

Article

The Impact of University Challenges on Students' Attitudes and Career Paths in Industrial Engineering: A Comparative Study

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Abstract: The educational landscape is undergoing a transformative shift from conventional teaching methodologies towards experiential approaches, such as flipped classrooms, case-based learning, and university challenges. This paradigm change spurred our investigation to evaluate the influence of university challenges on students' attitudinal development, alignment with future roles, and job satisfaction, aligning with Sustainable Development Goal 4: Quality Education. To achieve this, we devised a questionnaire and a personality test administered to two datasets of Engineering and Management students commencing in 2022. The first questionnaire integrated 249 items from the International Personality Item Pool (IPIP) and dimensions from the O*NET workstyles database, focusing on psychological constructs and job profile characteristics, contributing to the advancement of SDG 4's goal for inclusive and quality education. The second questionnaire covered various occupational dimensions. Our findings revealed a positive correlation between participation in university challenges and analytical thinking and innovation, demonstrating the potential impact of experiential learning on crucial skill development. However, job satisfaction seemed to be influenced by multifaceted factors, with no discernible impact stemming from contest participation during academic studies. This study quantitatively underscores the influence of experiential teaching methods, particularly challenge-based learning, within the context of SDG 4, shedding light on how these approaches significantly shape students' attitudes and perspectives. In the realm of education, the adoption of diverse teaching methodologies, such as collaborative teaching methods, learning factories, and active learning, has been on the rise, enriching the learning experience in university classrooms. Our research delves into the impact of integrating optional university challenges within Engineering and Management courses and their correlation with improved academic trajectories and enhanced job prospects. These findings carry significant implications for the evolution of university teaching methodologies and the definition of occupational profiles in the field of Industrial Engineering, offering valuable insights for business assessments in line with SDG 4.

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1. Introduction

Teaching methods play a pivotal role in shaping students' learning experiences, and traditional approaches have faced criticism for their perceived limitations, particularly the lack of practical applications. This shift has led to an increased adoption of experiential teaching methodologies, often accompanied by innovative game-based education systems, aimed at cultivating practical skills and real-world experience among students. Paradigms like flipped classrooms, case-based or project-based learning, Serious Games (SGS), and university challenges or hackathons have all emerged as significant mechanisms to ensure an interactive and hands-on learning journey [1].

Among these methodologies, university challenges and serious games have garnered significant attention due to their immersive and engaging characteristics [2,3]. University challenges, team-based competitions where students apply theoretical knowledge to real-world situations, have become especially popular in the Industrial Engineering sector [4]. They not only foster collaboration within the educational domain but also promote interaction between the public and private sectors. Similarly, SG, a tool integrating game design techniques into non-gaming environments, enhances student engagement and motivation, leading to a vibrant learning experience [5].

It is noteworthy that both of these methodologies possess a unique ability to bridge the gap between academic learning and the professional world [6,7]. They encourage teamwork and promote invaluable practical skills [1,5]. While the benefits of these methods are widely acknowledged, there remains a need for empirical evidence to substantiate their effectiveness, aligning with the goals of Sustainable Development Goal 4: Quality Education. In light of this, two primary research questions are formulated:

- RQ1: To what extent are university challenges and serious games effective in promoting attitudinal development, engagement, and motivation among students?
- RQ2: What specific attitudes are stimulated by these experiential teaching methods, and could participation in such activities serve as a useful tool during the hiring process?

Addressing these research questions, we conducted a group design study involving both methodologies and evaluated their impact on students' attitudes, development, and preparedness for professional responsibilities. We administered a survey and a personality test to two datasets of Engineering and Management students from Tor Vergata University of Rome, Italy.

The subsequent sections of this document are organized accordingly. An overview of the teaching methodology adopted is first provided, supported by critical scientific contributions. The design study is then detailed, covering methodological and experimental perspectives, as well as survey administration and personality tests. This is followed by a comprehensive discussion of the study's main outcomes, concluding with indications for further research and potential improvements. Through this comprehensive exploration, we aim to critically assess the effectiveness and influence of university challenges and serious games in contemporary academic scenarios, contributing to the advancement of Sustainable Development Goal 4.

2. Materials and Methods

Numerous studies have explored the impact of alternative teaching methods in higher education, with a focus on innovative learning approaches such as flipped learning, case-based learning, serious games, university challenges, and hackathons [8,9]. For example, the use of serious games has shown promising results in various contexts, triggering changes in education, developing new skills, and enhancing students' understanding of key concepts [10,11]. These findings align with research by Iten and Petko [12] and Berta et al. [13], indicating that different learning approaches can improve educational outcomes.

Among these experiential teaching practices, challenge-based learning stands out as a promising method, although it remains relatively underutilized in higher education [14,15]. However, the literature lacks clear evidence regarding its impact on learning outcomes and attitudinal development [14]. Notably, only a few authors have extensively explored this newly established teaching approach.

Membrillo-Hernández et al. [16] have emphasized the importance of developing partnerships with leading companies to create university challenges and hackathons, emphasizing that collaboration between educators and industry professionals can define challenges that yield both learning outcomes and real-life practice. A similar theme of students tackling real-world problems is evident in the works of Johnson et al. [17] and

Palma-Mendoza et al. [18], which demonstrate positive impacts on students' educational outcomes, such as improved critical thinking, creativity, and problem-solving skills, as well as higher grades [19].

Colombelli et al. [14] further contribute by showing that involvement in specific challenges enhances students' entrepreneurial mindset, creativity, financial literacy, and planning skills. While these findings suggest that university challenges and hackathons effectively enhance students' skills and motivation, there is currently a gap in evaluating their impact on attitudinal development, job satisfaction, and fit to role.

Furthermore, assessments of these teaching methods often rely on qualitative methodologies and data, posing limitations in terms of analysis replicability and result generalizability. Therefore, our study aims to bridge this gap by proposing a methodology and two questionnaires to evaluate the effectiveness of university challenges from a student's attitudinal perspective [20,21]. Through a group design study involving Industrial Engineering students, we intend to determine the effects and differences between students who participated in the challenge and those who did not, providing comprehensive insights into the potential impact of this experiential teaching method.

In this research, we delve into university challenges in the field of Industrial Engineering at Tor Vergata University of Rome, Italy, which commenced from 2017 and continued through 2022. These challenges were conducted in collaboration with major multinational companies from the Manufacturing, Logistics, and Retail sectors, focusing on subjects including Operations Management, Distribution and Transportation Management, and Supply Chain Management. These challenges engaged students primarily from Management Engineering courses such as Industrial Plants, Production Management, and Operations Management, aligning with the subject matter covered.

The challenges, regardless of the specific year, adhered to a consistent structure, encompassing five key phases:

- (1) **Problem Presentation:** Organizers introduced one or more company-specific problems to the students. Subsequently, the challenge rules and submission deadlines were defined.
- (2) **Solution Development:** Participating student teams collaborated to develop solutions for the challenges presented by the companies. During this phase, they could seek additional information from company representatives or professors to enhance their proposals.
- (3) **Evaluation Phase:** Following the submission deadline for solutions, finalists were determined based on criteria including solution effectiveness, cost-efficiency, and innovation.
- (4) **Deeper Problem Understanding:** Finalists were often offered the opportunity to visit the company's facilities related to the problem of interest, gathering additional insights to refine and enhance their solutions. In some cases, Human Resources (HR) conducted interviews to assess students' suitability for potential employment within the company.
- (5) **Winner Announcement:** The winning student team was announced, and they were rewarded with opportunities such as internships at the company or visits to other facilities.

This comprehensive study aimed to provide insights into the impact of university challenges on students' attitudes and career paths within the context of Industrial Engineering. These challenges, despite slight variations in themes and structures, consistently provided students with valuable practical experience and the opportunity to apply their knowledge to real-world industrial problems. The research evaluated the influence of these challenges on student performance, satisfaction, and their potential for shaping future career paths, offering valuable contributions to the field of higher education. To address the research questions effectively, we developed and administered two distinct questionnaires to both participating and non-participating students in the university challenges.

The first questionnaire, denoted as the "attitudinal assessment," was meticulously crafted to capture student characteristics related to soft skills, attitudes, and personality traits. It consisted of 249 items derived from the well-established International Personality Item Pool (IPIP) [17,22]. Furthermore, this questionnaire drew upon dimensions from the O*NET workstyles [23], a database renowned for its representation of psychological constructs and job profile characteristics.

Simultaneously, the second questionnaire, aptly named the "occupational assessment," was designed to assess students' academic careers. It aimed to evaluate whether there were significant differences in performance or satisfaction among students participating in the challenges, and whether these differences influenced or determined variations among different professional paths.

Both questionnaires utilized a standardized 5-point Likert scale for response options, with categories ranging from "Strongly Disagree" to "Strongly Agree". The dimensions probed through the first questionnaire align with the classification proposed by Fantozzi et al. [24] and revolve around the softer aspects of the human sphere. A total of seventeen dimensions were assessed through this questionnaire, each contributing unique insights into students' attitudes and traits. This comprehensive approach to assessing student attitudes and occupational profiles within the context of the university challenges aimed to provide valuable insights into the impact of experiential learning on students' personal and professional development. The amalgamation of psychological constructs, job profile characteristics, and academic performance evaluations offered a holistic perspective for an in-depth analysis of the effects of such challenges on students' growth and career trajectories. In total, seventeen aspects of individuals' personal dimensions were measured, and dimensions related to the occupational sphere are reported in Tables 1 and 2 along with their descriptions.

Table 1. Attitudinal traits considered.

N.	Attitudinal Trait	Description
1	Achievement/Effort	Establishing ambitious objectives and dedicating substantial effort towards mastering tasks.
2	Adaptability/Flexibility	Demonstrating a receptive attitude towards change, both positive and negative, and displaying adaptability.
3	Analytical thinking	Conducting thorough analyses of information and employing logical reasoning to address work-related issues.
4	Attention to Detail	Exercising diligence and meticulousness in task completion, ensuring comprehensive execution.
5	Concern for Others	Exhibiting empathy, understanding, and helpfulness towards the needs and emotions of colleagues in the workplace.
6	Cooperation	Cultivating a friendly and collaborative demeanor with coworkers, fostering a cooperative atmosphere.
7	Dependability	Assuming responsibility, dependability, and trustworthiness, consistently fulfilling job obligations.
8	Independence	Cultivating an autonomous approach to tasks, demonstrating initiative even with minimal supervision.
9	Initiative	Displaying proactive eagerness to embrace challenges and assume additional responsibilities.
10	Innovation	Utilizing creative and innovative thinking to conceive ideas and develop problem-solving solutions.
11	Integrity	Upholding honesty and ethical conduct in all job-related activities.
12	Leadership	Willingness to take the lead, assume charge, express opinions, and provide guidance.

13	Neuroticism	Displaying a tendency towards worry, self-doubt, and feelings of insecurity, coupled with increased sensitivity to criticism.
14	Persistence	Exhibiting perseverance and persistence in the face of obstacles.
15	Self-Control	Exercising emotional control and avoiding aggressive behavior during challenging situations.
16	Social Orientation	Preferring collaborative work over solitude and forging robust interpersonal connections.
17	Stress Tolerance	Gracefully accepting criticism and effectively managing high-stress situations.

Table 2. Occupational traits considered.

N.	Occupational Trait	Description
1	Path satisfaction	Assessment of how much the chosen academic path has positively contributed to the professional journey.
2	Added value of the challenge	Evaluation of the extent to which participating in university challenges can provide added value during interviews/recruiting processes.
3	Development soft skills	Assessment of how much the pursued study program has facilitated the development of essential soft skills for future professional endeavors.
4	Hard skills development	Evaluation of how much the participation in the academic journey has enabled the acquisition of significant hard skills for future professional development.
5	Evaluation of regret in not participating in the challenge	Perception of the potential regret associated with not having participated in the proposed challenges.
6	Added value in the assessment phase	Evaluation of how important it was to have participated in a Human Resources interview challenge
7	Value added in the recruitment	Evaluation of the importance of participating in a challenge in order to be hired by a company.
8	Career path satisfaction	Degree of satisfaction and fulfillment in individual experiences in chosen career path.
9	Work–life balance	Ability to balance work responsibilities with personal and family commitments.
10	Competence evaluation	Process of evaluating an individual's own competences in relation to job responsibilities.
11	Role evaluation	Degree of alignment between an individual's job responsibilities and personal values and goals.

3. Results

In this study, students enrolled in the Engineering and Management program at Tor Vergata University of Rome, Italy, were the focus of our investigation, as detailed in Section 2. The total respondent sample consisted of 86 individuals, although the distribution between those who participated in the challenges and those who did not was not uniform. Specifically, the majority of respondents, accounting for 64 individuals (74%), had taken part in the challenges, while the remaining 22 (26%) had not, resulting in a somewhat heterogeneous sample. Among these 86 students, 22 (26%) did not participate in any of the challenges, while the remaining 64 (74%) engaged in one or more challenges during their studies. It is worth noting that only 9 out of 86 students (10.5%) are not currently employed by any organization.

Using these responses, we evaluated attitudinal development and fit to role for both groups, with the aim of comparing their values and elucidating the significant characteristics and impacts of university challenges on students. To achieve this, we computed overall average values for each attitudinal and occupational dimension (as presented in Tables 1 and 2) and analyzed the correlation between challenge participation and the measured dimensional outcomes. The relationships hypothesized are shown in Table 3.

Table 3. Hypotheses of work.

Hypotheses	
H1.	<i>Adaptability/Flexibility is positively related to the participation in the university challenge.</i>
H2.	<i>Analytical thinking is positively related to the participation in the university challenge.</i>
H3.	<i>Cooperation is positively related to the participation in the university challenge.</i>
H4.	<i>Innovation is positively related to the participation in the university challenge.</i>
H5.	<i>Neuroticism is negatively related to the participation in the university challenge.</i>
H6.	<i>Career path satisfaction is positively related to the participation in the university challenge.</i>
H7.	<i>Participating in challenges represents added value in recruitment.</i>
H8.	<i>Those who do not participate in challenges find them not particularly useful.</i>
H9.	<i>Participation in challenges enables the development of soft skills.</i>

To validate the anticipated connections, we conduct Pearson correlation analyses between the measured dimensions and the students' engagement in university challenges. It is important to note that the participation index is binary, indicating whether a student participated in the contest or not. The results for the assessment of attitudinal development are presented in Tables 4 and 5, while Tables 6 and 7 displays the outcomes for the occupational evaluation. Additionally, we explore the occupational assessment by calculating correlations among the measured variables to ascertain if particular occupational statuses might influence satisfaction and motivation concerning organizational outcomes.

Table 4. Correlation results I.

	Path Satisfaction	Value Added Chal- lenge	Soft Skills Devel- opment	Hard Skills Development
Value added	−0.318			
Soft skills development	0.219	0.405 *		
Hard skills development	0.614 **	−0.089	0.068	
Regret evaluation	−0.349	0.769 **	0.271 *	−0.015

* $p \leq 0.05$, ** $p \leq 0.01$.

Table 5. Correlation results II.

	Path Satisfaction	Added Value in Assessment Phase	Value Added in Recruitment	Soft Skills Development
Added value in the assessment phase	0.565 **			
Value added in recruitment	0.584 **	0.567 **		
Soft skills development	0.604 **	0.578 **	0.442 **	
Hard skills development	0.417 **	0.382 **	0.374 **	0.377 **

** $p \leq 0.01$.**Table 6.** Correlation results III.

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

* $p \leq 0.05$, ** $p \leq 0.01$.**Table 7.** Correlation results IV.

	Challenge Particip.	Career Path Satis.	Work–Life Balance	Competence Evaluation
Career path satisfaction	-0.072			
Work–life balance	0.077	0.261 *		
Competence evaluation	-0.001	0.379 **	0.171	
Role evaluation	-0.030	0.500 **	0.267 *	0.638 **

* $p \leq 0.05$, ** $p \leq 0.01$.

As demonstrated in Tables 4 and 5, several correlations pertaining to attitudinal traits emerge as statistically significant. Notably, analytical thinking and innovation exhibit positive correlations with challenge participation, while there is no negative correlation between participation and any attitudinal dimension. This suggests that this teaching method positively influences individuals' development. Innovation emerges as a standout trait due to its notably strong correlation value. Thus, in line with our initial hypotheses, the analysis affirms the validity of H2 and H5.

To further assess analytical thinking and innovation, an *ANOVA analysis* is conducted concerning their average values, with the distribution presented in Figures 1 and 2. The substantial *F-values* resulting from this analysis *reject the null hypothesis* and emphasize the distinctions between their means. This reaffirms that analytical thinking and innovation are pivotal attitudinal traits associated with *challenge participation*. This observation holds substantial significance, as it underscores the capacity of experiential teaching methods to foster *the development of specific traits* that are typically not emphasized within *academic curricula*.

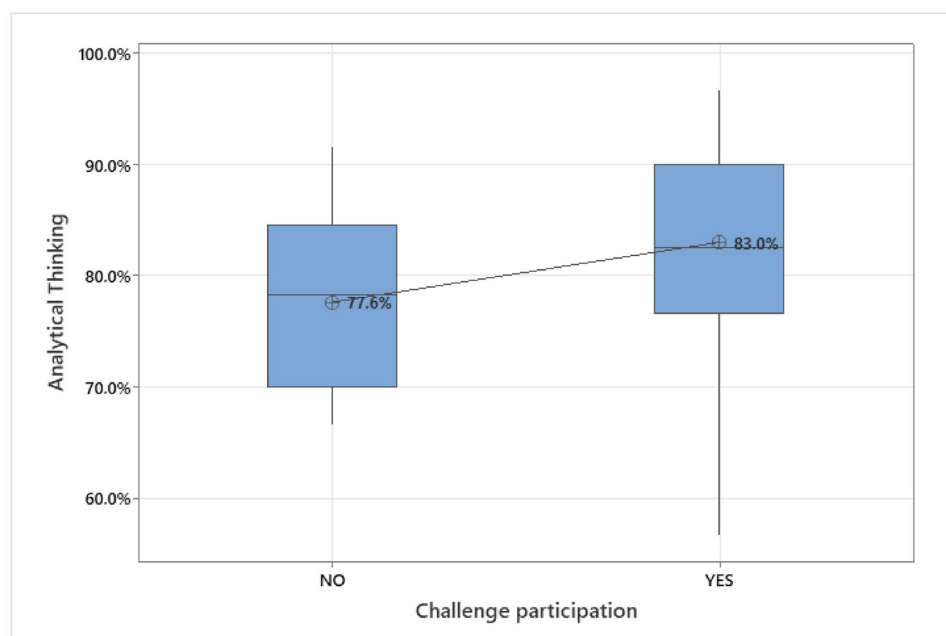


Figure 1. Distribution of analytical thinking dimension values.

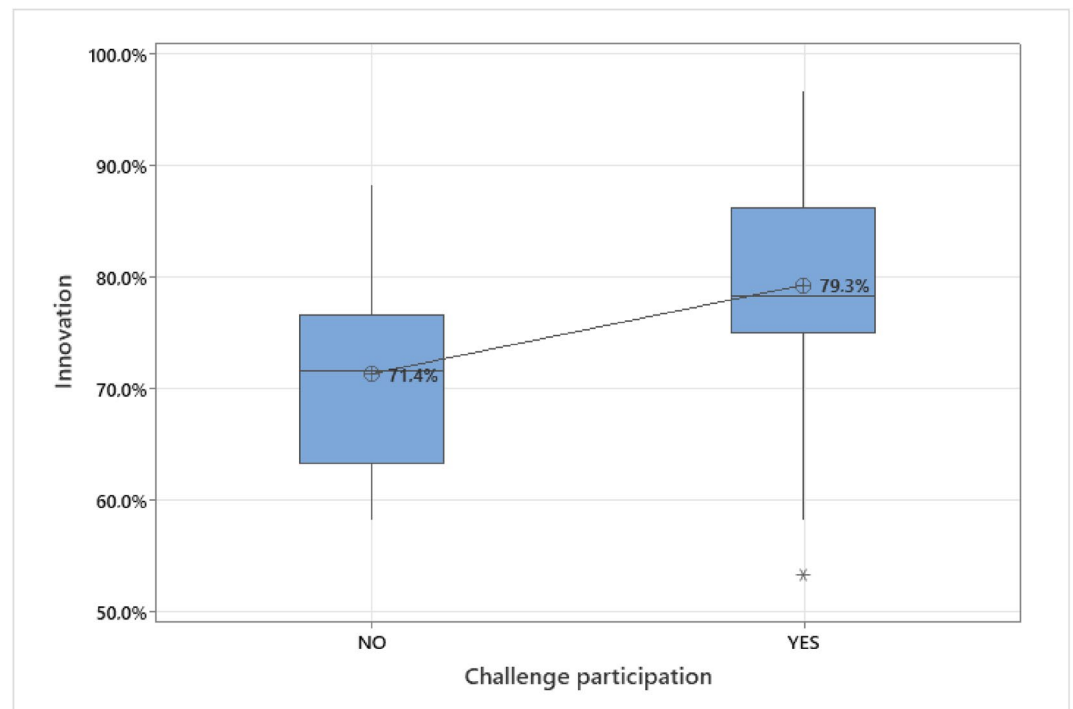


Figure 2. Distribution of innovation dimension values. * $p \leq 0.05$.

4. Discussion

The outcomes indicate that among students who did not participate in university challenges, there exists a belief that their chosen university path has facilitated the development of critical hard skills. However, two additional significant aspects surfaced in the correlation analysis. For non-participating students, university challenges play a pivotal role in the cultivation of soft skills, and not having engaged in these challenges is perceived as a missed opportunity in terms of the value they could have added to their skill set. Although the correlation between regret and the development of soft skills is less pronounced, all parameters in Table 4 demonstrate notably significant correlation values.

Analyzing the data presented in Table 4 reinforces the findings observed among non-participants. While it might be expected that participants would associate their challenge experience with enhanced HR assessments and future employment, it is noteworthy that non-participating students also perceive this experience as valuable for their CVs. It appears that participation in university challenges is an advantage for employment in their respective companies, aligning with the perception of non-respondents who view this experience as a potential asset.

In light of these results, hypothesis H2 is contradicted, as non-participating students believe that this opportunity represents a useful experience for all. Conversely, hypotheses H7 and H9 are validated, as they are supported by both participating and non-participating students, underscoring that involvement in such opportunities enhances students' professional prospects and serves as a valuable tool for the development of their soft skills. Regarding the occupational perspective, the results from Table 5 reveal several significant correlations. Unlike the attitudinal assessment, no occupational dimension displays a positive connection with participation in university challenges. This may be surprising, especially concerning career path satisfaction, as challenge participants might be expected to develop a better understanding of practical work situations and make more informed decisions regarding job positions. However, the data suggest that challenge participation does not significantly affect career path satisfaction.

Examining the correlations among various occupational dimensions, it is evident that career path satisfaction is positively associated with work–life balance, competence

evaluation, and role evaluation. This implies that job satisfaction is influenced by various factors within an individual's job sphere. Furthermore, role evaluation is positively linked with work–life balance and, more significantly, with competence evaluation.

This finding is particularly relevant, suggesting that individuals who perceive alignment between their personal values and career goals and their job responsibilities are more likely to evaluate their competences positively in relation to their job. Consequently, for organizations aiming to enhance personnel retention and optimize talent allocation, it is crucial to tailor job roles to align with required competences and to ensure a suitable match between individual traits and job requirements. University challenges can serve as a practical avenue for students to confront real-world situations, challenges, and the necessary competences and attitudes, contributing to the goals of Sustainable Development Goal 4: Quality Education. Organizations can utilize these challenges to assess the alignment between individuals and job positions, fostering a workforce equipped with the skills and attitudes required for lifelong learning and professional success.

5. Conclusions

The objective of this study was to assess the impact of university challenges on students, with a focus on enhancing their educational journey and providing superior prospects in recruitment, aligning with the United Nations' Sustainable Development Goal 4: Quality Education. In addressing the two research questions (RQ1-2), a dual questionnaire was designed—one for psycho-aptitude assessment and the other to collect data on employment status and the evaluation of the challenge experience.

Administered to two distinct groups of students (those who participated in challenges and those who did not), both enrolled in the Engineering and Management program at Tor Vergata University of Rome, Italy, the questionnaires revealed significant insights. While the psycho-aptitude assessment highlighted analytical thinking and innovativeness, responses from both groups emphasized the substantial importance of university challenge experiences. Expanding on these findings, it is noteworthy to examine how university challenges contribute to the attainment of quality education for all, as emphasized by Sustainable Development Goal 4. University challenges play a pivotal role in fostering the acquisition of essential, transferable skills. By engaging in these challenges, students are exposed to real-world problem-solving scenarios, promoting critical thinking, creativity, and collaboration—key components of a quality education.

Furthermore, the active participation encouraged by university challenges aligns with the principles of active learning. Rather than passively receiving information, students are actively involved in the learning process, enhancing their understanding and retention of knowledge. This dynamic approach not only enriches the educational experience but also cultivates a deeper understanding of theoretical concepts through practical application. The integration of challenges within university courses represents a strategic approach to enhance the academic offering and promote a holistic learning environment. These experiences not only augment the traditional curriculum but also contribute to the development of soft skills, such as communication, teamwork, and adaptability, essential attributes in today's rapidly evolving professional landscape. Despite the noted limitations of this study, including sample distribution and size, the results lay the groundwork for future research endeavors. Subsequent studies could delve into participant feedback, exploring how challenges can be further optimized to align with educational objectives and promote lifelong learning. The findings of this study underscore the significant impact of university challenge participation on the overall educational experience, thereby contributing to the realization of Sustainable Development Goal 4 and the pursuit of quality education for all.

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