personal career goals as a factor to decide their courses, shows that the vast majority of them think about their careers when making such decisions. It is also interesting to notice that about half the students have made curricular decisions based on the difficulty of the course and the decision of others.

Figure A.15: Experience with career exploration

Even if not in an ideal and structured way, it is great to realise that most students have explored different areas and career options as well as thought about the type of engineer they want to be. It is also reassuring to realise that the majority of students are confident about the success of their entry in the job market, as it can be seen in figure A.15.
Would you be interested in having an alumni mentor?

- Yes, only from Aerospace: 48.0%
- Yes, from any degree: 37.0%
- No: 15.0%

Figure A.16: "Would you be interested in participating in an alumni mentor programme?"

Finally, from the results presented in figure A.16, it is clear that the majority of students (85%) believe it would be beneficial to have alumni from Tecnico as mentors. From these, 56.5% would want to have a mentor from Aerospace Engineering while the remaining 43.5% don’t care from which degree this mentor would be.
Appendix B

Aerospace Engineering alumni survey

The information presented in this report comes from two main sources: a survey created and delivered in the context of the present work and the annual survey created and analysed by the Graduate Employability Observatory (OEIST).

Given the small sample of the survey created for this thesis, some of the data collected will not be included in this report, since a more comprehensive set of data has been collected by the OEIST.

Graduate Employability Observatory data

The OEIST annually sends a questionnaire to all graduates of Tecnico around 18 months after graduation. Table B.1 shows the number of students and responses per graduation year and respective year that the survey was sent.

<table>
<thead>
<tr>
<th>Survey year</th>
<th>Graduation year</th>
<th>Total graduates</th>
<th>Number of respondents</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>2016/17</td>
<td>72</td>
<td>37</td>
<td>51.4%</td>
</tr>
<tr>
<td>2018</td>
<td>2015/16</td>
<td>82</td>
<td>41</td>
<td>50.0%</td>
</tr>
<tr>
<td>2017</td>
<td>2014/15</td>
<td>53</td>
<td>25</td>
<td>47.2%</td>
</tr>
<tr>
<td>2016</td>
<td>2013/14</td>
<td>51</td>
<td>31</td>
<td>60.8%</td>
</tr>
</tbody>
</table>

Table B.1: Methodological information

As presented in table B.1, the response rate has been around 50% which is a decent number for a study of this kind.

<table>
<thead>
<tr>
<th>Professional situation</th>
<th>2016/17</th>
<th>2015/16</th>
<th>2014/15</th>
<th>2013/14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research fellow</td>
<td>13.5%</td>
<td>4.9%</td>
<td>12.0%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Unemployed</td>
<td>0.0%</td>
<td>2.4%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Intern (paid internship)</td>
<td>2.7%</td>
<td>7.3%</td>
<td>0.0%</td>
<td>9.7%</td>
</tr>
<tr>
<td>Employed</td>
<td>83.8%</td>
<td>85.4%</td>
<td>84.0%</td>
<td>74.2%</td>
</tr>
<tr>
<td>Self-employed</td>
<td>0.0%</td>
<td>0.0%</td>
<td>4.0%</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

Table B.2: Professional situation of alumni

The data regarding the professional situation around 18 months after graduation, presented in table B.2, shows that the vast majority of graduates is employed, with a relevant percentage doing research or doing an internship.
The salary of the graduates is clearly higher for the ones working abroad. From table B.3, we can also observe that there is a relatively high percentage of alumni working outside of Portugal. The numbers of internationalization for Aerospace Engineering graduates stands out when compared to other degrees in Tecnico.

Alumni survey data

The responses on this survey have been gathered between the 17th of August and the 13th of September of 2020. The questionnaire was sent by direct message on social media channels to 33 alumni from different graduation years and shared in social media groups. Additionally it was asked to respondents to share to their network of alumni. Unfortunately, only 39 valid responses were gathered. This number is not representative of the population of alumni and it only allows for some rough estimations.

This report also includes some comparative comments between the results and the data gathered from current students and reported in Appendix A.

Table B.3: Average monthly income

<table>
<thead>
<tr>
<th>Students working abroad</th>
<th>2016/17</th>
<th>2015/16</th>
<th>2014/15</th>
<th>2013/14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>1,500.6</td>
<td>1,408.8</td>
<td>1,432.3</td>
<td>1,342.1</td>
</tr>
<tr>
<td>Other country</td>
<td>3,603.8</td>
<td>3,955.9</td>
<td>2,931.3</td>
<td>2,326.0</td>
</tr>
<tr>
<td>Global</td>
<td>2,412.0</td>
<td>2,209.3</td>
<td>1,977.4</td>
<td>1,531.3</td>
</tr>
<tr>
<td></td>
<td>40.5%</td>
<td>34.1%</td>
<td>36.0%</td>
<td>25.8%</td>
</tr>
</tbody>
</table>

Table B.4: Methodological information

<table>
<thead>
<tr>
<th>Graduation year</th>
<th>Respondents</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019/20</td>
<td>4</td>
<td>10.26%</td>
</tr>
<tr>
<td>2018/19</td>
<td>14</td>
<td>35.90%</td>
</tr>
<tr>
<td>2017/18</td>
<td>9</td>
<td>23.08%</td>
</tr>
<tr>
<td>2016/17</td>
<td>1</td>
<td>2.56%</td>
</tr>
<tr>
<td>2015/16</td>
<td>3</td>
<td>7.69%</td>
</tr>
<tr>
<td>2014/15</td>
<td>2</td>
<td>5.13%</td>
</tr>
<tr>
<td>2013/14</td>
<td>2</td>
<td>5.13%</td>
</tr>
<tr>
<td>Before 2014</td>
<td>4</td>
<td>10.26%</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Table B.4 show that the distribution of responses per graduation year is not ideal, with 69.23% of alumni that answered the survey graduating over the past 3 years. As mentioned above, most of the information gathered regarding employability and salary will not be considered for this report.

Regarding their first job, students were asked to rate the alignment between the first job and their areas of professional interest. Converted to a ten-point scale, the average rating was 7.5/10 with a 2.5 standard deviation. This indicates that the majority of respondents started working in their area of interest.

Still regarding their professional experience, from the 39 alumni answering the survey, 69% of respondents reported having worked in the areas of Aeronautics, Space and/or Defense and 13% reported working in non-engineering fields (such as finance and consulting). These numbers are aligned with the 72% of current students interested in working in Aeronautics, Space and/or Defense industries.
As represented in figure B.1, around 70% of respondents identified problem-solving as one of the three most important skills for their careers and a slightly higher percentage put autonomous learning in the list as well. This result matches with the perception of students that autonomous learning and problem-solving skills are the most important that they acquire in Tecnico. Similarly to the study with students, programming is the third most selected competence, even if the percentage is smaller for alumni. Regarding all the other competencies, it seems like they are perceived as more important by students than by alumni (except for maths knowledge which is included in the top-three by 15% of students and 18% of alumni).

Alumni perceive that, by the end of the degree, they were confident in all the competencies highlighted in the Planned Happenstance theory discussed in chapter 2.2, as shown in figure B.2. It is worth noting that all the respondents feel moderate or very confident about persistence. Also interesting to realise that risk-taking is the competence alumni were less confident about with 31% stating they felt
little confidence by the time of graduation.

As mentioned in the report of the survey for students, the results presented in figure B.3 should be analysed considering that this question is done some years in retrospective, meaning some respondents may have participated and not remember.

Figure B.3: "Which activities/tools did you make use of?"

Figure B.4 illustrates the impact perceived by the alumni that participated in each activity. Despite being implicit by the section and the possible responses that the question referred to career impact, it was not specified in the question whether it was impact in their careers or impact in general, meaning that some respondents may have perceived the question differently. The response regarding the coaching sessions from NDA was not included here, since only one of the respondents had participated.

Figure B.4: "From the activities you participated in, how much impact did they have?"
of curricular and career planning associated with them, the Mentoring and Tutoring programmes are not designed to have an impact in the careers of students; and the Tecnico JobBank is a very recent platform, which is still being developed.

The trend noticed for students that the activities with the most perceived impact are the ones that allow them to have direct contact with companies also applies for alumni, with a slightly higher percentage of alumni considering networking events important.

![Perception of alumni regarding access to information](image)

Figure B.5: Perceptions of alumni regarding access to information while students

From figure B.5 it is clear that most alumni believe they had access to information regarding the curricular units, while a much smaller percentage (18%) agrees or strongly agrees that they had access to information regarding career opportunities, while at Tecnico. These results are very similar to the opinions of current students.

![Alumni perceptions as students](image)

Figure B.6: Perceptions of alumni regarding understanding the applicability of theoretical concepts and regarding career support

By comparing the data from figure A.11 and B.6, it can be concluded that while around 30% of current students believe they understand the applicability of theoretical concepts, only 13% of alumni believe they had this understanding as students. This may indicate that what students perceive as the applicability of theoretical concepts is different from the real applicability experienced by professionals.
Regarding the perceived support in making career decisions, it is also noteworthy that while 15% of students feel supported (figure A.13), only 5% of alumni felt this way. In the same way, while 46% of students disagree or strongly disagree with the statement, this number is 69% for alumni. This may indicate that support systems are improving over time.

![Made course decisions based on...](image)

Figure B.7: Factors influencing curricular unit decisions

The main factors influencing decisions of curricular units of alumni are in line with the factors influencing current students, with an increased importance of the difficulty of the course and a smaller importance of the decisions of peers, as it is presented in figure B.7.

![Career exploration experiences and career success confidence](image)

Figure B.8: Alumni experiences with career exploration as students

By comparing the data presented in figure A.15 and B.8, it is clear that the experiences of alumni regarding career exploration and their confidence in finding a job they would like are similar to what students report, with 55% to 67% of alumni agreeing or strongly agreeing with the three sentences.
Figure B.9: "Would you be interested in becoming a mentor for students from your degree?"

Figure B.9 represents the interest of alumni in becoming a mentor for Aerospace Engineering students. The fact that the questionnaire was voluntary can possibly be a factor influencing the answers to this question, as the sample is probably more available to help and interested in supporting the degree than the average alumni. In any case it is reassuring to realise that the vast majority of respondents (67%) would be interested in becoming a mentor.
Appendix C

Aerospace Industry survey

The responses on this survey have been gathered between the 5th of October and the 3rd of November of 2020. The questionnaire was sent to more than 40 companies involved in the Aerospace industry with activity in Portugal through general email addresses. Representatives from some of these companies, especially bigger ones, were also contacted through social media. These efforts resulted in 14 valid answers to the questionnaire.

All these 14 companies have activity in Aeronautics and/or Space industries and have at least one office in Portugal. The names of the companies that participated in the survey are the following: Active Space Technologies, Albatroz Engenharia, Caetano Aeronautic, Ceia, D-Orbit, Edisoft, Foco Aeronautical Services, GMV, LusoSpace, Omnidea, QSR, TAP Air Portugal, Thales and Valispace.

The low number of answers doesn’t allow for a statistically relevant analysis of the results and the results shouldn’t be seen as a generalisation, but rather of a specific case of these 14 companies. The information presented in this report does not specify the interests of each company but this information can be made available to the relevant bodies for implementation purposes.

![Survey respondent function in the company](image)

Figure C.1: "What’s your function in the company?"

It is important to note that the responses to the survey are not an official stance of the company but
rather the view of the respondent. The respondents were all managers, executives or human resources managers of the companies participating in the survey, being this distribution presented in figure C.1.

The companies answering the survey vary a lot in size, both in terms of number of employees and annual billing. Figure C.2 shows the division of the companies by number of employees.

Regarding recruitment practices, the average number of yearly hires of recent engineering graduates is around 13, with responding companies recruiting between 0 and 50 recent engineering graduates per year. Most of these companies had a reasonable to high interest in recruiting Tecnico students (11 out of 14 rated their interest 5 or higher in a scale from 1 to 7), some of them being particularly interested in Aerospace Engineering graduates.

Similarly to what was asked to students and alumni, company representatives had to identify the three most important skills of an engineer. The results presented in figure C.3 show that the two competencies most mentioned are aligned with the views of students and alumni.

Most of the companies answering the survey (8 out of 14) reported having recently participated in
an activity organised by Tecnico or by one of its nuclei. This number does not pretend to represent the percentage of companies in the Aerospace industry in Portugal that participated in activities related to Tecnico, since there is a probable relation between the likelihood of answering this survey and having a strong connection with Tecnico.

Figure C.4: "What are the main objectives to make a possible partnership with Tecnico?"

In figure C.4 the most common objectives identified by companies when establishing a possible partnership with Tecnico are presented. Companies were asked to select all the objectives that apply or leave the answer blank in case they had no interest in establishing a partnership. It is relevant to note that all companies answered this question, not only the ones that had recently participated in an activity.

Figure C.5: "What are the main challenges to make a partnership with Tecnico?"

As shown in figure C.5, when asked about the main challenges in establishing a partnership with Tecnico or its nuclei, the main two reasons identified were financial and timeline incompatibility. From the challenges studied, the unclear return on investment seemed to be an issue for the least companies.

Companies were asked to rate from 1 to 7 their interest in possible collaborations. The number of companies that rated their interest 5 or higher, in a scale from 1 to 7, is presented for each possible
collaboration in brackets:

- Having a company representative in an advisory board for the coordination of the Aerospace Engineering degree. (9/14)

- Present project proposals and support 3rd year students developing PIC1 projects during one semester. (11/14)

- Present Master’s thesis proposals and support final year students developing those projects during one semester. (13/14)

- Having engineers from the company as guest speakers to present specific contents in the context of some curricular unit. (12/14)

- Receive 1st year students at the company offices for some hours to better understand the work of an engineer. (10/14)

All these possible collaborations (except the one related to the Master’s thesis) are presented in chapter 4 as suggestions. Detailed information about the interests of the companies can be provided to the relevant bodies for implementation purposes.

Finally, companies had the opportunity to make comments and suggestions regarding career planning and university-industry collaboration. The points raised by some companies are summarised below:

- There are other valuable sources of Aerospace engineers for these companies, particularly Aeronautic Engineers from UBI and graduates from other European universities.

- Students from Aerospace Engineering lack necessary knowledge in the field of space.

- Master’s specializations should be more aligned with the industry needs.

- In the past, professors were not receptive to the implementation of new ideas/software.

- The corporate partnerships unit was inefficient developing proposals aligned with the financial constraints of startups.