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Validation of a Structural Model for Analyzing Expectations and Perceptions in Industrial Engineering: The Case of TecNM / Instituto Tecnológico de Morelia

Validação de um modelo estrutural para a análise de expectativas e percepções em Engenharia Industrial: Caso TecNM / Instituto Tecnológico de Morelia

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Resumen

La globalización y las crecientes exigencias del mercado laboral han incrementado la presión sobre las instituciones de educación superior para ofrecer una formación pertinente y de alta calidad. En el ámbito de la Ingeniería Industrial, surge la necesidad de evaluar si las competencias adquiridas por los estudiantes corresponden a las demandas profesionales actuales. Este estudio tuvo como propósito comparar las expectativas iniciales y las percepciones finales de los estudiantes del Tecnológico Nacional de México/Instituto Tecnológico de Morelia, con el fin de comprender la evolución de sus valoraciones sobre la formación recibida y su alineación con las necesidades del entorno productivo.

Se empleó un enfoque mixto con predominio cuantitativo. Se aplicaron encuestas tipo Likert a 420 estudiantes: 210 de primeros semestres, representando expectativas iniciales, y 210 de especialidad, reflejando percepciones consolidadas. La confiabilidad de los instrumentos se confirmó mediante coeficientes Alfa de Cronbach de 0.78 para expectativas y 0.93 para percepciones, y su validez mediante KMO de 0.74 y 0.78 respectivamente, junto con pruebas de Bartlett ($p < .001$). El análisis factorial exploratorio identificó cinco dimensiones clave en ambos grupos, mientras que el modelo de ecuaciones estructurales (SEM) desarrollado en AMOS reveló relaciones significativas entre las variables y un coeficiente negativo (–0.13) entre expectativas y percepciones, evidenciando un desfase entre lo esperado y lo experimentado. Aunque los estudiantes valoran la calidad docente, la infraestructura, las visitas industriales y el desarrollo socioemocional, señalaron deficiencias en la actualización bibliográfica, las prácticas aplicadas y la homogeneidad docente. Estos resultados subrayan la necesidad de fortalecer la pertinencia curricular, diversificar las experiencias prácticas y consolidar la preparación docente para alinear la formación con las demandas del mercado laboral y elevar la satisfacción estudiantil.

Palabras claves: Calidad educativa, Modelado de ecuaciones estructurales (SEM), Expectativas y percepciones.

Abstract

Globalization and the growing demands of the labor market have increased pressure on higher education institutions to provide relevant, high-quality training. In the field of Industrial Engineering, there is a need to assess whether the competencies acquired by students align with current professional requirements. This study aimed to compare the initial expectations and final perceptions of students at the Tecnológico Nacional de México, Morelia campus, in order to understand the evolution of their assessments of the training received and its alignment with the needs of the productive sector.

A mixed-methods approach with a quantitative emphasis was employed. Likert-type surveys were administered to 420 students: 210 in early semesters, representing initial expectations, and 210 in the specialization stage, reflecting consolidated perceptions. Instrument reliability was confirmed through Cronbach's alpha coefficients of 0.78 for expectations and 0.93 for perceptions, and validity was verified using KMO values of 0.74 and 0.78, respectively, along with Bartlett's tests ($p < .001$). Exploratory factor analysis identified five key dimensions in both groups, while the structural equation model (SEM) developed in AMOS revealed significant relationships among variables and a negative coefficient (–0.13) between expectations and perceptions, indicating a gap between what was anticipated and what was experienced. Although students value teaching quality, infrastructure, industrial visits, and socioemotional development, they reported shortcomings in updated bibliographic resources, applied practices, and teaching consistency. These findings highlight the need to strengthen curricular relevance, diversify practical experiences, and enhance faculty preparation to align training with labor market demands and improve student satisfaction.

Keywords: Educational Quality, Structural Equation Modeling (SEM), Expectations and Perceptions.

Resumo

A globalização e as crescentes demandas do mercado de trabalho aumentaram a pressão sobre as instituições de ensino superior para oferecerem formação relevante e de alta qualidade. Na área de Engenharia Industrial, surge a necessidade de avaliar se as competências adquiridas pelos alunos correspondem às demandas profissionais atuais. Este estudo teve como objetivo comparar as expectativas iniciais e as percepções finais dos alunos do Instituto Tecnológico Nacional do México/Instituto Tecnológico de Morelia, a fim de compreender a evolução de suas avaliações sobre a formação recebida e seu alinhamento com as necessidades do ambiente produtivo.

Foi utilizada uma abordagem de métodos mistos com predominância quantitativa. Questionários do tipo Likert foram aplicados a 420 alunos: 210 alunos do primeiro semestre, representando as expectativas iniciais, e 210 alunos de pós-graduação, refletindo as percepções consolidadas. A confiabilidade dos instrumentos foi confirmada pelos coeficientes alfa de Cronbach de 0,78 para expectativas e 0,93 para percepções, e sua validade pelos coeficientes KMO de 0,74 e 0,78, respectivamente, juntamente com os testes de Bartlett ($p < 0{,}001$). A análise fatorial exploratória identificou cinco dimensões-chave em ambos os grupos, enquanto a modelagem de equações estruturais (MEE) desenvolvida no AMOS revelou relações significativas entre as variáveis e um coeficiente negativo (-0,13) entre expectativas e percepções, demonstrando uma lacuna entre o que era esperado e o que foi vivenciado. Embora os alunos tenham valorizado a qualidade do ensino, a infraestrutura, as visitas à indústria e o desenvolvimento socioemocional, eles apontaram deficiências na atualização dos materiais didáticos, nas práticas aplicadas e na consistência do corpo docente. Esses resultados ressaltam a necessidade de fortalecer a relevância curricular, diversificar as experiências práticas e consolidar a formação docente para alinhar a educação às demandas do mercado de trabalho e aumentar a satisfação dos alunos.

Palavras-chave: Qualidade educacional, Modelagem de equações estruturais (MEE), Expectativas e percepções.

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Introduction

In the current context of higher education, the pursuit of quality is paramount so that graduates can meet the challenges of a globalized world. The transformation of production systems, driven by globalization and technological advances, has increased the demands of society and employers on educational institutions to offer relevant and up-to-date programs (OECD, 2015; UNESCO, 2014).

Despite efforts, a significant gap persists between the skills demanded by companies and those possessed by graduates, affecting their employability (Sánchez, Castillo-Pérez & Martínez-Lazcano, 2022). Students enter university with high expectations of an education that will guarantee them job opportunities, but they often face a different reality upon entering the job market (Rojas & López, 2019). This situation is particularly relevant in Michoacán, where the manufacturing industry is strategic and demands specific profiles for programs such as Industrial Engineering.

To address this challenge, key performance indicators (KPIs) have emerged as an essential tool for continuous improvement. However, quantitative data alone are insufficient if they are not analyzed comprehensively and within their context (Cullen, 1999; Kenna, 1998), since a correct interpretation facilitates informed decision-making and prevents the obsolescence of academic programs (Cotta-Schomberg, 1995; Lancaster, 1996).

The concept of educational quality is equally complex, encompassing everything from meeting expectations (Berry, 1988; Harrington, 1990) to the student's perspective as the ultimate judge of quality (Juran, 1993). This implies that their development must be holistic, encompassing technical skills, socio-emotional abilities, and values (Espasa, 2007; Valls, 2007; Wang, 2024). Ruiz-Ortega & Berrios-Martos, 2025). Theorists such as Piaget (1972) and Vygotsky (1978) reinforce this view, highlighting that learning is an active and social process that should foster both autonomy and collaboration.

Methodologically, structural equation modeling (SEM) offers a robust approach for analyzing educational quality, allowing the identification of relationships between complex variables such as expectations, perceptions, and outcomes (Bollen, 1989; Ruiz, Pardo, & San Martín, 2010; Sun , Peng , & Lin, 2023). Its application strengthens the validity of analyses in educational research (Kaplan, 2009; Kline, 2011; Salgado, 2009), provided that the reliability of the measurement instruments is ensured using indices such as Cronbach's alpha (Nunnally & Bernstein, 1994).

At the National Technological Institute of Mexico / Morelia Institute of Technology, this discussion is fundamental to the Industrial Engineering program, whose graduates must possess technical skills, leadership, critical thinking, and adaptability (Martínez, 2021; Gómez & Torres, 2022). This research proposes the use of a structural model to evaluate educational quality from the students' perspective, comparing their initial expectations with their final perceptions. The objective was to identify the gaps between what they expect and what they receive, in order to provide evidence to guide institutional improvement.

The central research question was: To what extent do students' perceptions at the end of their training differ from their expectations upon entering, and how are these differences related to academic and practical factors? It was hypothesized that a significant gap would exist, explained by curriculum updates, resource availability, industry internship opportunities, and teaching experience. The results aim to strengthen the program's relevance and offer a replicable framework for fostering a culture of academic excellence (Anderson & Krathwohl, 2001; Kirkpatrick & Kirkpatrick, 2016).

Materials and methods

This study employed a mixed-methods approach, prioritizing the quantitative component while also incorporating qualitative elements to enrich the interpretation of the findings. The quantitative approach allowed for the statistical analysis of students' expectations and perceptions through structured surveys and structural equation modeling, while the qualitative component relied on the review and interpretive analysis of open-ended comments included in the instruments, as well as the contextualization of the results based on institutional experience and the theoretical framework. This methodological combination facilitated, on the one hand, the establishment of statistical correlations between educational indicators and, on the other hand, the understanding of the subjective perceptions of the various stakeholder groups involved in the educational process.

The strategy included the systematic collection of data, the design and application of measurement instruments, and fieldwork, which made it possible to construct a structural model aimed at comprehensively evaluating educational quality at the National Technological Institute of Mexico / Morelia Technological Institute. This methodological approach ensured both the robustness of the quantitative results and the depth of the qualitative analysis, offering a more complete and contextualized view of the phenomenon under study.

Participants

The target population of this study consisted of students of the Industrial Engineering program at the National Technological Institute of Mexico/Morelia Technological Institute, distributed into two strategic groups with the purpose of carrying out a comparative analysis between the initial expectations and the consolidated perceptions of their academic training.

Including both groups allows for a comparison of expectations with actual perceptions throughout the educational process, providing a comprehensive view of the academic program's impact. This design facilitates the analysis of the evolution of competencies, soft skills, and learning experiences, and helps identify potential gaps that may limit the relevance of the training to the demands of the productive sector.

Tools

For data collection, two self-developed surveys were designed and applied, directed at the two previously defined interest groups:

Survey 1: Applied to first-semester students, with the objective of identifying their initial expectations regarding training in Industrial Engineering, covering dimensions such as academic development, technical skills, soft skills, institutional infrastructure and professional projection.

Survey 2: Applied to students in the specialization stage, with the purpose of evaluating their consolidated perceptions on the quality of educational processes, the relevance of the curriculum, the preparation for the work environment and the impact of academic resources and practical experiences.

Both instruments were structured under the format of a five-point Likert scale (1 = totally disagree to 5 = totally agree), which allowed for obtaining comparable quantitative data and facilitated factor analysis.

Sampling

The sample design was carried out using simple random sampling, with the aim of ensuring representativeness of the results. The sample size was determined using the statistical formula proposed by Holický (2013):

$$n = \frac{N\, Z^2\, p\, q}{(N-1)e^2 + Z^2\, p\, q}$$

where n is the sample size, N is the population size, Z corresponds to the confidence level, pa is the probability of success, qa is the probability of failure, and ye is the expected error. For this study, the following parameters were established: 95% confidence level (Z = 1.96), 5% sampling error (e = 0.05), probability of success (p) of 0.5 and probability of failure (q) of 0.5, considering a finite population size of 400 students per group.

Based on these criteria, a total sample of 420 Industrial Engineering students from the National Technological Institute of Mexico/Morelia Technological Institute was defined. Of this total, 210 are first-semester students, who provide information about their initial expectations regarding academic training, the use of technologies, industrial visits, and the acquisition of basic skills. The other 210 participants are students pursuing their specialization, whose opinions reflect more consolidated perceptions about the relevance of the curriculum, the application of knowledge in practical contexts, and professional preparation for the job market.

This sampling design allowed for a rigorous comparison between expectations and perceptions, providing empirical evidence on the evolution of the learning experience throughout the academic journey. The inclusion of both student groups enriches the validity of the analysis by capturing the perspectives of both those beginning their studies and those in the advanced stages of their degree.

Analysis

Data processing and analysis were carried out using the IBM SPSS Statistics statistical package (version 21) and AMOS software, which allowed for the organization, cleaning, and interpretation of the information obtained from the surveys. The analysis was structured in several complementary stages:

1. Descriptive statistics. In a first phase, measures of central tendency (mean, median and mode) and dispersion (standard deviation, kurtosis and skewness coefficient) were calculated, with the purpose of characterizing the general behavior of the variables and obtaining a preliminary view on the expectations and perceptions of the students.
2. Sampling adequacy tests. The Kaiser-Meyer- Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were applied to confirm the suitability of the data for factor analysis. The results confirmed the existence of significant correlations

between the items, an essential requirement for the validation of the proposed statistical models.

3. Exploratory factor analysis (EFA) was conducted using the principal component method with Varimax rotation , which allowed for the identification and grouping of latent dimensions from the responses obtained. This technique reduced the complexity of the data and revealed the underlying factors that structure students' expectations and perceptions.
4. Reliability of the instruments. The internal consistency of the surveys was assessed using Cronbach's Alpha coefficient.
5. Regression and Structural Equation Models. Finally, multiple linear regression analysis and structural equation modeling (SEM), implemented in AMOS, were applied to evaluate the relationships between the identified dimensions (academic development, competencies, soft skills, academic training, and teaching experience). The structural equation model was chosen for its ability to analyze complex relationships between latent and observable constructs, following the recommendations of recent studies that apply it in multidimensional university contexts (González-Medina, Gutiérrez-González & Llorente-Cejudo, 2025). These models allowed for the estimation of direct and indirect effects, as well as the validation of the theoretical framework proposed around expectations and perceptions.

Taken together, these phases of analysis ensured a solid and rigorous statistical approach, aimed at contrasting the students' initial expectations with the perceptions obtained during their specialization stage, providing empirical evidence for the discussion and consolidation of the proposed structural model.

Results

Expectations

Before proceeding with the exploratory factor analysis, it was necessary to assess the quality and adequacy of the data obtained from the surveys administered to first-semester students. This preliminary step ensured that the collected responses showed sufficient correlations between items and met the statistical requirements necessary to guarantee the validity of the model.

The Kaiser-Meyer- Olkin (KMO) test of sampling adequacy (KMO = 0.740) and Bartlett's test of sphericity (χ^2 = 531.117; df = 153; p < .001) confirmed that the data were suitable for factor analysis. This indicates that there were significant correlations among the analyzed items, validating the appropriateness of the statistical procedure.

Table 1 presents the exploratory factor analysis with Varimax rotation , through which five statistically significant dimensions were identified that structure the expectations of Industrial Engineering students, providing a solid framework for their interpretation:

1. Academic Development (AD): Includes four items related to the impact of technology use, industrial visits, and the ability to solve practical problems.
2. Competencies (COM): Composed of six items that measure the relevance of learning foreign languages, stress management, teamwork, and academic stays abroad.
3. Soft Skills (BS): Covers three items related to frustration management, stress control, and leadership.
4. Academic Training (AT): It brings together three items on institutional infrastructure, the relevance of laboratory practices and personal safety as part of effective communication.
5. Teaching Experience and Optimization (EDO): Includes two items related to the teaching staff's work experience and the relevance of process optimization in the industry.

These results reflect that students value both the technical aspects of their training and the socio-emotional skills and practical experience. The findings confirm that Industrial Engineering education should be conceived as a comprehensive process that combines academic development, the acquisition of technical skills, the strengthening of soft skills, and access to practical experiences.

The Academic Development dimension highlights the importance students place on technological updates and industry visits as mechanisms for connecting theory with practice. This aligns with the OECD's (2015) assertion that integrating practical experiences into university education is essential for improving employability.

In the Competencies dimension, there is a clear expectation of acquiring complementary skills, such as foreign languages and participation in academic exchanges. This finding reflects the influence of globalization on student perceptions and aligns with UNESCO's (2014) emphasis on the importance of preparing students for multicultural work environments.

The soft skills analysis shows that students consider leadership and emotional intelligence to be fundamental. This result is consistent with recent research that recognizes these competencies as key determinants of professional performance in dynamic industrial environments.

On the other hand, the Academic Training dimension shows that institutional resources, such as laboratories and infrastructure, are perceived as key factors in ensuring meaningful learning. However, some items related to outdated materials reflect the need to update teaching resources, which represents a priority area for improvement.

Finally, the Teaching Experience and Optimization dimension highlights the importance of having professors with practical experience in industry. Students perceive that their training is enriched when professors integrate real-world examples and encourage the application of knowledge to optimization processes.

Table 1. Results of the exploratory factor analysis: principal component matrix with Varimax rotation

		Rotated factors matrix					
Dimension	Item	Ask	Factor				
			1	2	3	4	5
1	1	Is the use of current technologies during your classes important for your academic development?	.800	.095	.161	-.041	-.056
	2	Is studying industrial engineering a good choice?	.745	-.074	.175	-.012	.065
	3	Industrial visits foster better academic development	.692	.084	-.065	.062	.147
	4	Do you think that studying industrial engineering will increase your ability to solve real-world problems within the industry?	.658	.242	.056	.103	-.039
2	1	Do you consider material used in class to be obsolete if it is older than 12 years?	-.018	.786	.057	-.053	.175
	2	As a future industrial engineer, it is essential to have the ability to identify problems in industry as a primary skill.	.020	.678	.082	.362	-.014
	3	Does learning foreign languages give you better opportunities as an industrial engineer?	.197	.634	.173	.156	.138
	4	Is it essential to teach stress management during a degree program?	.174	.507	.335	.124	.015
	5	Teamwork is important for the development of your academic skills.	.472	.499	.030	.202	-.199
	6	Applying for an exchange program or stay in another country contributes to your development as an engineer.	.410	.472	.099	-.300	-.316
3	1	Proficiency in various CAD software programs helps you become a competitive industrial engineer	.143	.060	.848	.058	-.005
	2	Is it important during your studies to be taught how to manage frustration?	.088	.190	.770	-.109	.238
	3	Do you assume that leadership in an industrial engineer is vital for delegating?	-.012	.195	.660	.342	-.161
4	1	Having personal confidence influences good communication in the workplace	-.017	.096	.100	.695	-.007
	2	ITM's infrastructure is relevant for better academic training	.411	.177	-.187	.503	.269
	3	Is it important to do laboratory work during your degree?	.063	.340	.385	.496	.080
5	1	Process optimization in industry is of vital importance to an industrial engineer	-.056	.140	-.040	-.074	.814
	2	Having teachers with work experience helps to create a more dynamic classroom environment and a better understanding of the topics.	.229	.011	.266	.325	.635

Note: The questions are presented verbatim, exactly as they were formulated in the original instrument applied to the participants, without any modifications to their wording.

Source: Prepared by the author based on data obtained from surveys applied to first-semester Industrial Engineering students at the National Technological Institute of Mexico/Technological Institute of Morelia

The results reveal that Industrial Engineering students value an academic education that goes beyond theoretical knowledge and integrates practical experience, innovation, leadership, and continuous professional development. This perspective reinforces the need for institutions to adapt their academic programs to the current demands of the job market, thereby promoting a more relevant, comprehensive, and competitive education.

Table 2. Results of the exploratory factor analysis of the perceptions of Industrial Engineering students

		Rotated factors matrix					
Dimension	Item	Ask	Factor				
			1	2	3	4	5
1	1	The dynamic nature of the classes provides meaningful experiences for our training by contrasting theory with practice.	.841	.127	.245	.053	.080
	2	The teaching methodology applied has helped us to acquire knowledge about the career.	.836	-.069	.257	.095	.039
	3	The teachers who teach the subjects explain the topics clearly.	.730	.212	.096	.221	-.006
	4	The contents of the educational program and the digital bibliographies offered are up to date.	.676	.202	.036	.189	.222
	5	We have developed reasoning skills during the classes.	.660	.256	.071	.264	.198
	6	The infrastructure offered at ITM supports our training.	.658	.103	.036	.317	.192
	7	The subjects taught are useful for professional application.	.655	.090	.401	.048	.377
	8	The staff of the institution are willing to provide institutional support (facilitating procedures, timely attention, resolving complaints, suggestions, etc.)	.492	.446	.003	.151	.294
2	1	Carrying out projects with an impact on the environment and solving real problems has been useful for us in relating to the outside world.	.219	.950	.151	.030	.008
	2	Industrial visits and professional residencies provide knowledge and experience for our learning.	.018	.740	.280	.152	.190
	3	Our work experiences have been useful for our training.	.103	.669	.196	.182	.154
	4	We can communicate in a language other than Spanish.	.199	.371	.302	.110	-.145
3	1	We are capable of performing statistical analysis and proposing solutions to industrial problems.	.104	.072	.862	.114	.143
	2	How often do we manage to identify production processes?	-.017	.262	.805	.367	.046
	3	We are able to use software related to the field.	.339	.353	.671	.061	-.030

	4	We have the ability to solve process problems and propose methods for their optimization	.316	.235	.664	.308	.003
4	1	We are capable of accepting our mistakes and learning from them for the future.	.187	.176	.313	.871	.079
	2	We are capable of solving problems and managing our levels of frustration, stress, and uncertainty.	.536	.133	.175	.650	-.043
	3	We can apply leadership when working as a team.	.383	.357	.339	.528	.133
	4	We are able to communicate our ideas effectively when working as a team.	.348	.153	.326	.502	.179
5	1	The specializations offered are in accordance with the needs of the industrial and work environment.	.438	.156	.113	.037	.816
	2	The training I received during my degree allows me to critically analyze situations in the work environment in order to make appropriate decisions.	.217	.534	.014	.357	.563

Note: The questions are presented verbatim, exactly as they were formulated in the original instrument applied to the participants, without any modifications to their wording.

Source: Prepared by the author based on data obtained from surveys applied to students in the specialization stage of Industrial Engineering at the National Technological Institute of Mexico/Technological Institute of Morelia.

Perception

Before presenting the specific results, it was necessary to evaluate the quality and consistency of the data collected from upper-level students. This preliminary analysis verified that the responses met the statistical requirements for conducting a reliable factor analysis. This ensured that the students' perceptions validly and consistently reflected their educational experience, facilitating the identification of the key dimensions that structure their assessment of the quality of education they received.

Table 2 shows the results of the factor analysis applied to the perceptions of students in their final semesters of Industrial Engineering. The Kaiser-Meyer- Olkin (KMO) test of sampling adequacy (KMO = 0.783) and Bartlett's test of sphericity ($\chi^2 = 1045.643$; df = 231; $p < .001$) confirmed the relevance of the analysis, demonstrating significant correlations between the items and validating the resulting factor structure. Furthermore, the reliability value obtained using Cronbach's alpha ($\alpha = 0.938$ with 22 items) indicates excellent internal consistency of the indicators used.

Factor analysis with Varimax rotation allowed the identification of five main dimensions that group the perceptions of the students.

1. First, the Academic Training and Curriculum Map dimension (V26) comprises eight items that assess the quality of education received, the updating of content, and the clarity of instruction. This factor highlights the importance of having well-prepared professors, up-to-date bibliographies, adequate infrastructure, and subjects relevant to professional training.
2. The second dimension corresponds to Analytical and Abstract Reasoning (V27), comprised of four items that assess students' ability to analyze complex situations, identify processes, and propose solutions based on statistical tools. This dimension reflects the technical skills acquired throughout their studies.
3. The third dimension, called Capacity to Solve Problems in the Productive Sector (V28), is made up of four items that measure students' perception of their preparedness to face real industry challenges, through the application of optimization methodologies and the use of specialized software.
4. The fourth dimension corresponds to Soft Skills Development (V29), also comprised of four items that include leadership, effective communication, teamwork, and stress management. These results show that students perceive socio-emotional competencies as fundamental for their future professional performance.
5. Finally, the fifth dimension, Relevance and Reasoning in Personal Training (V30), groups two items linked to the suitability of the training received with the demands of the labor market, as well as the development of critical thinking as a tool for decision making.

These five dimensions show that students in their final semesters perceive their education in a comprehensive way, valuing both technical aspects and interpersonal skills and the development of critical reasoning, which coincides with international trends that point to the need for higher education oriented towards employability and the integral development of the student.

The contrast between Industrial Engineering students' initial expectations and their perceptions at the end of their studies reveals a significant evolution in their evaluation of their academic training. Initially, expectations focused on aspects such as academic development, the acquisition of technical and socio-emotional skills, and the importance of practical experience through industrial visits, up-to-date technologies, and process optimization. These expectations reflect an idealized view of the degree, in which academic programs are expected to provide comprehensive and modern tools to meet the challenges of industry.

However, perceptions gathered in recent semesters show a shift towards a more realistic and applied view. Students recognize the relevance of their academic training and positively value the quality of the faculty, infrastructure, and course content, although they also identify areas for improvement, such as the need for updated literature and methodologies. In this regard, while initial expectations projected an emphasis on acquiring technical knowledge, final perceptions highlight the role of analytical skills, critical thinking, and the development of soft skills as central elements for employability and professional performance.

Comparing both perspectives also reveals a convergence in the importance attributed to practical experience. In both expectations and perceptions, students emphasize the value of industry visits, internships, impact projects, and laboratory work as key mechanisms for linking theory with practice. This aligns with the recommendations of international organizations such as the OECD (2015) and UNESCO (2014), which advocate for integrating real-world experiences into higher education programs.

A key finding is that, throughout their academic journey, students shift from viewing technical skills as the core of their education to recognizing the importance of socio-emotional skills—leadership, effective communication, stress management, and teamwork—in their holistic development. This change in focus reflects a process of academic and professional maturation, where their final perceptions align more closely with the demands of the globalized job market.

Overall, the comparison between expectations and perceptions leads to the conclusion that, while the Industrial Engineering program meets many initial expectations, challenges remain related to consistency in teaching experience, updated materials, and the strengthening of practical skills. These areas for improvement represent strategic opportunities to ensure a more relevant, comprehensive education aligned with the requirements of contemporary industry.

Structural Equation Modeling (SEM)

To delve deeper into the relationship between initial expectations and consolidated perceptions of Industrial Engineering students, a structural equation model (SEM) was applied as a confirmatory factor analysis technique. This approach allowed for the simultaneous evaluation of interactions between multiple latent and observed variables, validating the theoretical framework proposed based on the results of the exploratory factor analysis. The use of SEM provided a comprehensive view of how different dimensions—both academic and socio-emotional—contribute to explaining the overall perception of the training received and its alignment with the demands of the professional environment.

As shown in Figure 1, the structural equation model (SEM) establishes the relationship between the expectations and perceptions of Industrial Engineering students. The perception construct is explained by five observed variables: academic background and network map (V26), analytical and abstract reasoning skills (V27), problem-solving in the productive sector (V28), development of soft skills (V29), and relevance and reasoning in personal development (V30). The standardized factor loadings of these indicators range from .64 to .79, demonstrating adequate internal consistency and a robust representation of the underlying construct.

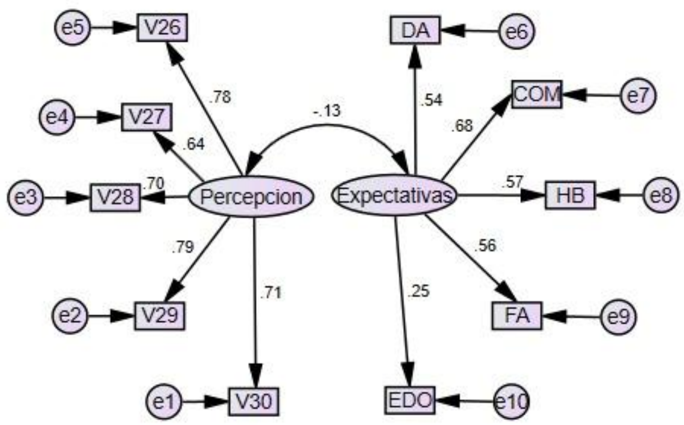
For its part, the construct of expectations was structured in five dimensions: Academic Development (AD), Competencies (COM), Soft Skills (HS), Academic Training (AF) and Teaching Experience and Optimization (EDO), with standardized coefficients that varied between 0.25 and 0.68. These results reflect that expectations integrate both the acquisition of technical knowledge and the development of transversal competencies and the interaction with teachers with professional experience, although the EDO dimension presented a moderate contribution ($\lambda = 0.247$), which suggests a lower relative weight within the model.

The structural model fit was assessed using various goodness-of-fit indices, which indicated an adequate fit ($\chi^2 = 52.844$, df = 34, p = .021; χ^2/ df = 1.554; CFI = 0.920; TLI = 0.870; RMSEA = 0.051, 90% CI [.021, .077]; PCLOSE = 0.436), according to the criteria established in the specialized literature. All reported coefficients correspond to standardized values, which facilitates their interpretation.

The relationship between the two constructs shows a negative and non-significant coefficient ($r = -.13$, $p = .431$), suggesting that students' perceptions do not always align with the initial expectations set at the beginning of their training. This finding is relevant, as it indicates a gap between what is expected and what is experienced, possibly explained by factors such as the availability of resources, the updating of content, and practical opportunities throughout their studies.

The model confirms that, although students perceive significant progress in key areas such as analytical skills, problem-solving, and soft skills, these perceptions do not fully meet initial expectations. This discrepancy highlights the need to strengthen the relevance of academic programs, ensuring greater alignment between what students expect to receive and what they actually experience throughout their educational journey.

Figure 1. SEM model of the relationships between dimensions of expectations and perception



Source: Prepared by the author based on data from surveys applied to Industrial Engineering students of the National Technological Institute of Mexico/Technological Institute of Morelia.

The contrast between the expectations and perceptions of Industrial Engineering students reveals both significant points of agreement and disagreement regarding their training. On the one hand, the results show a convergence in the importance attributed to technological updates, practical experiences, and the development of socio-emotional skills. In both cases, students recognize that these elements are fundamental for achieving a comprehensive and competitive education in the job market. However, the structural model reveals a gap between expectations and perceptions, reflected in a negative coefficient (-.13) between the two constructs. This indicates that final perceptions do not always meet initial expectations, which could be explained by limitations in areas such as the updating of teaching materials, the heterogeneity of teaching experience, and the lack of practical experiences that link theory and industrial practice.

These findings have direct implications for higher education institutions. First, it is necessary to strengthen the relevance of academic programs, ensuring that curricula remain aligned with the demands of the productive sector and global trends. Second, it is recommended to increase opportunities for practical training through internships, impactful projects, and updated laboratories that allow students to consolidate their technical skills in real-world settings. Finally, it is a priority to promote faculty development programs that guarantee the incorporation of professional experience into teaching, fostering a stronger connection between theory and practice.

The comparison between expectations and perceptions reinforces the need to conceive of Industrial Engineering education as a dynamic and comprehensive process, one that integrates academic excellence, practical experience, socio-emotional development, and continuous professional development. Only in this way will it be possible to respond effectively to the demands of the labor market and ensure that student expectations translate into positive and satisfying perceptions by the end of their academic journey.

Discussion

The results of this study confirm the initial hypothesis by revealing a significant gap between the expectations that Industrial Engineering students have upon entering the National Technological Institute of Mexico/Technological Institute of Morelia, and the perceptions they develop upon graduation. The negative coefficient obtained in the SEM model (-.13) shows that, although final perceptions are mostly positive, they do not fully meet initial expectations. This finding suggests that educational experiences, available resources, and opportunities for practical application do not always satisfy the aspirations that students project at the beginning of their studies. The research question posed at the end of the introduction is thus answered directly: final perceptions differ from expectations, and this difference is mediated by academic and practical factors such as curriculum updates, teaching experience, and infrastructure availability.

These results are consistent with those reported by Sánchez et al. (2022) and Rojas and López (2019), who documented similar gaps between acquired skills and labor market demands in other Mexican institutions. They also align with the recommendations of the OECD (2015) and UNESCO (2014) regarding the need to integrate practical experiences and strengthen the relevance of academic programs to improve employability. However, the students' emphasis on soft skills—leadership, stress management, and effective communication—expands upon the findings of previous studies that focused primarily on technical skills (Berry, 1988; Ishikawa, 1988). This finding reinforces recent trends that consider socio-emotional skills as key determinants of professional performance in globalized and dynamic environments.

Nevertheless, some positive perceptions, such as the recognition of teaching quality and the appreciation of industry visits, suggest significant progress in the program. These points of convergence with previous studies show that institutional efforts have succeeded in generating meaningful learning and relevant connections between theory and practice. However, the shortcomings identified by students regarding updated course materials, applied practices, and teacher consistency highlight areas where institutions must take action to align their training processes with the demands of the productive sector.

Among the study's limitations is its focus on a single academic program, which restricts the generalizability of the results to other contexts. Furthermore, the cross-sectional design and the use of self-administered surveys could have introduced social desirability bias or errors in item interpretation. Despite these limitations, the use of structural equation modeling (SEM) provided a comprehensive and robust view of the relationships between latent and observed variables, offering a more in-depth analysis than traditional descriptive approaches.

Taken together, the findings offer valuable empirical evidence to guide curriculum improvement and institutional strategies. They suggest that universities should diversify practical experiences, continuously update their teaching materials, and strengthen faculty development by incorporating professionals with industry experience to enrich the educational process. Furthermore, they highlight the importance of considering the development of socio-emotional competencies as a central focus in engineering education, aligning student expectations with the real demands of the labor market. These results, when compared with previously published data, confirm global trends and provide a replicable basis for future research in other disciplines and higher education institutions. In line with recent studies on educational innovation based on structural models (Zhou & Chen, 2024), the results of this work reinforce the importance of updating learning methodologies and environments to strengthen educational quality and student satisfaction.

Conclusions

The results of this study allow us to conclude that Industrial Engineering education should be conceived as a comprehensive process that integrates academic development, the acquisition of technical skills, the strengthening of socio-emotional abilities, and the incorporation of meaningful practical experiences. The analysis of expectations and perceptions reveals a consensus regarding the relevance of technology, industrial visits, and personal development; however, it also reveals a gap between expectations and perceptions, suggesting the need to improve the coherence between curriculum, institutional resources, and educational experiences.

The structural equation modeling (SEM) applied revealed a notable shift in student valuation: while initial expectations focused on acquiring technical skills and mastering professional tools, final perceptions show a growing recognition of socio-emotional competencies—leadership, effective communication, teamwork, and stress management—as essential factors for professional performance. This evolution reflects a change in the educational paradigm and aligns with the recommendations of the OECD (2015) and UNESCO (2014), which emphasize the need to integrate transversal skills into higher education to meet the challenges of a globalized and constantly evolving environment.

The study's findings highlight the importance of updating teaching materials, diversifying practical experiences, and consolidating teacher training based on professional experience. Promoting a balance between technical and socio-emotional skills will not only improve graduate employability but also train engineers capable of responding creatively, with leadership, and with resilience to the demands of the contemporary labor market. Thus, this study provides empirical evidence supporting the transformation of Industrial Engineering education toward a more humanistic, collaborative, and adaptive approach, solidifying educational quality and relevance as pillars for continuous institutional improvement.

Future lines of research

Based on the findings and limitations identified in this study, several avenues emerge that could deepen and broaden the analysis of educational quality in Industrial Engineering and other higher education programs. First, it is recommended that the study be replicated across the different educational programs at the Morelia Institute of Technology to determine if the observed behavior is consistent throughout the institution. This intra-institutional comparison would allow for the identification of specific strengths and areas for improvement for each academic program.

A second line of research would be to extend the study to other institutions, regions, or disciplinary areas to determine whether the gaps between expectations and perceptions represent a widespread phenomenon or are due to specific contextual factors. This comparative approach would offer a broader view of the regional, institutional, or cultural factors that influence student satisfaction and the relevance of educational programs.

Another important direction involves designing longitudinal studies that follow the same students from enrollment until after graduation. This approach would allow researchers to observe the individual evolution of their perceptions, identify critical moments when discrepancies arise, and evaluate the impact of specific interventions, such as curriculum reforms or teacher development programs.

Furthermore, it is necessary to delve deeper into the analysis of the role of socio-emotional skills and their relationship to employability. Future research could incorporate qualitative methodologies—such as in-depth interviews or focus groups—to capture the subjective experiences of students and graduates. It would also be valuable to link these perceptions with data on professional performance, employer feedback, and labor market trends, establishing direct relationships between the training received and outcomes in the workplace.

Finally, the use of advanced analytical techniques, such as multigroup structural equation modeling or mediation and moderation analysis, would allow researchers to explore how variables like gender, academic background, or prior work experience modulate the relationship between expectations, perceptions, and satisfaction. These lines of research would contribute to a more comprehensive understanding of educational quality and the formulation of more effective institutional policies and strategies.

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