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# **A Cross-Sectional Analysis of the Career Paths of Chemical Engineering Graduates: The Impact of University Education on Professional Success and Community Involvement Based on a Graduate Tracer Study**

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## **ABSTRACT**

### **BACKGROUND & CONTEXT**

In the Philippines, higher education institutions (HEIs) face pressure to keep academic programs relevant to global, industry, and societal needs. Graduate tracer studies are used to evaluate program effectiveness and guide curriculum improvement. Prior research supports their role in evidence-based academic reform. However, long-term career outcomes of Chemical Engineering graduates remain understudied.

### **PURPOSE OR GOAL**

This paper examines how Philippine Chemical Engineering programs prepare graduates for career success, leadership, and community engagement. It uses tracer study data to identify factors that influence career outcomes for curriculum improvements.

### **APPROACH OR METHODOLOGY**

A tracer study was conducted using an online survey of Chemical Engineering graduates from 2007 to 2017. Data collected included personal information, educational background, employment history, training undertaken, and program assessment. Selected variables were measured using a 5-point Likert scale. Random forest regression and Bootstrap Forest models were used to identify key predictors of career success and related outcomes.

### **OUTCOMES**

Results showed that awareness of social responsibility was the most influential and consistent predictor across all outcomes while perceived usefulness of coursework and internship experiences contributed moderately to strongly to career development. University preparation showed a weaker direct influence.

### **CONCLUSIONS**

Findings highlight the role of values-based, experiential learning in graduates' career success and community engagement. They support literature and guide curriculum improvements in leadership and social responsibility

### **KEYWORDS**

professional development, social responsibility, engineering education.

## Introduction

Universities in the Philippines are currently facing pressure to ensure that their academic programs are highly relevant and responsive to the needs of the industry and society. For Chemical Engineering, this expectation is to meet the challenges of the industries, sustainable initiatives, and changing workforce requirements. In view of this and consistent with the requirements of the Commission of Higher Education (CHED) and various national and international accreditation bodies, Program Educational Objectives (PEOs) have been established to serve as long term targets for what graduates are expected to achieve within 3-5 years after completion of their degrees. In the Chemical Engineering discipline, PEOs are defined as career success manifested in leadership skills and communication aptitude, professional development through continuous learning, and sense of social responsibility through professional and community-based organizations.

Employers value engineers with good leadership and communication skills because technical knowledge is not enough with the changing work environment. Communication aptitude is important because engineers may work in multidisciplinary teams, manage projects and work with non-engineering departments that would require explaining technical principles to non-technical stakeholders (O'Regan, 2023). A good leader must know how to be decisive, manage resources well and supervise team members (Felder & Brent, 2014). Effective communication is important in conveying and translating ideas especially when it involves problem solving (Nestsiarovich et al., 2020).

Engineering professionals must also engage in lifelong learning to keep up with the relevant changes in society (Vindigni, 2023). Lifelong learning is one of the PEOs that focuses on continuous participation on professional development and contribution to the field by technological developments and innovations. Graduates who pursue advanced studies, attend workshop-seminars and conferences, or contribute to scholarly scientific work represent this outcome. This indicator shows how the academic program has encouraged its graduate to pursue lifelong learning and innovation.

Engineering graduates also have an ethical and civic responsibility to their profession and society. They are involved with community issues and contribute through community-based initiatives and professional organizations (Smith et al., 2021). Presently, engineers play an important role in sustainability, equity and inclusion (Pellissier, 2022). Engineering programs must go beyond technical training but should promote values such as community service, collaboration and social accountability.

Systematic, data-driven methods are used for evaluating the extent of preparation of the university on graduate success to ensure that the PEOs are attained. Based on cross-sectional data on the career paths of the graduates, tracer studies have shown that the experiences, professional and personal careers of the graduate can be indicators of their professional performance (Badiru & Wahome, 2016). Data gathered from the graduate tracer study (GTS) are critical in determining whether the PEOs are achieved within five years of graduation (ABET, 2023).

A tracer study is an experiential method of gathering feedback from graduates about outcomes of their education and training. It provides data on professional success (career, status, income), relevance of knowledge and skills (courses useful on the job, internship relevance, professional position) and how well academic programs prepared them for professional work (Schomburg, 2007). GTS allows the HEIs to evaluate graduate employability, workplace readiness and alignment between university preparation and workforce requirements. Studies have shown that employability is influenced by a combination of academic preparation and personality traits like self-efficacy and leadership (Zhan et al., 2024, Li et al., 2022). This feedback support curriculum development, quality assurance and aligning the industry needs with academic offerings.

The modern workforce has undergone a lot of changes and academic institutions must align the curricula with the demands of the job market. However, linking career success and factors such as academic experience, awareness of PEOs and the observed usefulness of training has not been widely studied. Thus, this study aims to address these gaps by using the Bootstrap Forest model to predict how these educational factors influence graduates' career success in leadership and communication, professional development, and social responsibility.

## Theoretical Framework

This study is based on the CareerEDGE model graduate of employability developed by Dacre Pool (O'Regan et al., 2023), based on five key components: career development learning, experience (work and life), degree subject knowledge, generic skills and emotional Intelligence. It stresses that graduate success is also dependent on leadership, adaptability and lifelong learning outlook (Jackson & Tomlinson, 2021). In this study, career success is measured in terms of leadership skills and communication aptitude, professional development and active involvement in organizations. The independent variables – university preparation, awareness of PEOs in leadership and communication skills, professional development and social responsibility and the perceived usefulness of academic coursework and internships – reflect the CareerEDGE model's elements of self-evaluation; alignment with program goals, and real-world experience. The Bootstrap Forest model was used in the study to predict which educational factors can significantly predict career success outcomes across the three soft skill domains.

## Methodology

The study utilized a descriptive design using a Graduate Tracer Survey (GTS) to analyze the career paths of Chemical Engineering graduates from 2007 to 2017. The first phase of the study included the establishment of the address data bank. Information was sourced through the university registrar, social media, alumni offices, and academic department offices and was filed in the form of a spreadsheet with the complete names and contact details per batch graduate.

The conduct of the GTS was the second phase of the study. The survey was conducted using the institutional instrument for tracer studies, validated and verified by the Center for Research and Engagement (CRE) (Olivares et al., 2008). Graduates were contacted via email with an introduction to the study, including informed consent information and the link to the online survey. The first three sections of the questionnaire consisted of the respondent's demographics, academic background and current employment status. The last section of the GTS asked the respondents to rate various factors (university preparation, usefulness of academic courses and impact of internship) influencing their career, including awareness of PEOs, all rated using a 5-point Likert scale. Instructions were clearly stated to ensure accuracy in completion of the survey and multiple follow-ups were made to encourage participation.

Data collection started in early 2020 but was extended for several years due to the halt of some activities brought about by pandemic. To ensure the easy access and processing of the data, it was regularly backed up. Only questionnaires that were fully accomplished were included in the study to ensure the reliability and validity of the results.

The last phase of the study involved the descriptive and predictive analysis. Answers to the survey were exported to the JMP Pro software. Descriptive statistics to determine mean scores, standard deviations and distributions, were calculated and predictive analysis was done by handling the dependent variables – career success in leadership, professional development, and social commitment – as ordinal and categorical outcomes. The Bootstrap Forest model was used to predict the influence of the following educational factors: (1) extent of university preparation, awareness of PEOs related to (2) leadership and communication skills, (3) professional development, and (4) social responsibility and the perceived usefulness of (5) academic courses and (6) internships. This model was chosen because it can handle

complex, non-linear relationships and evaluate the importance of each predictor variable across the different outcomes. The influence of each factor on each domain of career success was based on the contribution scores and classification metrics of the model.

## Results

There were 273 chemical engineering graduates from 2007 – 2017. The respondents of the study consisted of 59 graduates which represents 21.61% of the target respondents. The low response rate may be attributed to the deaths, lack of contact, refusal, and immigration of some graduates.

Figure 1 shows the employment status of the respondents across the different years graduated. In general, around 72.88% of the respondents were employed on a regular basis, indicating that the graduates have high job security. Around 15.25% of the respondents were employed casual, contractual or part-time basis and less than 7% were not employed. Those who were not employed may not be looking for their first job but rather looking for another opportunity in the region or abroad. About 48% of the respondents were working in the mining industry, food industry, sugar industry and distillery, which is aligned to their degrees. This finding signals the need for more emphasis on the chemical engineering applications in the course work. Less than 10% of the respondents joined the academe industry while the rest were in the semiconductor industry, energy and power sector, bottling companies, chemical industry, banking and business process outsourcing industries.

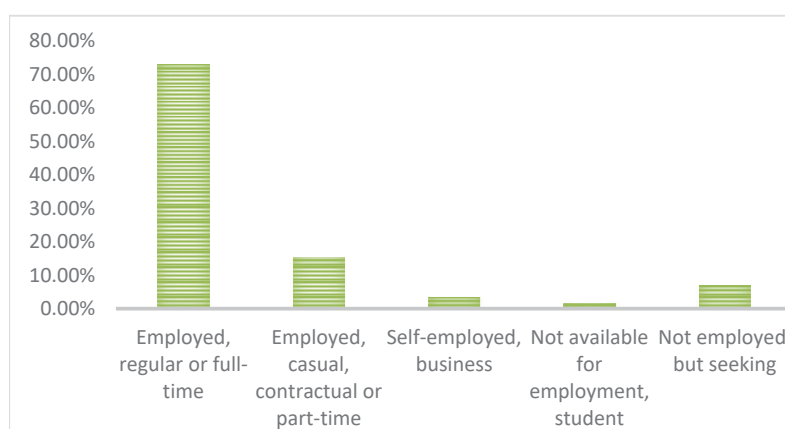


**Figure 1: Employment status of respondents**

The first job of the respondents was classified into four categories: Managerial, Supervisory, Rank-and-File and Unemployed. Around 44% of the respondents had their first job under the Supervisory level shown in Figure 2. This may indicate that many graduates have been placed in roles with greater responsibility, showing a rapid increase in their careers and the trust that the organization has placed on their skills. The Rank-and-File group follows with 39% of the



**Figure 2: Employment categories of the first job of the graduates.**

respondents assuming technical roles. Entry-level jobs for engineers working in the industry begin in the Rank-and-File category because these are foundational and hands-on-experience roles that is needed for technical competence. At this level, the engineering graduates were still learning the specific systems of the industry, and earning the experience needed for promotion. A small portion, 12%, of the respondents were able to land Managerial positions, which was expected because this position requires more experience in the field. Only 5% of the respondents were Unemployed which suggests that majority of the surveyed graduates had employment.

Table 1 shows the perception of the respondents regarding the extent of the university preparation for the workplace. About 60% of the respondents responded that the chemical engineering department of the university has prepared them for the workplace to a great extent or to a very great extent. Engineering programs that have strong theoretical and practical training tend to have graduates that are more adaptable to the workplace (Soupeze, 2025). Moreover, 27.12% of the respondents felt only prepared to a moderate extent probably due to misalignment between their academic training and their job roles as some were working as technicians in the laboratory. This may be due to the curriculum of chemical engineering being more focused on academics and laboratory exercises are tailored to course requirements rather than industry applications. A minority – 10.17% and 1.69% - rated their preparation as to some extent or to a small extent, respectively. This is probably due to job roles which are not aligned with their field of study, like technician roles, which can make their academic preparation irrelevant (Male et al., 2011). To improve the university preparation of the students, course experience surveys are given to students every semester so that they can give feedback on the courses they are taking. The faculty is responsible for working on this feedback so that every semester, they can improve on their course content and delivery.

**Table 1: Perceived Extent of University Preparation for the Workplace (n = 59)**

| <i>Extent of University Preparation for the Workplace</i> | <i>%</i>       |
|-----------------------------------------------------------|----------------|
| 1) To a Very Great Extent                                 | 13.56%         |
| 2) To a Great Extent                                      | 47.46%         |
| 3) To a Moderate Extent                                   | 27.12%         |
| 4) To Some Extent                                         | 10.17%         |
| 5) To a Small Extent                                      | 1.69%          |
| <b>Grand Total</b>                                        | <b>100.00%</b> |

University preparation is important for students because it will provide them with the foundational knowledge and skills that they need when they enter the workforce. Academic courses in chemical engineering are the core foundation for developing the technical knowledge and problem-solving skills needed in the professional practice. Courses such as Stoichiometry, Thermodynamics, and Equipment Design equip students with the tools needed in manufacturing, research, quality control and other engineering fields. An organized curriculum is important because it ensures that the graduates can shift effectively from academic setting to real-world applications (Wankat & Oreovicz, 2021). Table 2 shows that majority of the respondents (59.32%) found their academic courses useful in their line of work, while another 30.51% rated them as moderately useful, indicating that most of the graduates find their academic preparation as relevant to their jobs. Only a small portion (5.08%) felt that the academic courses were slightly useful, which may mean a job mismatch or there is insufficient integration of the courses in the work (Melchor, 2022). In view of this, the department does an annual evaluation to ensure alignment of curriculum with the dynamic requirements of the industry.

**Table 2: Perceived Usefulness of Academic Courses in Relation to Job Responsibilities (n = 59)**

| <i>Perceived Usefulness of Academic Courses</i> | <i>%</i>       |
|-------------------------------------------------|----------------|
| 1) Extremely Useful                             | 5.08%          |
| 2) Very Useful                                  | 59.32%         |
| 3) Moderately Useful                            | 30.51%         |
| 4) Slightly Useful                              | 5.08%          |
| <b>Grand Total</b>                              | <b>100.00%</b> |

To link the theoretical principles and concepts learned inside the classroom, the chemical engineering curriculum has an embedded OJT and internship program. The purpose of which was to make sure that classroom learning was applicable to real-world practice. These programs allowed the students to have a first-hand experience of how to develop their soft skills like communication, teamwork, problem-solving and resiliency (O'Regan). They offer students opportunities to have professional networks career paths and increase employability (Tran, 2015).

Table 3 shows that majority of the respondents (81.36%) found their OJT as useful. This means that their OJT experience has effectively prepared them for their workplace. Less than 7% felt that the program was not useful which can be attributed to limited exposure, insufficient guidance or their internship was not related to their present job (Shethiya et al., 2025). Less than 12% of the respondents struggled to recall their OJT experience due to the passage of time. The chemical engineering department consistently partners with industries through Memorandums of Agreement to ensure that the students' training is relevant and supports both the curriculum and the actual needs of the industry.

**Table 3: Usefulness of On-the-Job Trainings and Internship Programs (n = 59)**

| <i>Usefulness of OJTs / Internship Programs</i> | <i>%</i>       |
|-------------------------------------------------|----------------|
| Yes                                             | 81.36%         |
| No                                              | 6.78%          |
| Can't recall/remember                           | 11.86%         |
| <b>Grand Total</b>                              | <b>100.00%</b> |

The preparation of the university in terms of academic courses and OJTs is not enough to assess whether the graduates understand the long-term goals of their academic program. The

PEOs serve as long-term indicators of graduate success. Figure 3 shows the graduates' awareness of these educational objectives.

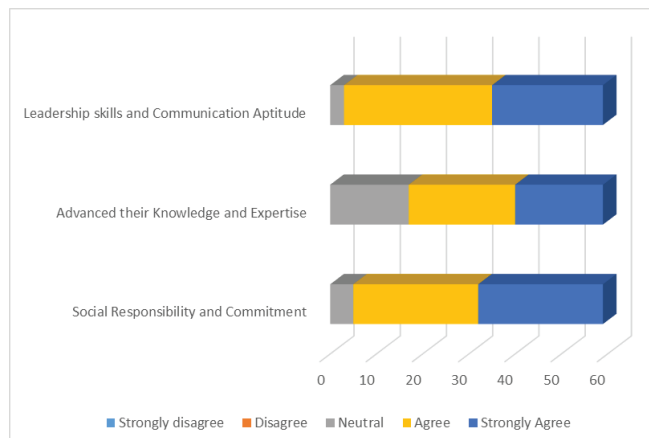


**Figure 3: Awareness of the PEO's of the chemical engineering program**

The results show that 49.15% and 40.68% of the respondents are moderately and extremely aware of the program's objective, respectively, to produce graduates with successful careers in engineering as attested by their strong leadership skills and communication aptitude. This shows that the university has effectively incorporated these skills in both the academic and extracurricular activities of the students. Engineering curricula do not integrate leadership because it is not well-defined (Daley & Baruah, 2021). However, leadership concepts are integrated into courses like National Service Training Program (NSTP), Engineering Management and other professional chemical engineering courses. To support the program's strong emphasis on communication, public speaking is included in the curriculum to help students build confidence in communicating their ideas clearly and effectively. Extracurricular activities like joining academic organizations are also encouraged to allow the students to strengthen their soft skills not only academically but also socially and professionally.

Asides from being aware of the importance of leadership and communication in career success, the need to analyze the significance of lifelong learning and professional advancement is also essential. Being aware of lifelong learning is important for career growth, adaptability and maintaining professional relevance (Felder & Brent, 2014). It encourages the individuals to take charge of their own growth by getting trainings, certifications or graduate studies to further their knowledge and skills. Professionals who pursue further studies and conduct research and innovations contribute significantly to their organization (Zhang, 2024). Figure 3 shows that most graduates (45.76%) were moderately aware and 35.59% were extremely aware of the PEO concerning lifelong learning and contributing to scholarly or innovative work. This objective is important because the chemical engineering field is evolving in advanced technologies and sustainability endeavors (Felder & Brent, 2014). The department has made efforts through the years by fostering strong research skills in the courses and requiring the students to attend external seminars and industrial plant tours for continuous learning, both of which are included in the syllabi.

Lifelong learning promotes a sense of social responsibility as the individual continues to develop their skills and knowledge to tackle the needs of the community. This sense of responsibility is important in engineering because any innovation can affect the environment and community (Cederholm & Roberts, 2020). Figure 3 shows that 47.46% of the respondents are extremely aware and 38.98% are moderately aware of this educational objective. As early as their first year in the university, courses like NSTP and religious studies have inculcated the value of civic duty and environmental awareness. Students would go to the less fortunate communities to do civic works like organizing feeding programs, helping young children to read

and write, and assist during calamities. They also engage in promoting environmental awareness by doing tree planting, coastal clean-ups, recycling projects and advocating environmental policies. Some professional courses in chemical engineering integrate the Christian Service-Learning Program (CSLP) where students would coordinate with the needs of the community and transfer the technology by training the recipients shown in Figure 4.



**Figure 4: Graduating chemical engineering students conducting technology transfer about soil conditioners in one community**

Engineering education standards stress the need to instill social and ethical responsibility among students (NSPE, 2020). Engineers must not only be technically competent but should make sure that what they contribute to the society is also ethical and moral (Jing & Doorn, 2020). By integrating service learning and ethics courses into the curriculum, students can significantly have a strong sense of social responsibility after they graduate.

The awareness of the PEOs among graduates is translated in their perceived success in their engineering career. Majority of the respondents either agreed (54.24%) or strongly agreed (40.68%) that they have achieved successful careers, particularly through the development of leadership skills and communication aptitude. These significant values indicate that the university has focused on training not only the technical knowledge but also on the soft skills of leadership and communication in preparation for the demands of the workplace. Some of these respondents were leaders in their field holding top management positions. Moreover, some of these respondents were officers of professional organizations. These skills are recognized by employers as essential traits for engineers to meet the demands of the professional environment (O'Regan, 2023). The results agree that graduates are not only aware of these skills, but they are practicing them in their current workplace.

Nearly 71% of the respondents (agree and strongly agree combined) stated that they were actively engaging professional development opportunities like further studies, training or innovation initiatives. About 83% of the respondents have master's degree while around 17% have doctorate degrees. The high level of engagement suggests that many graduates understand the importance of lifelong learning in keeping up with the times and career advancement (Felder & Brent, 2014). The respondents were aware that professional growth does not end at employment – it extends to beyond their participation in a never-ending quest to learn.

Chemical engineers do not focus on technology alone because they have a moral and ethical responsibility to protect the environment and help maintain a sustainable society. Graduates of the chemical engineering program are taught to be morally responsible for their designs and creations while in the university. In view of this, the professional chemical engineering organization has established the Code of Ethics to guide professionals to uphold the safety, health and welfare of the public (Padilla, 2024). A combined 91.52% (agree and strongly agree) indicated an active involvement in community-based and professional organizations. Moreover, industries practice corporate social responsibility, and the graduates employed there are also sharing their technical expertise to the community. The awareness of this

educational objective indicates that the program has instilled the values of social responsibility and professional commitment to the graduates.

Based on the results of the outcomes of the different aspects of academic experience, it is essential to analyze if these outcomes predict career success in three key areas: leadership and communication aptitude, professional development and social responsibility. Figure 5 illustrates the relative influence of the six predictors on the three career success outcomes from the Bootstrap Forest analysis. The analysis showed that among the six predictors, the awareness of PEO, especially in social responsibility, was the most consistent and influential for career success across the three outcomes: leadership, professional development, and social responsibility. The model has a good fit in social science research based on generalized R-square ( $G-R^2$ ) values – 0.504 for leadership, 0.554 for professional development, and 0.6415 for social responsibility (Fox & Weisberg, 2019) University preparation showed weak influence consistently; however, the usefulness of coursework and internships moderately to strongly influenced career success in terms of professional development. The results imply that academic programs should continue to promote the awareness of social responsibility because the graduates have internalized this value and tend to perform better in their career outcomes. Moreover, unlike other predictors that only influence one outcome, this predictor has an impact on the other outcomes using the Bootstrap Forest model. Social responsibility should be integrated in the curriculum and policy development because it has the potential to enhance not only ethical awareness but also leadership and communication skills and professional development capacities.

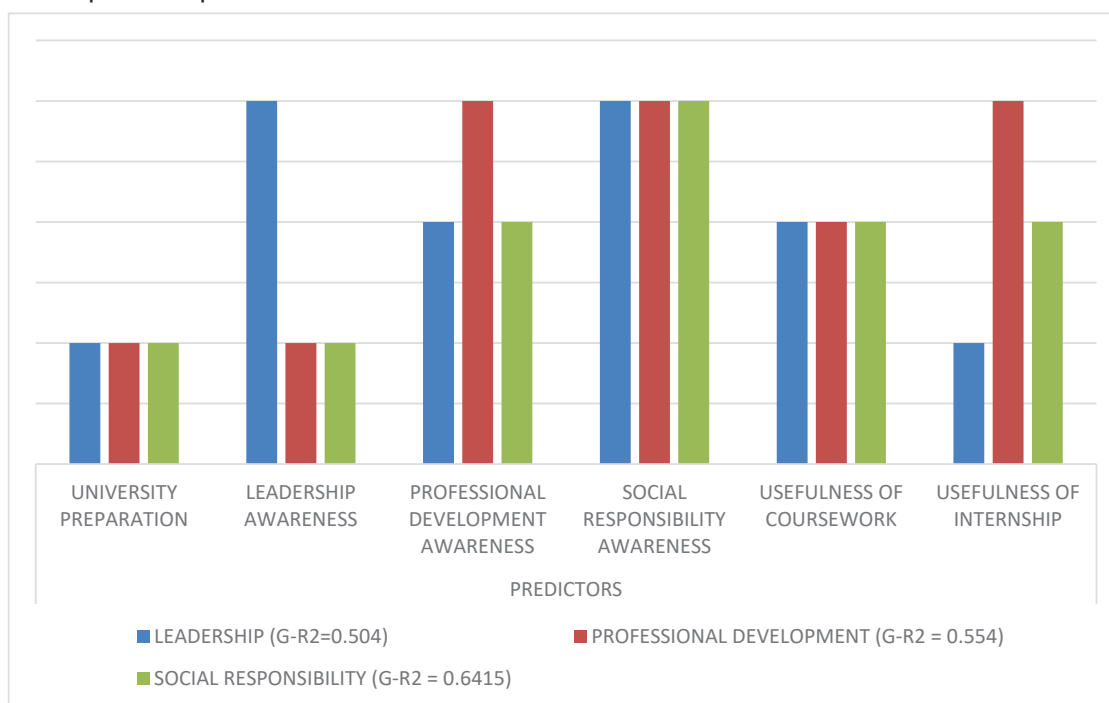


**Figure 5: Relative contribution of predictors to career success outcomes**

## Conclusion

Universities and professional organizations play a key role in shaping the graduates' professional identity. The predictor variables are more effective in predicting the outcome for Professional Development and Social Responsibility compared to Leadership and Communication Skills. Awareness of social responsibility consistently influenced career success, while university preparation had the weakest influence across all the outcomes.

Curricula and extra-curricular activities should incorporate leadership roles and communication training to enhance career readiness of students. These findings support the OBE approaches that align with the academic content, internship experiences, and extra-curricular involvement relative to the PEOs. The results highlight that experiential learning plays an active role in career advancement and civic responsibility more than just being aware of the educational objectives. Future research should explore additional variables or other methodologies that can improve prediction accuracy. Thus, the university can use the Bootstrap Forest model to trace how various educational factors can influence specific graduate outcomes over time.

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