(01-011) - Keys to Increasing Engineers' Motivation Today

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The motivation of project managers has been a topic of interest for a long time due to its impact on the success of project development. A study has been conducted by the School of Industrial Engineers in Madrid (UPM) aimed at evaluating the types of motivations experienced by students in the Bachelor's Degree in Industrial Technologies Engineering (GITI) and the Master's Degree in Industrial Engineering (MII) based on the self-determination theory (SDT). The goal is to understand what motivates our engineers (future project managers) in order to propose measures that can help enhance it. The EME-E motivation questionnaire, previously validated by researchers, has been employed for this study. The measurement tool takes into account demotivation as well as three factors of extrinsic motivation and three factors of intrinsic motivation.

359 students participated in the study. The results highlight that external motivational factors have a greater impact, with internal motivation being lower. No significant differences were detected between men and women or between courses. However, it was found that academic performance is a factor with a significant impact on motivation. The results invite us to reflect on how to increase the motivation of engineers today in order to enhance their performance.

Keywords: Motivation; Project managers; Engineering students

Claves para aumentar la motivación en los ingenieros de proyectos hoy

La motivación de los directores de proyecto ha sido un tema de interés durante mucho tiempo debido a su impacto en el éxito del desarrollo del proyecto. Se ha realizado un estudio por la Escuela de Ingenieros Industriales en Madrid (UPM) con el objetivo de evaluar los tipos de motivaciones experimentadas por los estudiantes del Grado en Tecnologías Industriales (GITI) y el Master en Ingeniería Industrial (MII) basándose en la teoría de la autodeterminación (TAD). El objetivo es comprender qué motiva a nuestros ingenieros/as (futuros directores de proyecto) para proponer medidas que puedan ayudar a potenciarla. Para este estudio, se utilizó el cuestionario de motivación EME-E. La herramienta de medición considera la desmotivación, así como tres factores de motivación extrínseca y tres factores de motivación intrínseca.

En el estudio participaron 359 estudiantes. Los resultados resaltan que los factores motivacionales externos tienen un impacto mayor, siendo la motivación interna más baja. No se detectaron diferencias significativas entre hombres y mujeres ni entre cursos. Sin embargo, se encontró que el rendimiento académico es un factor con un impacto significativo en la motivación. Los resultados nos invitan a reflexionar sobre cómo incrementar la motivación de los ingenieros hoy para mejorar su rendimiento.

Palabras clave: Motivación; Directores de proyecto; estudiantes de ingeniería.

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1. Introduction

The motivation of project management professionals has been and continues to be a relevant aspect in facilitating success in project management, due to the complexity of this role and the personal and professional challenges it entails (Brill, Bishop, & Walker, 2006; Chipulu et al., 2013; Jha & Iyer, 2007; Müller & Turner, 2007; Wateridge, 1997). Without motivation, it will not be possible to find good professionals willing to deal with all these aspects and manage human teams effectively (El-Sabaa, 2001). Motivation is presented as one of the key competencies identified in the PMBOK Guide (2021), along with others such as leadership, communication, or decision making. To become a project manager, it will then be necessary to combine technical expertise with a set of personal skills and attitudes to effectively manage human relationships and work motivations (Ahsan & Ho, 2013; Kerzner, 2013; PMI, 2021; Stevenson & Starkweather, 2010).

This research focuses on empirically investigating the motivation of students in the academic training of industrial engineering at UPM (Technical University of Madrid) since many undergraduate and master's engineering students end up working as project management professionals, which provides an opportunity to understand from the outset what their intrinsic and extrinsic motivations are during their training as future professionals (Ballesteros-Sánchez, 2021).

Beyond being a mere examination of motivation, this study seeks to deeply understand its nuances, explore the orientation of motivation, and its "quality." It will analyze the types of motivation according to Self-Determination Theory (SDT) and their intensity, as well as the relationship of motivations with the academic year, academic performance, and gender.

It is important to note that Self-Determination Theory has evolved over time. The concept of self-determination originated from motivation studies conducted by Edward L. Deci and Richard M. Ryan in the seventies of the last century, culminating in the publication of the book "Intrinsic Motivation and Self-Determination in Human Behavior" (Ryan & Deci, 1985). While it has undergone development and expansion over the years, the foundational principles date back to Deci & Ryan's studies in 1985, laying the groundwork for their ideas. Subsequently, it evolved with Ryan's contributions in 1995, becoming a cornerstone for analyzing the quantitative motivations of populations and their causes and consequences. Finally, in 2017, Deci and Ryan published the comprehensive theory with empirical research in a volume titled "Self-Determination Theory: Basic psychological needs in motivation, development, and wellness" (Deci & Ryan 2017). This theory is considered one of the most robust for understanding human motivation due to its comprehensive and sturdy perspective.

The Self-Determination Theory (SDT) is a comprehensive theory that addresses both human motivation and personality, focusing on aspects related to development and innate psychological needs. Its purpose is to understand the motives behind individual decisions in a way that can be applied to various contexts and cultures. This theory has been applied to workplace, educational, and even clinical settings with a wide range of applications.

Intrinsic motivation is a key concept in SDT. It refers to motivation that naturally arises within an individual, independent of external factors such as rewards or punishments. Intrinsic motivation is driven by the pleasure of engaging in an activity or the inherent satisfaction and enjoyment associated with the activity itself. Intrinsic motivation can be sparked by factors like the attractiveness, challenge, or novelty of an activity (Deci et al. 1991).

On the other hand, if an activity is pursued for some form of reward, the nature of motivation shifts away from intrinsic and is considered extrinsic motivation. When a person engages in an action as a means to achieve an external goal rather than out of genuine interest in the activity, it is considered extrinsic motivation. This becomes evident in situations involving performance evaluations, workplace performance assessments, the granting of distinctions and merits, as well as the appreciation and respect of the social environment (Alonso, 1984).

The SDT advocates for a renewed approach to motivation, considering what drives an individual at a specific moment, rather than treating motivation as a singular entity. In this sense, SDT makes differentiations between various types of motivation and the associated repercussions of each.

The theory focuses on measuring the extent to which a person's behavior arises from their intrinsic motivation and self-determination (Ryan & Deci, 1985). In summary, SDT posits that individuals have three fundamental psychological needs: autonomy, competence, and relatedness. Depending on the satisfaction of these fundamental needs, individuals tend toward psychological well-being and improved functioning. The fulfillment of these basic psychological needs is also closely tied to self-determined behavior, i.e., intrinsically motivated behavior (Ryan & Deci, 2000).

SDT is built on the premise that people, naturally, seek psychological growth and self-organization. In other words, individuals strive to expand their understanding of themselves by integrating new experiences, nurturing aspirations and interests, and establishing connections with others and the external environment. However, SDT suggests that this inherent inclination toward personal development should not be taken for granted, and individuals may experience a state of lack of control, and disconnection if their fundamental psychological needs for autonomy, competence, and relatedness are not adequately satisfied (Legault, 2017).

1.1. Motivation and SDT in the context of education

Many studies suggest that motivation is the most crucial factor influencing students' academic performance (Pintrich & Schunk, 2002). However, as explained by SDT, it is important to emphasize that it is intrinsic motivation that truly makes a difference in students' actions. Psychological well-being and intrinsic motivation extend and contribute to the academic realm in empirically researched ways, as explained below (Ryan & Deci, 2000).

Various studies have investigated and demonstrated a relationship between self-determined motivation and academic outcomes in both university and school students. Research conducted by Daoust, Vallerand, & Blais in 1988 found that school dropout was related to a lack of intrinsic motivation. A connection has also been shown between intrinsic motivation or self-determined forms of extrinsic motivation and successful academic performance (Pintrich & De Groot, 1990). A study by the Pontifical Catholic University of Peru found a negative correlation between procrastination and intrinsic motivation (Arenas Wong, et al. 2022).

Other researchs have concluded that students with more intrinsic motivation achieve a better understanding and assimilation of concepts than students who learn with the purpose of being evaluated (Benware & Deci, 1984; Grolnick & Ryan, 1987).

In a study by Gottfried, intrinsic motivation was assessed in specific subjects such as mathematics and reading in elementary and secondary school students (Gottfried, 1985). Correlations were observed between academic performance and intrinsic motivation. Similar results were obtained in similar studies (i.e. Hunt et al. 1977; Lloyd & Barenblatt, 1984).

Pelletier and Vallerand (1989) discovered that students with higher intrinsic motivation exhibited more positive emotions in the classroom and greater enjoyment and satisfaction with academic work than those whose motivation was less self-determined. Wong and Bridges concluded that intrinsic motivation is related to the desire to face new challenges (Wong & Bridges, 1995).

Similarly, Ryan and Connell found a correlation between students with greater autonomy (and therefore more self-determined) and enjoyment of school activities. In the same study, it was verified that more regulated and controlled behavior was associated with poor handling of failure and increased anxiety (Ryan & Connell, 1989). Even self-esteem is favored by intrinsic motivation (Deci et al. 1981). Another study found that self-determined students studied more intensively, paid more attention in class, and obtained better grades (Vansteenkiste, 2004). Self-determination even promotes aspects such as cognitive flexibility (McGraw & McCullers, 1979) or creativity (Amabile, 1979).

As demonstrated in numerous studies, when this type of motivation is achieved, higher academic performance, lower dropout rates, better assimilation of concepts, increased interest, creativity, greater satisfaction, etc., are evident. It is undeniable that this type of behavior is of great importance in the academic sphere, and a self-determined behavior should be aspired to both individually and collectively for society. It is crucial for educators to ignite students' curiosity to capture their interest and foster intrinsic motivation. This is achieved by placing greater importance on the learning experience than on grades or rewards.

1.2. Motivation measurement methods

There are several scales that have been used for quantification of motivation. Although each adopts a different approach to measure motivation, they all share the goal of understanding how motivation is affected. In this section, various tools for the quantification and measurement of motivation in the academic context will be shown.

One possibility for measuring motivation is the "Motivated Strategies for Learning Questionnaire (MSLQ)," developed in 1993 (Pintrich, 1991). This scale was designed to examine motivational inclinations and various knowledge acquisition tactics of students. This measurement instrument is useful for understanding students' mindset when facing a subject. By assessing: (1) value (orientation to intrinsic and extrinsic goals, task value), (2) expectancy (beliefs about control over learning, self-efficacy), and (3) affect (exam anxiety), one can precisely analyze a student's motivation. This questionnaire, with its 81 questions, is significantly longer and requires more time for completion than other options. However, it is frequently used in academic research for motivation (Lynch, 2006; Matuga, 2009).

While the mentioned scale measures the intensity of motivation, the "Maslach Burnout Inventory" (Maslach, et al. 1997) tool measures the lack of motivation. It is a common scale for motivation studies and has been adapted to a version for university students called the MBI – Student Survey (Schaufeli et al. 2002). In a 15-question survey, this tool determines levels of exhaustion, cynicism, and reduced efficacy. This tool has been widely used (Densten, 2001). It is noteworthy that the results of this survey indicate that the more intrinsically involved an individual is, the less likely they are to experience burnout (Pisarik, 2009).

Motivation towards a particular task is often determined by the individual's "self-concept", which describes a student's perception of their own ability in an academic achievement context (Wigfield & Karpathian, 1991). The so-called "Academic Self-Concept Questionnaire" is a tool to quantify and measure "self-concept" in an academic context (Reynolds, 1988). Research

conducted by Choi (Choi, 2005) confirmed that this parameter proves to be an effective tool for anticipating academic performance in university students. The ACS is a 40-question survey that quantifies overall confidence or "self-concept" towards academic performance.

The true objective of this study is to analyze the orientation of motivation, or in other words, the type of motivation present in engineering students. The aim is to examine the degree of intrinsic or extrinsic motivation using the SDT as a basis. This involves placing the behavior of students on the continuum of self-determination. None of the tools mentioned earlier have this objective except for the MSLQ. However, the MSLQ provides a broader view of motivation. It not only examines motivational categories but also analyzes knowledge acquisition tactics, the importance attributed to the task, perspectives on learning control, and the application of cognitive approaches. Other tools specifically focus on assessing the type of motivation driving student engagement, which is why the MSLQ is ruled out as a study tool for this research. Additionally, its length of 81 questions could pose challenges in data collection.

There are other scales to measure the types of motivation proposed by SDT. The Intrinsic vs. Extrinsic Orientation Scale developed by Harter in 1981 (Harter, 1981) contrasts intrinsic motivation against extrinsic motivation on the same spectrum and thus prevents an independent assessment of these two constructs.

Another option for measuring motivation type is the Academic Intrinsic Motivation Inventory for Children by Gottfried (Gottfried, 1985). This scale examines intrinsic interest in learning in various subjects (e.g., reading, social sciences) and towards school in general. Therefore, it does not measure different types of intrinsic motivation, extrinsic motivation, or demotivation. Thus, it is ruled out as a study tool.

Finally, it is worth noting that all the scales mentioned above are designed for elementary and secondary school students. However, there is a tool oriented towards post-secondary students within the present theoretical framework. Moreover, it is a tool that accurately measures different types of intrinsic motivation, extrinsic motivation, or demotivation. This tool, called the "Échelle de Motivation en Éducation" (EME), will be explained in detail in the next section.

1.3. Échelle de Motivation en Éducation (EME)

The Échelle de Motivation en Éducation (EME) (Vallerand et al. 1989) is a measurement scale based on the ideas of SDT. The EME allows determining the degree of self-determination and the type of motivation. It is a questionnaire consisting of 28 items evaluated on a seven-point Likert scale that responds to the reasons why a student is attending university. These items are classified into seven subscales, each with four items. The 7 subscales measure the three types of intrinsic motivation (MI for stimulating experiences, MI for achievement, MI for knowledge), the three types of extrinsic motivation (identified regulation, introjected regulation, external regulation), and demotivation (Vallerand et al. 1989).

Within the framework of the EME, motivation is defined as the underlying "why" of behavior, according to the conceptualization of Deci and Ryan (Deci & Ryan, 1985), focusing on perceived reasons for participating in an activity. For this reason, the scale formulates the question "Why do you attend university?" and the elements represent possible answers to that question, reflecting different types of motivation.

In the validation studies of the EME conducted by Vallerand in 1989, it was demonstrated that the scale exhibited high levels of internal consistency. This implies that the questions on the scale were related coherently to each other. This level of consistency was measured using the

Cronbach's alpha index, yielding an average of 0.8. Such a high Cronbach's alpha value indicates that the scale consistently measures motivation (Vallerand et al. 1989).

The validity of the EME was further confirmed by calculating temporal stability indices. Additionally, validity was assessed through correlations between the seven subscales (Vallerand et al. 1989). Furthermore, researchers applied a factorial analysis to confirm that the observed data fit the seven subscales of the questionnaire. Findings from the confirmatory factor analysis indicated that the seven-dimensional configuration of the EME satisfactorily matched the collected data (Vallerand et al. 1989). Therefore, the elements of the scale were consistently grouped into the theoretical dimensions proposed, strengthening the content validity of the scale.

In summary, the EME is a robust tool capable of measuring motivation in an academic context.

2. Objectives

The first objective of this study focuses on evaluating the types of motivations according to SDT experienced by industrial engineering students at UPM in the courses of the Bachelor's Degree in Industrial Technologies Engineering (GITI) and the Master's Degree in Industrial Engineering (MII). It aims to understand possible variations and changes in motivations throughout the university education to gain a deeper perspective on the evolution of motivation.

The second objective is to determine the possible relationship between the intensities of different types of motivations exhibited by students and their academic performance.

An additional objective of the research is to investigate whether motivation depends on the gender of the student.

Based on these objectives, the following key research questions are proposed:

RQ1. What is the nature of motivation among GITI and MII students and how does it vary throughout their academic journey?

RQ2. How does motivation affect students' academic performance?

RQ3. Is there a gender influence on students' motivation patterns?

Since this is the first study oriented towards researching motivation in industrial engineering students at UPM, its relevance and pertinence lie in several aspects. Understanding the motivation of Industrial Engineering students can contribute to the design of more effective or optimal educational strategies in the GITI at UPM. Additionally, by exploring how motivation varies during the course of education, possible points of intervention can be identified to improve the educational experience of students.

3. Methodology

The SDT is applied as the theoretical foundation of the research, along with its associated measurement tool (EME-E), to address the research objectives mentioned earlier. Specifically, the methodology followed in this project's research is as follows:

First step: Measurement of academic motivation applying the EME-E: Data will be collected using the EME-E questionnaire based on self-determination theory, thus measuring the types of motivation and intensity of a set of students from all four courses of GITI and MII students.

Second step: Statistical analysis: Using the statistical tool R-Studio, a comprehensive analysis of the collected data will be conducted to address the study's objectives.

Third step: Interpretation of results: Based on the statistical analysis, precise conclusions will be drawn regarding the results and their implications.

3.1. Study variables

In the study, data is collected on demographic variables and motivational profile variables for each student responding to the questionnaire. These variables are used to understand the relationship between motivation, academic performance, academic stage, and gender in the context of Industrial Engineering. Here is a brief summary of the variables:

Demographic Variables:

Gender: Male or Female.

Academic Year: 1 GITI, 2 GITI, 3 GITI, 4 GITI, MII.

Repeater: Yes or No.

The "Repeater" variable is indirectly determined from the two-digit figure in the enrollment number, indicating the year of initiation of university education.

Motivational Profile Variables:

D (Demotivation): Mean of associated items.

MERE (Extrinsic Motivation - External Regulation).

MEIN (Extrinsic Motivation - Introjected Regulation).

MEID (Extrinsic Motivation - Identified Regulation).

MIC (Intrinsic Motivation - Knowledge).

MIL (Intrinsic Motivation - Achievement).

MIEE (Intrinsic Motivation - Stimulation Experiences).

The levels of each type of motivation are calculated as the mean of scores on their 4 associated items (in the EME questioner).

3.2. Research design

The research adopts a cross-sectional approach, conducted at a specific point in time, precisely during the first week of November 2023. The choice of a cross-sectional design is supported by the high temporal stability demonstrated by the measurement tool (EME-E) in previous research. The temporal stability, assessed through t-test correlations over a one-month period, averaged at 0.75. This suggests that motivation measurements using EME-E do not significantly vary over a short period, allowing for precise measurement without the need for long-term longitudinal tracking.

Unlike longitudinal research, which demands continuous follow-up over time, a cross-sectional study streamlines data collection and study administration. This design proves highly efficient

in terms of both resources and time. It enables a snapshot understanding of student motivation, identifying similarities and differences among various groups, crucial for research objectives.

3.3. Data collection procedure

The data collection procedure is designed to achieve broader population coverage at School of Industrial Engineers. Google Forms is chosen as the platform for collecting questionnaire data. This online survey and form tool developed by Google includes the 28 EME-E items and 4 additional demographic questions. The Google Forms questionnaire is disseminated through existing GITI and MII class WhatsApp groups. In total, there are 22 WhatsApp groups for GITI and 10 groups for MII, with an average of 95 participants in each group.

Considering the research objectives, the decision to collect data through Google Forms combined with WhatsApp group dissemination proves optimal for several reasons. Google Forms is highly accessible, efficiently reaching a large number of participants, encompassing all GITI and MII degree students. It allows reaching a diverse audience geographically. Another advantage is the anonymity it provides, encouraging more honest responses by maintaining participant privacy.

The Google Forms questionnaire has no time limit, allowing participants to take as much time as needed for thoughtful responses. Limiting the time could compromise the quality of results by inducing unnecessary pressure and rushed responses. Allowing an unlimited timeframe encourages deeper reflection on each questionnaire item.

3.4. Study population

The study population consists of students enrolled in the Industrial Engineering degree (GITI) and the Master's in Industrial Engineering at UPM. GITI students are categorized into first, second, third, and fourth-year students. Regarding MII students, no distinction is made between the first and second year. Each group contributes a unique perspective to the analysis of motivation in the academic context.

For the study, a student's academic year is determined by the year with the highest number of enrolled credits. This classification more accurately reflects the stage of the students' academic journey. The study population was randomly selected to ensure equitable representation across academic stages. The majority of the study population is Spanish, mainly from the Madrid region. Both male and female participants are included to ensure gender diversity and analyze potential differences between the two groups.

4. Results

Demographic results are presented in Table 1.

Table 1: Demographic results

Demographic variables	n (N=359)	%	Characteristics of academic performance			
			no repeater		repeater	
			n	%	n	%
Gender						
Male	226	62.95	124	54.87	102	45.13
Female	130	36.21	73	56.15	57	43.85
Other	3	0.84	2	67	1	34
Academic year						
1st GITI	54	15.04	51	94.44	3	5.56

2nd GITI	60	16.71	36	60	24	40
3rd GITI	75	20.89	30	40	45	60
4th GITI	87	24.23	37	42.53	50	57.47
MII	83	23.12	45	54.22	38	45.78

4.1. General Motivational Profile Analysis

Table 2 (questioner in Spanish as it was delivered) provides a comprehensive initial overview of responses to the 28 items of the EME-E on an extended Likert scale (1-7). These data correspond to the entire study population. Items with relatively higher averages are observed, indicating that students are more in agreement with the statement, as is the case with item #15 or #22 corresponding to extrinsic motivation of external regulation. Additionally, item #15 also has a very low standard deviation (1.14), implying that students' responses are more uniform. The statement with which students are least in agreement on average pertains to #19 and #26, corresponding to the demotivation subscale. The skewness in most items is positive, indicating a tendency toward responses of agreement or strong agreement on the scale. Standard deviations vary for each statement. Response variability is higher in item #25 with a SD value of 2.25.

Before analyzing the differences in means between the different groups analyzed (Year; Academic performance; Gender) to see if there are significant differences, it should be noted that for all cases a normality and equality of variances analysis was performed to ensure that the bases of the statistical process were fulfilled.

Table 2: Answers of students to the EME –E questioner (in Spanish). M=mean; σ=typical deviation; A= asymmetry;

Ítem		% answers							M	σ	A
		1	2	3	4	5	6	7			
D	***Desmotivación***										
#5	Sinceramente no lo sé; verdaderamente, tengo la impresión de perder el tiempo en la universidad.	28.1	28.4	16.0	10.7	9.6	5.1	2.2	2.69	1.62	0.84
#12	En su momento, tuve buenas razones para ir a la universidad; pero, ahora me pregunto si debería continuar en ella.	32.9	23.3	11.2	8.4	11.5	8.4	4.2	2.85	1.87	0.72
#19	No sé por qué voy a la universidad y francamente, me trae sin cuidado	55.6	25.0	9.6	3.7	3.7	1.1	1.4	1.84	1.28	1.96
#26	No lo sé; no consigo entender qué hago en la universidad.	51.7	25.3	10.1	4.2	5.3	2.5	0.8	1.97	1.37	1.62
MERE	ME Regulación Externa										
#1	Porque sólo con el Bachillerato no podría encontrar un empleo bien pagado	28.7	12.4	10.7	9.8	12.6	8.4	17.4	3.60	2.25	0.24
#8	Para poder conseguir en el futuro un trabajo más prestigioso.	2.0	2.2	2.8	7.3	19.4	31.5	34.8	5.74	1.37	-1.40
#15	Porque en el futuro quiero tener una “buena vida”.	0.8	1.1	0.8	6.2	18.3	32.9	39.9	5.98	1.14	-1.49
#22	Para tener un sueldo mejor en el futuro.	0.8	1.1	2.2	5.9	15.7	34.0	40.2	5.97	1.18	-1.52
MEIN	ME Regulación introyectada										
#7	Para demostrarme que soy capaz de terminar una carrera universitaria.	14.3	6.2	8.1	18.0	18.8	17.7	16.9	4.41	1.97	-0,41
#14	Porque aprobar en la universidad me hace sentirme importante	15.4	14.3	15.7	19.4	17.7	11.0	6.5	3.68	1.80	0.07
#21	Para demostrarme que soy una persona inteligente.	14.6	14.3	9.8	17.4	20.8	13.5	9.6	3.94	1.90	-0.10
#28	Porque quiero demostrarme que soy capaz de tener éxito en mis estudios	11.8	7.3	7.6	17.1	22.5	21.3	12.4	4.45	1.85	-0.51
MEID	ME Regulación identificada										
#3	Porque pienso que los estudios universitarios me ayudarán a preparar mejor la carrera que he elegido	5.1	3.1	7.6	15.7	19.7	25.8	23.0	5.12	1.65	-0.82
#10	Porque posiblemente me permitirá entrar en el mercado laboral dentro del campo que a mí me guste.	1.1	0.8	4.5	5.9	14.9	31.7	41.0	5.92	1.27	-1.45
#17	Porque me ayudará a elegir mejor mi orientación profesional	1.7	1.7	5.9	10.1	20.8	31.5	28.4	5.54	1.38	-1.06
#24	Porque creo que unos pocos años más de estudios van a mejorar mi competencia como profesional.	2.0	2.0	4.5	7.0	16.6	34.3	33.7	5.72	1.39	-1.38
MIC	MI al conocimiento										
#2	Porque para mí es un placer y una satisfacción aprender cosas nuevas.	3.1	7.0	10.4	16.9	28.1	18.8	15.7	4.79	1.58	-0.47
#9	Por el placer de descubrir cosas nuevas desconocidas para mí	3.4	5.3	12.4	20.5	24.7	17.4	16.3	4.75	1.58	-0.37
#16	Por el placer de saber más sobre las asignaturas que me atraen.	3.9	8.1	11.2	18.8	23.6	18.3	16.0	4.69	1.65	-0.39
#23	Porque mis estudios me permiten continuar aprendiendo un montón de cosas que me interesan	4.2	8.4	11.8	20.2	23.9	16.3	15.2	4.61	1.65	-0.33
MIL	MI al logro										
#6	Por la satisfacción que siento cuando me supero en mis estudios.	3.4	6.2	7.3	14.3	23.6	26.4	18.8	5.03	1.60	-0.74
#13	Por la satisfacción que siento al superar cada uno de mis objetivos personales.	1.7	5.3	6.5	15.2	20.2	28.4	22.8	5.23	1,52	-0.77
#20	Por la satisfacción que siento cuando logro realizar actividades académicas difíciles	4.2	5.6	6.5	13.8	23.3	25.6	21,1	5.07	1.64	-0.80
#27	Porque la universidad me permite sentir la satisfacción personal en la búsqueda de la perfección dentro de mis estudios.	9.8	13.2	14.6	19.1	19.4	17.4	6.5	4.03	1.74	-0.15
MIEE	MI a las experiencias estimulantes										
#4	Por los intensos momentos que vivo cuando comunico mis propias ideas a los demás.	16.6	20.2	18.0	24.2	11.5	5.3	4.2	3.27	1.63	0.38
#11	Por el placer de leer autores interesantes	46.9	21.9	10.1	13.2	5.3	0.8	1.7	2,17	1,45	1.20
#18	Por el placer que experimento al sentirme completamente absorbido por lo que ciertos autores han escrito.	50.0	20.8	9.3	11.2	5.3	1.7	1.7	2.13	.1.48	1.30
#25	Porque me gusta meterme de lleno cuando leo diferentes temas interesantes.	22.2	19.7	13.5	19.1	12.9	6.7	5.9	3.25	1.81	0.40

4.2. Comparison of Motivation Types by Year:

In Table 3, the means of the types of motivations for the different courses are indicated. The data show a series of interesting trends. In the 5 academic cycles studied (4 cycles of GITI and 1 cycle of MII), the most predominant and least predominant motivations are the same, in descending order of predominance across all courses: MEID, MERE, MIL, MIC, MEIN, MIEE, and finally D. However, each type of motivation varies slightly over the years.

Table 3: means 7 types of motivation per year and program (GITI and MII)

Year	D	MERE	MEIN	MEID	MIC	MIL	MIEE
1 GITI	2.16	5.24	4.48	5.71	4.72	5.09	3.00
2 GITI	2.49	5.28	4.43	5.61	4.81	4.88	2.73
3 GITI	2.30	5.24	3.79	5.34	4.67	4.77	2.35
4 GITI	2.32	5.38	4.05	5.53	4.60	4.68	2.72
MII	2.39	5.42	4.02	5.72	4.79	4.89	2.80

The results obtained from the Kruskal-Wallis test indicate that there are no statistically significant differences in the majority of cases. The p-values obtained are well above the commonly accepted threshold of 0.05; therefore, it cannot be concluded that there is a significant difference in the medians of motivations between the courses. However, motivations MEIN and MIEE show a p-value very close to the 0.05 threshold, especially MEIN, suggesting a potential difference between the courses.

4.3. Relationship between Academic Performance and Motivation Types:

The table 4 offers a comparison between the means of the seven different types of motivation for students who have repeated a course and those who have not. From the data, it can be inferred that students who have repeated tend to show higher levels of D and MERE compared to students who have not repeated. On the other hand, non-repeating students record higher averages in the other categories of motivation, including MEIN, MEID, MIC, MIL, MIEE. Visually, illustration 9 highlights these differences.

This initial approach to the effect of academic performance on types of motivation indicates truly revealing results. However, to establish statistically significant differences and understand the relationship between motivation and academic performance, additional statistical analyses would be necessary.

Table 4: means of 7 types of motivation for repeaters and no repeaters

Repeater?	D	MERE	MEIN	MEID	MIC	MIL	MIEE
No	2.07	5.27	4.21	5.75	4.96	5.13	2.90
Yes	2.67	5.39	4.00	5.36	4.40	4.48	2.45

The Mann-Whitney U test shows significant differences in motivations D, MEID, MIC, MIL, and MIEE, evidenced by p-values that are lower than the standard threshold of 0.05, suggesting statistically significant variations between repeating and non-repeating for these types of motivation.

4.4. Relationship between Gender and Motivation Types:

When comparing the means of different types of motivations based on gender, slight differences can be observed. It can be noted that the motivation types that stand out the most are MEIN and MIL, with higher values for the female gender in both cases (Table 5). Again, a statistical analysis is necessary to ensure whether the difference between the means is significant for each case.

Table 5: Comparison of types of motivation based on gender

Gender	D	MERE	MEIN	MEID	MIC	MIL	MIEE	SDI
Female	2.41	5.42	4.50	5.69	4.68	5.24	2.66	4.32
Male	2.28	5.29	3.92	5.52	4.75	4.64	2.73	4.43
Other	3.33	3.75	3.17	4.58	3.00	2.25	2.33	-0.49

The Mann-Whitney U test reveals that there are significant differences between male and female genders in motivations MEIN ($p < 0.001$), MEID ($p = 0.045$), and MIL ($p < 0.001$). There are no statistically significant gender differences in the other types of motivation, as their p-values exceed the threshold of 0.05.

5. Conclusions

This research has been dedicated to addressing fundamental questions related to the motivation of industrial engineering students at the UPM with rigor and detail.

Regarding RQ1 *What is the nature of the motivation of GITI and MII students, and how does it vary throughout their academic journey?* We can affirm that industrial engineering students at the UPM tend to be more motivated by external factors than internal ones. They are predominantly motivated by an extrinsic motivation of identified regulation and an extrinsic motivation of external regulation. That is, motivation driven by personal goals and the value of the activity and by external factors or tangible rewards such as grades or academic recognition. In comparison, intrinsic motivation for achievement and knowledge is less prominent, and the extrinsic motivation of introjected regulation is presented to a moderate degree, meaning that motivation driven by maintaining self-esteem or avoiding feelings of guilt is lower. Intrinsic motivation for stimulating experiences is reduced, indicating that students in general do not find pleasure and excitement in engaging in intellectually stimulating activities. Additionally, students show a very low level of demotivation. This configuration of motivations points to a moderate level of self-determination in the student body.

Throughout their education in industrial engineering, a slight decrease in intrinsic motivation for achievement and intrinsic motivation for stimulating experiences is perceived over the years. These decreases are more noticeable in the third year of GITI. However, variations in the level of self-determination according to the academic year are not significant.

When specifically examining the group of students who have repeated courses, more pronounced variations in the types of motivation are observed over the academic years. For this particular group, a decrease in intrinsic motivation for achievement, extrinsic motivation of introjected regulation, and intrinsic motivation for stimulating experiences is noted as they progress in their academic formation.

RQ2 *How does motivation affect students' academic performance?* In the analysis, a significant correlation between motivation levels and academic performance in industrial engineering students has been identified. The results indicate that students with lower academic performance, those who have repeated courses, present significantly reduced levels

in all forms of intrinsic motivation. In particular, significant decreases are observed in intrinsic motivation for knowledge, intrinsic motivation for achievement, and intrinsic motivation for stimulating experiences. Additionally, this same group of students demonstrates lower extrinsic motivation of identified regulation, implying that they are less likely to carry out their activities based on personal recognition and internal valuation of their importance. Moreover, a considerably higher level of demotivation is observed in students with poorer performance.

Furthermore, repeating students also exhibit a significantly lower level of self-determination. These results highlight a clear correlation between academic performance and different types and degrees of motivation, emphasizing the relevance of intrinsic and extrinsic motivation in the context of academic performance in industrial engineering students.

RQ3*. Is there a gender influence on student motivation patterns?* The results have demonstrated statistically significant differences in motivation patterns between genders.

Specifically, it has been observed that female students of industrial engineering exhibit higher levels in certain categories of motivation compared to their male counterparts. These differences are manifested in extrinsic motivation of introjected regulation, extrinsic motivation of identified regulation, and intrinsic motivation for achievement. These results indicate that women are more motivated to avoid feelings of guilt, maintain self-esteem, and achieve personal challenges and goals. These findings are of great relevance, as they suggest that both extrinsic and intrinsic motivations vary in intensity according to gender, with a tendency towards higher motivation in female students in the mentioned areas.

This discovery provides an important perspective on gender dynamics in the academic field of industrial engineering and emphasizes the need to consider gender differences in the development of pedagogical and student support strategies.

The results presented should encourage professors to reflect on how to motivate their students (intrinsic motivation), awakening their interest in the concepts taught, in the same way that project managers must motivate the people in their teams. Also, these results can help improve academic programs and promote motivation at all levels from the beginning of careers leading to future engineering project management professionals.

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