On the effectiveness of experiential teaching methods: the impact of University Challenges on students' attitudinal development

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Abstract: The adoption of experiential teaching methods (e.g., flipped classroom, case-based learning, university challenges, etc.) with respect to traditional ones is gaining momentum in educational institutions. Due to the spread of those experiential methodologies, the aim of this study is to evaluate the impact of university challenges on students' attitudinal development, impact on fit to role and job satisfaction. We developed a questionnaire and a personality test, which we administered to two datasets of Engineering & Management students, from 2022 onwards. The first questionnaire was developed by combining 249 items from the International Personality Item Pool (IPIP) and dimensions from the O*NET workstyles, which respectively represent a database of psychological constructs and job profiles characteristics. The second questionnaire was designed by integrating dimensions from occupational dimensions and occupational dimensions. The study found that Analytical Thinking and Innovation are positively related to the participation to the University Challenge. Job satisfaction is influenced by many different factors, with no evident impact generated by participation to contests during academic studies. The research allowed to quantitatively demonstrate the impact and influence played by one of the experiential teaching methods - namely, challenge-based learning, although not yet widely adopted.

Keywords: Human Factor; Attitudes; Education; Teaching; Challenge; University; Industrial Engineering

I. INTRODUCTION

Teaching methods play a pivotal role in shaping the learning process for students (Afzal & Crawford, 2022; Lau, 2015), and traditional approaches have been criticized for their limitations, such as a lack of practical applications (Preiksaitis et al., 2023). As a result, institutions are adopting experiential teaching methods to provide students with practical skills and experience. Among those possible approaches, several main categories can be identified:

1. Flipped classrooms: involve students in the classroom learning the course material prior to class, then using class time to discuss and apply the course material (Akçayır & Akçayır, 2018; Johnson, 2021).
2. Case-based or project-based learning: involve relying on real or simulated case studies to facilitate students' understanding and application of concepts in a practical context (Ulvik et al., 2022; Zhang et al., 2022).
3. Serious games: refers to the adoption and use of game design technique in a non-gaming environment with the aim of increasing students' engagement and motivation (Din & Gibson, 2019; Esposito et al., 2022; Jääskä et al., 2022; Jääskä & Aaltonen, 2022).
4. University Challenges or Hackathons: represent team-based competitions in which students apply their theoretical knowledge to real-world problems, gaining practical skills and experience (Colombelli et al., 2022; Garcia, 2023; Preiksaitis et al., 2023).

In this context, the latter cluster of teaching methods has been raising popularity among educational institutions and industrial organizations, also fostering collaboration between the public and private sector (Colombelli et al., 2022). Specifically, these challenges have gained a growing audience in the Industrial Engineering field, due to their ability to attract students and allow the development of partnership mechanisms among universities and private companies.

Indeed, by participating to a University Challenge, students work on a specific project over a set period, which can range from designing a new product to optimizing a manufacturing process (Membrillo-Hernández et al., 2019). The Formula Student competition is a prime example of a University Challenge (Bischof et al., 2009). Engineering students design and build a single-seat race car, which they then compete against other teams in various events. This challenge offers hands-on experience in areas such as design, manufacturing, and project management. Another example of a university challenge is the Google Online Marketing Challenge (Neale et al., 2009). This global competition requires students to create and run an online advertising campaign for a real business, providing

practical experience in digital marketing and business environment complexities.

The diffusion of University Challenges can be traced back to their specific characteristics (Palma-Mendoza et al., 2019). They offer a unique and engaging learning experience for students by encouraging teamwork and promoting practical skills highly valued by employers. Additionally, the participation to such activities promotes students' attitudinal development, since they usually need to face and overcome practical tasks that are typically experienced only during real-world situations (Johnson et al., 2009). However, while the intangible benefits of experiential teaching methods are widely acknowledged, there is a need for empirical evidence to support their effectiveness (Connolly et al., 2012).

For this reason, it is possible to express the research question of the manuscript as follows:

RQ: To what extent are University Challenges effective in promoting attitudinal development among students and what specific attitudes are stimulated by this experiential teaching method?

To address this gap, we conducted a group design study to evaluate the impact of University Challenges on students' attitudinal development and impact on fit to role and job satisfaction. We developed a survey and a personality test, which we administered to two datasets of Engineering & Management students from Tor Vergata University of Rome, in Italy.

The rest of the paper is organized as follows. The introduction section presents the background of the teaching method and describes some of the most important scientific contributions. The design study is described from a methodological and experimental point of view, as well as from the point of view of survey administration and personality test. Then the results and discussions of the main outcomes are reported. Finally, we conclude the document with indications for further research and progress.

II. EXPERIENTIAL TEACHING METHODS: RESEARCH FIELD REVIEW

The research background on alternative teaching methods in Industrial Engineering disciplines is largely developed (Ameerbakhsh et al., 2019), showing the academic interest towards potential innovative learning approaches (Connolly et al., 2012). In this context, flipped learning, case or project-based learning, serious games and university challenges or hackathons are some of the most relevant types of approaches currently under use in learning environments.

For instance, the usage of serious games is found to be relevant in a Project Management (PM) context, allowing to trigger changes in a PM education (Jaccard et al., 2022) and to develop new skills, competencies and relationships that are not typical of the traditional teaching methodologies. A similar outcome, yet on a different context, is obtained by the work of Ameerbakhsh et al. (2019), which demonstrates that a greater learning effectiveness is achieved with an expert demonstration of the simulation game. The latter experiment was conducted in a marine ecology course, and the students emphasized a better understanding of the main concepts and an increased entertainment of the lecture. These results are explained by the students' expectations that a different learning approach would enhance their educational outcomes, as demonstrated by the research of Iten & Petko (2016) and by the one of Berta et al. (2015).

Among those experiential teaching practices, challenge-based learning appears to be one of the most promising, though not yet widely adopted. Moreover, no clear evidence of its learning and attitudinal development outcomes is found in the scientific literature (Colombelli et al., 2022). Indeed, only few authors have concentrated their attention so far towards this newly established teaching method.

Membrillo-Hernández et al. (2019) have stressed out the importance of developing partnership relationships with national and multinational leading companies to create university challenges and hackathons. The collaboration between professors and organizational personnel allows the definition of challenges aimed both at obtaining learning outcomes and a hands-on practice on real-life situations. The same concept of having students face real-world problems is considered by Johnson et al. (2009) and Palma-Mendoza et al. (2019). Even though the first contribution focuses on challenges carried out by high school students and the latter on university students, a positive impact on educational outcomes is registered in both cases. Indeed, the research found that critical thinking, creativity, problem-solving skills were perceived as improved after participating to the challenge, along with better overall performances of the students in terms of grades. On a similar fashion, Colombelli et al. (2022) demonstrate that entrepreneurial mindset, creativity, financial literacy and planning are improved by the involvement in specific challenges.

Although the above considerations suggest that university challenges and hackathons are effective in enhancing students' skills and motivation, no evaluation of their impact on attitudinal development, job satisfaction and fit to role has been provided. Furthermore, assessments are often carried out based on qualitative methodologies and data, with serious limitations in terms of replicability of the analysis and generalizability of the results.

Therefore, our manuscript aims to propose a methodology and two questionnaires to evaluate the effectiveness of university challenges from the students' attitudinal perspective. Indeed, by implementing a group design study for Industrial Engineering students, it is possible to determine the effects and differences between

students that participated to the challenge and students who did not, in order to obtain relevant outcomes and analyse potential effects of this experiential teaching method.

III. A DEEP DIVE ON UNIVERSITY CHALLENGES UNDER EVALUATION

We refer to university challenges carried out in the Industrial Engineering venue at Tor Vergata University of Rome, Italy, from 2022 onwards. The challenges were developed in collaboration with major multinational companies in the Manufacturing, Logistics and Retail sectors, with topics concerning Operations Management, Distribution and Transportation Management, Supply Chain Management.

All the challenges adopted a similar structure, composed of five main steps:

1. Presentation of the problem: during this phase one or more industrial problems are shown to the students. Successively, they should establish a team and select the issue to be addressed.
2. Teamwork and proposal of the solution: the teams start working and provide a solution to the selected problem. In this phase, further details can be requested to the professor or the company personnel.
3. Evaluation and selection of the finalists: after the teams propose their solutions, they are evaluated, and finalists are selected based on the effectiveness, feasibility, and innovation of their proposals.
4. Visit to the company headquarters or plant and deep dive on the project: finalists are then invited to visit company headquarters or plant to better understand the project and adjust their proposals. In this step, organizations' HR perform a round of interviews to each of the finalists for a potential hiring process.
5. Winner selection and reward: finally, the winning team is selected, and the reward is proved to the different team members (e.g., stage proposal, visit to additional company plants, etc.).

IV. METHODOLOGY AND EXPERIMENT

For the scope of the research, we developed two different questionnaires for evaluating the attitudinal profile of students along with their occupational profile and job satisfaction evaluation. Both of the questionnaires implement a 5-point Likert scale graded from 1 = "does not correspond at all" to 5 = "corresponds exactly".

The first questionnaire ("attitudinal assessment") was developed by combining 249 items from the International Personality Item Pool – IPIP (Battistoni & Fronzetti Colladon, 2014; Johnson, 2014) and dimensions from the O*NET workstyles (Kossek & Perrigino, 2016), that respectively represent a database of psychological constructs and job profiles characteristics. Additionally, the second questionnaire ("occupational assessment") concerns the occupational state of participants and allows to derive measures of satisfaction and fit to role with respect to their study or career path. A description of the measured dimensions is reported as in Table I and II.

TABLE I

Attitudinal assessment dimensions

Attitudinal trait	**Description**
Achievement/ Effort	Setting challenging goals and putting effort towards mastering tasks.
Adaptability/ Flexibility	Being open to change, whether positive or negative, and comfortable with variation.
Analytical Thinking	Analyzing information and using logical reasoning to address work-related issues.
Attention to Detail	Being diligent and careful about details, ensuring work tasks are completed thoroughly.
Concern for Others	Being empathetic, understanding, and helpful towards needs and feelings of others on the job.
Cooperation	Being friendly and collaborative with co-workers and displaying a cooperative attitude.
Dependability	Being responsible, dependable, and trustworthy, and fulfilling job obligations.
Independence	Developing one's own way of doing things, with little or no supervision and taking initiative.
Initiative	Willingness to take on challenges and responsibilities proactively.
Innovation	Using creative and alternative thinking to develop ideas and solutions to problems.
Integrity	Being honest and ethical in all job-related activities.
Leadership	Willingness to lead, take charge, offer opinions, and provide direction.
Neuroticism	Being prone to worry, self-doubt, and feelings of insecurity, and be more sensitive to criticism.
Persistence	Demonstrating perseverance and persistence in the face of obstacles.
Self-Control	Controlling emotions and avoiding aggressive behaviour in difficult situations.
Social Orientation	Preferring to work with others rather than alone and building strong interpersonal connections.
Stress Tolerance	Accepting criticism calmly and dealing effectively with high-stress situations.

TABLE II

Occupational assessment dimensions

Occupational trait	Description
Career path satisfaction	Degree of satisfaction and fulfilment an individual experiences in its chosen career path.
Work life balance	Ability to balance work responsibilities with personal and family commitments.
Competence evaluation	Process of evaluating an individual's own competences in relation to its job responsibilities.
Role evaluation	Degree of alignment between an individual's job responsibilities and its personal values and goals.

Those same questionnaires were then submitted to two different groups of students, one composed of students that participated to the challenges, one who did not. The sample consisted of 86 first and second-year graduates from the Engineering & Management program, who were enrolled in the Industrial Systems Engineering class in 2022-2023 and took the abovementioned challenges. Among those 86 students, 22 (26%) did not participate in any of the contests while the remaining 64 (74%) took part in one or more of them. The distribution is not equal due to the majority of people participating to the challenges, and due to the lower rate of survey responses of the first group of people. Note that only 9 out of 86 (10,5%) students are not currently employed in any organization.

Starting from those responses, it has been possible to perform the evaluation of attitudinal development and fit to role for both groups, with the aim of comparing their values and demonstrating the relevant characteristics and impacts of university challenge on students. For this reason, we computed the overall average values for each of the attitudinal/occupational dimensions (see Table I and II) and analyzed the correlation between the participation to the challenge and the measured dimensional outcomes. For the reason described as in Section II, we expect the relationships hypothesized as in Table III.

TABLE III

Expected relationships between attitudinal, occupational dimensions and participation to the University Challenges

Hypotheses	
H1.	Adaptability/Flexibility is positively related to the participation to the University Challenge.
H2.	Analytical Thinking is positively related to the participation to the University Challenge.
H3.	Cooperation is positively related to the participation to the University Challenge.
H4.	Innovation is positively related to the participation to the University Challenge.
H5.	Neuroticism is negatively related to the participation to the University Challenge.
H6.	Career path satisfaction is positively related to the participation to the University Challenge.

V. Results: the effectiveness of University Challenges

To verify the hypothesized relationships, we perform Pearson correlation between the measured dimensions and participation to University Challenges (note that this index is dichotomous, showing if a student participated or not to the contest). Table IV reports outcomes for the attitudinal development evaluation, while Table V for the occupational assessment. Moreover, occupational assessment is performed also by calculating correlations among the measured variables, in order to determine if a specific occupational status may drive satisfaction or motivation in terms of organizational outcomes.

TABLE IV

Pearson's correlation between attitudinal traits and participation to the challenge

Attitudinal trait	Correlation
Achievement/Effort	0,016
Adaptability/Flexibility	0,141
Analytical Thinking	0,264*
Attention to Detail	0,088
Concern for Others	0,135
Cooperation	0,173
Dependability	0,244
Independence	-0,079
Initiative	0,169
Innovation	0,326**
Integrity	0,069
Leadership	0,197
Neuroticism	-0,064
Persistence	0,023
Self-Control	0,106
Social Orientation	0,097
Stress Tolerance	0,216

* $p < .05$
** $p < .01$

TABLE V

Pearson's correlation matrix between occupational dimensions and participation to the challenge

	Challenge particip.	Career path satis.	Work life balance	Competence evaluation
Career path satisfaction	-0,072			
Work life balance	0,077	0,261*		

	Challenge particip.	Career path satis.	Work life balance	Competence evaluation
Competence evaluation	-0,001	0,379**	0,171	
Role evaluation	-0,030	0,500**	0,267*	0,638**

* p < .05
** p < .01

As Table IV shows, some correlations are significant for the attitudinal traits. Analytical Thinking and Innovation are positively correlated with participation to the challenge; conversely, not a single attitudinal dimension is negatively correlated with participation to the challenge, meaning that this teaching method drives positive individuals' development. In this context, Innovation stands out as the most important trait related to challenge participation, due to its strong correlation value. With respect to the initial hypothesis, the analysis hence confirms H2 and H5.

To perform a further evaluation concerning Analytical Thinking and Innovation, an ANOVA analysis is carried out with respect to their average values and their distribution are shown as in Figure 1 and 2. The high resulting F-values allow to refuse the null hypothesis and to highlight the differences between their means.

This confirms once again, as expected, that Analytical Thinking and Innovation are relevant attitudinal traits linked to the challenge participation. This consideration appears extremely significant, since it shows how experiential teaching methods can drive the development of specific traits that are not typically taught during academic course.

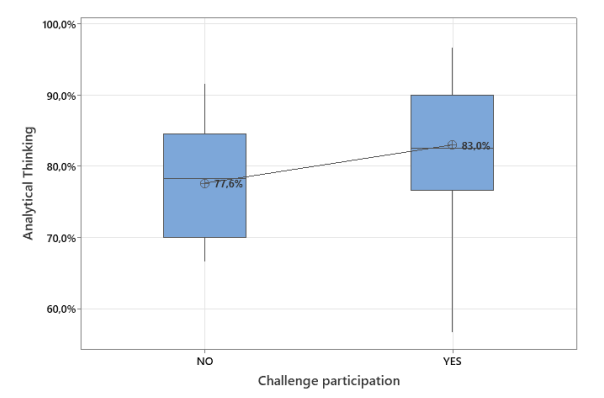

Figure 1: distribution of Analytical Thinking dimension values

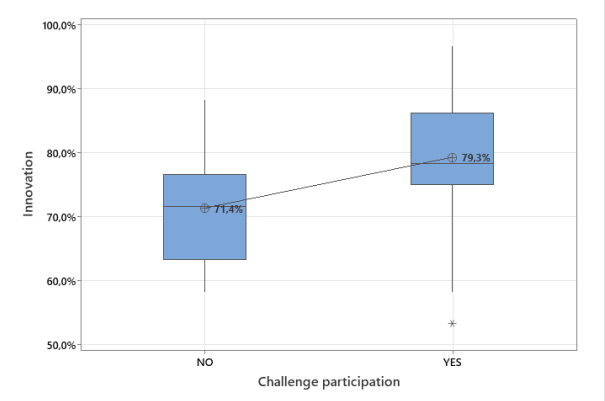

Figure 2: distribution of Innovation dimension values

On the occupational perspective, results from Table V shows several significant correlations. However, differently from the attitudinal assessment, no occupational dimension is positively related to the participation to the University Challenge. This appears surprising, at least for the career path satisfaction, since having participated in one or more challenges students should develop a higher awareness of the practical work situations and, in turn, may perform better decisions in terms of job positions. The outcome hence leads to state that no difference in terms of career path satisfaction should be expected considering challenge participation.

Different observations can be performed considering the correlations between the many occupational dimensions. Indeed, career path satisfaction is positively associated with work life balance, competence evaluation and role evaluation, leading to affirm that job satisfaction is driven by the evaluation of many other aspects around the individuals' job sphere. Additionally, role evaluation is positively linked with work life balance and, more strongly, with competence evaluation. The latter result is particularly relevant since it allows to state that people who find their personal values and goals aligned with their individual's job are prone to evaluate in the same direction the individual's own competences in relation to the job responsibilities.

Thus, to increase personnel retention and maximize the talent density within the company, organizations should pay a great attention towards right-sizing of roles (in terms of required competences) and define accurate matching between individual's traits and needed ones. For this reason, University Challenges may serve as a way for students to practically face real-world situations, problems and required competences/attitudes, and for organizations to evaluate the correct matching between individuals and job positions. Additionally, this approach can be exported and expanded to professional training and lifelong learning. Indeed, by designing tailored challenges that allow the development of specific attitudinal traits, organizations can ensure the

qualification of personnel along its professional development.

VI. Discussion and conclusions

The aim of this study was to evaluate the impact of university challenges on students' attitudinal development and impact on fit to role and job satisfaction. We developed a questionnaire and a survey, which we administered to two datasets of Engineering & Management students from Tor Vergata University of Rome, Italy, from 2022 onwards. The first questionnaire was developed to determine the attitudinal profile of students and designed by combining 249 items from the International Personality Item Pool - IPIP and dimensions from the O*NET workstyles. The second questionnaire was designed to assess the occupational profile of students.

The study found that there is a positive relationship between Analytical Thinking and Innovation and the participation in the University Challenge. However, the study did not confirm the hypothesis that career path satisfaction is positively associated with participation in the University Challenge, but it shows that is driven by multiple other aspects within an individual's job environment (work life balance, competence evaluation, role evaluation). Hence, it can be reasonably concluded that job satisfaction is influenced by many different factors, with no evident impact generated by participation to contests during academic studies.

The research allowed to quantitatively demonstrate the impact and influence played by one of the experiential teaching methods – namely the challenge-based learning – on the students' attitudinal development. From this consideration, Academics and Higher-Educations may draw up conclusions on the definition of curricula and educational programmes with specific learning objectives, by also exploiting the potential of those practices. Moreover, the outcomes of this research lead to state that attitudinal development represents a significant element for students' progress, and that should be taken into account by organizational Human Resources when designing job positions and roles.

Lastly, the research has some limitations that should be considered. First, concerning the experiment, there is no equal distribution between the groups numerosity, which may have impacted the overall research outcomes. Secondly, it was limited only to Engineering & Management students, since those students were mainly addressed by the challenges. For this reason, further development of the study may be defined with the aim of filling those limitations and replicating the study for a bigger number of students and courses-faculties. Lastly, an extension of this study may be represented by the implementation of a pre-test and post-test methodology in order to evaluate the degree of attitudinal development of the students that have participated to the university challenge. Indeed, by implementing this methodology it would be possible to clarify potential influences of native personality traits played on the decision-making process concerning the challenge participation.

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