Tackling perception and deception in STEM: A critical thinking skill for early-career development

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ABSTRACT

The Universitat Politècnica de Catalunya (UPC), the Instituto Superior Técnico (IST-Universidade de Lisboa) and the Czech Technical University (CTU) have recently launched the Engine4STEMers project, a joint initiative whose objective, among others, is to guide young graduates in their transition to the job market and motivate them to adopt management and leadership skills early in their careers. In this context, this short paper describes the objectives and contents of a Critical Thinking seminar, currently underway at UPC, which is aimed at motivating young STEM graduates to develop the principles of a skeptical attitude towards the information and stimuli that we perceive in order to face uncertainty, biased information and hidden agendas. Engine4STEMers needs analysis has revealed the importance of a good understanding of the concepts of perception and deception to develop effective interpersonal skills and, more importantly, to ease decision-making processes in a VUCA (volatile, uncertain, complex and ambiguous) environment.

1 INTRODUCTION

1.1 The Engine4STEMers context and motivation

The emphasis of STEM student education has been almost exclusively on acquiring technical and scientific knowledge, leaving a gap in terms of their preparation for the labour market that needs to be filled. In order to cope with fast-changing social and economic environments, STEM graduates are increasingly needing specific personal

and professional development techniques aligned to their career evolution in the technology business [1][2]. To embrace continuous innovation, companies are progressively flattering, less hierarchical, evolving from traditional pyramidal and segregated organizations to an organizational model of shared responsibility (Fig. 1). This new and highly demanding context requires the STEM graduate to undertake a rapid change in attitude and work methodology to evolve from a user culture (student) to a service provider culture (employee or entrepreneur) (Fig. 2). That is, moving quickly from a task executor role (doing) to assuming greater responsibility in terms of management roles (directing) and finally to leadership roles (deciding) (Fig. 1).
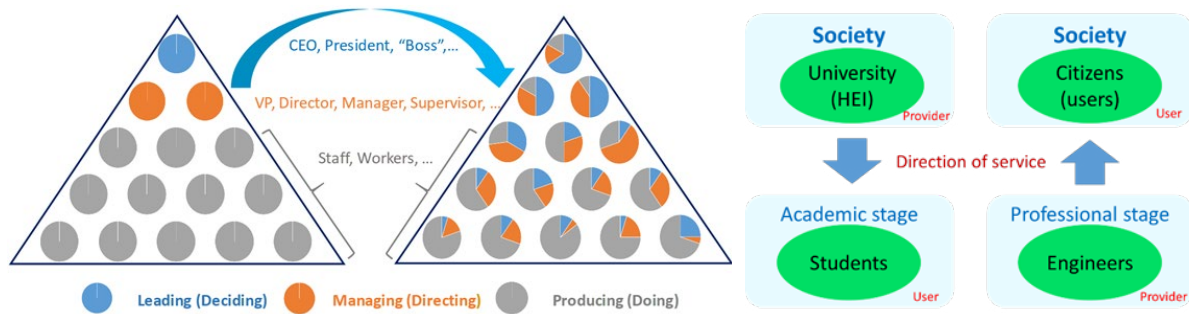

Fig. 1. Companies tend to be flatter and less hierarchical   Fig. 2. Direction of service

Given the greater than ever impact of technology and engineering in our lives, STEM students are particularly important in leading XXI century societal transformation towards a sustainable and prosperous future, and must be ready to play that role. In this sense, Engine4STEMers aims to develop a set of short teaching and learning modules organized around three themes:

- Early career tools in the tech arena.
- Critical thinking for successful career development in STEM.
- Leadership: the STEM graduate as an effective fair human being

1.2 Critical thinking for successful career development in STEM.

The increasing acceleration of change, the need for continuous innovation, or the reduction in the useful life of products and services, requires a new brand of STEM professionals prepared to deal with VUCA (volatile, uncertain, complex and ambiguous) labour market demands. To attend to these demands, recent surveys give growing importance to social, emotional and higher cognitive skills, such as Critical Thinking, as key transversal competences demanded by employers [3]. In this context, Engine4STEMers aims to provide last year's students with a grasp on critical thinking basics: creativity and innovation, growth by generating added value, creative problem solving and (ethical) engineering design. Critical thinking has also emerged as a crucial skill in decision-making processes to manage the overwhelming amount of information we have to deal with. In addition, given that it is becoming increasingly clear that the information we perceive may be tainted with intentional or unintentional

biases intended to influence our behavior, special attention should be paid to developing a skeptical attitude towards the information we perceive, as a fundamental step in the decision-making process. Likewise, STEM graduates must be aware that "what is technically impeccable does not necessarily have to be humanly correct". The motivation of final-year STEM students to start this path is one of the main objectives of the seminar presented in this short paper.

2   METHODOLOGY

2.1 Impact of perception bias on personal and professional development

The first block of this seminar is related to developing how information is generated, transmitted and perceived by people (Fig. 3). The main sources of perception bias are discussed with the students in terms of their impact on the development of personal and professional competences. Discussions focus on three key issues:

-Self-awareness: The seminar uses practical examples to discuss the fact that we do not react to the real world but to how we perceive it. Being aware of potential sources of information bias emphasizes the need to be skeptical, even of one's own beliefs and perceptions. This first section aims to motivate students toward a self-awareness attitude as the first step to self-manage their personal and professional growth.

-Interpersonal relations: The seminar presents how the fact that different people perceive the real world in different ways has a strong influence on how we interact and communicate. This stresses the need to develop open-mindedness and active listening: first, understand, be empathetic, then communicate in a fair, inclusive way.

-Proactivity. Discussions about perception bias and the limitations of self-awareness aim to emphasize the importance of inhibiting the automatic (emotional) reaction to the stimuli we receive. It helps develop the principles of the strong habit of making decisions based on reason rather than emotion. This is important in a number of situations, particularly when risk and uncertainty are involved, as illustrated by an introduction to the principles developed by Nobel Prize D. Kahneman [4].

This first block concludes with an introduction to the concept of selective perception to reinforce the need to be skeptical of the information we receive. It is illustrated with examples of fakes, frames, storytelling, and nudges to engage students in discussions and to raise their awareness of the need to be very proactive in understanding the big picture before any decision-making process.

2.2 Data literacy

The second seminar block is devoted to data literacy. While STEM graduates have a good ability to read, write, and communicate data in context, they are often not fully aware of the main sources of deception that they may have to address due to intentional or unintentional misuse of data (Fig. 3). The implications that data misuse deception can have on decision-making processes are particularly highlighted. To engage students in discussions, this concept is illustrated with examples extracted

from the media and the literature [5]. The main sources of bias in (poor) data analysis are also introduced.

Finally, a section is devoted to probability. The general public's low knowledge of probability theory is a major source of non-rational decisions and is highly prone to be used in demagoguery and deception [4]. Students are challenged with probability-related examples to highlight that, in many cases, emotions can be more decisive than reason in decision-making. This section ends with some case studies related to conditional probability (e.g. the prosecutor's fallacy) and the important implications that a deficient understanding of the Bayes' theorem can have on trials or epidemiology studies, given as examples. As discussion exercises, challenged with misleading headlines, students are asked to ascertain the induced message and then to rephrase them in terms of conditional probability to provide a better insight (Fig. 4).

Fig. 3. Critical thinking seminar content

Fig. 4. Misleading headlines

3   CONCLUSION

This short paper presents a seminar on Critical Thinking that focuses on how we acquire and transfer knowledge and the main sources of information bias that a young STEM graduate may have to face. The main objective of the seminar is to introduce STEM students to the concept of perception and highlight the great influence that self-awareness and the knowledge of how others may perceive reality can have on the development of personal and professional skills. It has also been highlighted that, to thrive in the tech labour market, in a fair and responsible way, STEM graduates may have to deal with potential sources of deception in graphs and statistics, with (poor) data analysis, and with people's misunderstanding of probability.

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