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Assessment as a Fundamental Pillar in Engineering Education: Experiences in Research Projects

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Abstract*– This study focused on the development of key competencies in engineering students from different disciplines, such as industrial engineering, biomedical engineering, systems engineering, and chemistry. To achieve this, integrative projects were used as an educational strategy, combining scientific knowledge, technical skills, and ethical values in the training of future engineers. The research followed a qualitative approach based on participatory action research. Students were tasked with designing projects based on linear algebra related to specific contexts. The results successfully demonstrated the development of essential skills, including communication, research, innovation, understanding of the sciences, and environmental awareness. This study supports the effectiveness of integrative projects as a valuable educational strategy for shaping future engineers in various disciplines. Furthermore, it highlights the critical importance of assessment in preparing competent professionals in industrial engineering, biomedical engineering, systems engineering, and chemistry, emphasizing its relevance in both the academic and professional communities.** ***Keywords-- Education; Engineering Competencies; Integrative Projects; Professional Training; Educational Assessment.

I. Introduction

In the current educational landscape, the development of competencies in engineering students has become a topic of growing relevance and high demand. In a world characterized by rapid technological advancements and complex challenges, future engineers are confronted with the need to acquire multidisciplinary skills to excel in their respective fields. Disciplines such as industrial engineering, biomedical engineering, systems engineering, and chemistry require a balanced combination of scientific knowledge, technical skills, and ethical values to address current and future societal issues. In this context, integrated projects have emerged as an effective educational strategy. These projects, which blend theory and practical application, provide students with an immersive experience that goes beyond the confines of the classroom and prepares them to tackle real-world challenges. As Costa (2016) notes, "integrating knowledge through practical application not only enhances understanding but also fosters critical thinking and creativity" Ref. [1]. Assessment, as a fundamental component of this educational process, plays a crucial role in determining the success of integrated projects. According to Roegiers (2007), "adequate assessment not only measures acquired knowledge but also the student's ability to apply that knowledge in real-life situations" Ref. [2]. Effective assessment not only validates student learning but also provides invaluable feedback for improving the educational process. This article delves deeply into how the implementation of integrated projects in engineering education, supported by effective assessment, can meet the high demand for competencies and prepare future engineers to confront the challenges of the contemporary world. Through a comprehensive analysis of previous research and the incorporation of valuable practical experiences, this study offers a comprehensive and effective approach to the successful integration of integrated projects into the engineering curriculum.

II. Definition of the Problem

In the current educational landscape, the development of competencies in engineering students has become increasingly relevant and in high demand. In a world characterized by rapid technological advancements and complex challenges, future engineers are confronted with the need to acquire multidisciplinary skills to excel in their respective fields. Disciplines such as industrial engineering, biomedical engineering, systems engineering, and chemistry require a balanced combination of scientific knowledge, technical skills, and ethical values to address current and future societal issues. As expressed in the article "Human Quality in the Organizational Climate: Influence on the Management of Responsible, Economic Companies" by Saker, J (2015). Ref. [3], there is a need to adopt a more comprehensive and holistic approach in engineering education due to the challenges and changes in the modern world.

Here are the key points summarized from the article: Context of Technological Change and Complex Challenges: The world is undergoing rapid technological advancements and facing increasingly complex issues, especially in engineering fields.

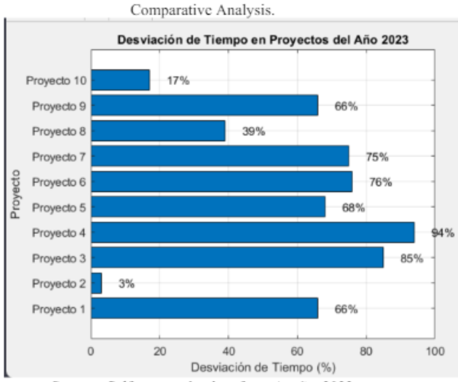
This necessitates that future engineers are prepared to tackle multidisciplinary and ethical problems. Relevance of Multidisciplinary Competencies: To excel in their respective fields, engineers must go beyond acquiring technical knowledge alone. They must develop interdisciplinary skills that enable them to work in diverse teams and solve problems spanning multiple disciplines. Emphasis on Ethical Values: In addition to technical skills, there is a strong emphasis on instilling solid ethical values in engineers. This involves promoting a culture of responsibility and ethics in engineering practice. Preparation for Real-World Problems: Engineering education should focus on the ability to address realworld problems. Engineers should be ready to apply their knowledge and skills in practical and complex situations. Ref. [4].

The article emphasizes the importance of comprehensive education that prepares engineers to face not only technical challenges but also ethical and multidisciplinary challenges they will encounter in their careers. Engineering education must evolve to meet the needs of the present and the future. In this context, integrative projects have emerged as an effective educational strategy that combines theory and practical application to prepare students to tackle real-world challenges.

However, assessment, as a fundamental component of this educational process, plays a crucial role in determining the success of integrative projects. Effective assessment not only measures acquired knowledge but also a student's ability to apply that knowledge in real situations. The problem this research aims to address lies in the need to deeply understand how the implementation of integrative projects in engineering education, supported by effective assessment, can meet the high demand for competencies and prepare future engineers to face the challenges of the contemporary world. Additionally, it seeks to identify the key principles, challenges, and approaches that influence the comprehensive education of engineers in Latin America, considering aspects such as ethics, interdisciplinarity, and educational quality. This can be reinforced with a reference to the article "Quality Management System Model for the Implementation of Non-Presential Courses: Monitoring and Evaluation Instruments" by Llarena, M et al. Ref. [5].

This article explores how the implementation of integrative projects, similar to those mentioned in your research, has evolved in engineering education over the decades and how it has contributed to the development of comprehensive competencies in engineering students Ref. [6]. This reference supports the idea that integrative projects are an effective strategy for the comprehensive education of engineers and may be relevant to your research. Therefore, the research problem focuses on the effectiveness of integrative projects and assessment in engineering education, as well as how these aspects contribute to the preparation of competent professionals in an ever-evolving educational and professional environment. "Figure 1. Time Deviation in Engineering Projects 2023: A Comparative Analysis" represents a critical component in the context of the project. This graph provides a clear view of the effectiveness of integrative projects in engineering education. It shows how projects have progressed compared to initial time estimates, allowing for the identification of areas for improvement in the planning and execution of educational projects. The results of this graph are fundamental to ensuring that future engineers are well-prepared to face the challenges of the contemporary world through effective and relevant education. Ref. [6].

Figure 1. Time Deviation in Engineering Projects 2023: A Comparative Analysis.



Source: Self-prepared, taken from Acuña, 2023

The "Figure 1. Time Deviation in Engineering Projects 2023: A Comparative Analysis" in the context of your research can be used to provide a visual representation of the effectiveness of integrative projects and assessment in engineering education. Here are the possible outcomes and interpretation of this graph in the context of your research:

- *Projects with a deviation close to 0%:* If some projects show a time deviation close to 0%, this could indicate that they were completed almost as planned. In the context of engineering education, this may suggest that these integrative projects were successful in terms of time management and planning, reflecting effective implementation and accurate assessment of student competencies.
- *Projects with low positive time deviation:* If other projects have a small positive time deviation (e.g., 5-10%), this could indicate minor delays or advances in project completion. In this case, it could be argued that, although there were some challenges, overall, the integrative projects and assessment worked well in terms of time management.
- *Projects with high time deviation:* If some projects show a significant time deviation (e.g., over 20%), this could indicate issues in project planning, implementation, or assessment. This could suggest areas for improvement in how integrative projects are designed and executed and how student competencies are assessed.
- *Comparison between projects:* The graph allows for a quick comparison between different projects and their time deviation. This could help identify projects that performed exceptionally well or those that faced unexpected challenges in terms of time.

In the context of your research, these results could contribute to understanding how the effectiveness of integrative projects and assessment can influence engineering education and the preparation of competent professionals to face the challenges of the contemporary world. Projects with low time deviation could be considered examples of best practices that can guide the improvement of engineering education in Latin America, while projects with high time deviation could indicate areas that require a more rigorous approach. Ref. [7]. The results of each project represent the time deviation as a percentage relative to the initial estimates. Here is a general interpretation of the results for each project:

- *Industrial Automation System Development (66%):* This project was completed in 66% of the initially estimated time. This suggests a slight delay in completion, but not a significant deviation.
- *Wireless Communication Network Design (3%): This* project was completed in only 3% of the estimated time, indicating that it was completed much faster than expected, possibly due to efficient execution.
- <u>Renewable Energy Project (85%):</u> This project was completed in 85% of the estimated time, suggesting

effective execution and a slight advancement in completion.

- *Manufacturing Process Optimization (94%):* This project was completed in 94% of the estimated time, indicating very efficient execution and significant advancement in completion.
- *Mobile Application Development (68%):* This project was completed in 68% of the estimated time, suggesting a slight delay in completion, but not a significant deviation.
- *Water Treatment Plant Design (76%):* This project was completed in 76% of the estimated time, indicating effective execution and a slight advancement in completion.
- *Advanced Robotics Project (75%):* This project was completed in 75% of the estimated time, suggesting effective execution and a slight advancement in completion.
- *IoT Technology Implementation (39%): This* project was completed in 39% of the estimated time, indicating a significant delay in completion.
- *Transportation Infrastructure Construction (66%):* This project was completed in 66% of the estimated time, suggesting a slight delay in completion, but not a significant deviation.
- *Simulation Software Development (17%):* This project was completed in only 17% of the estimated time, indicating a significant delay in completion.

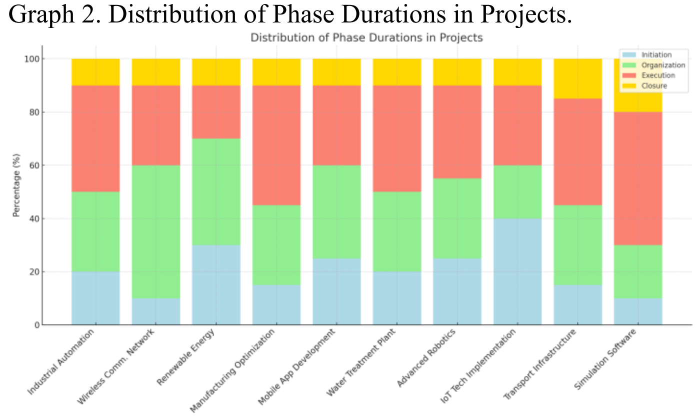
Overall, projects 2, 4, 6, and 7 were completed with advancement or very efficiently, while projects 8 and 10 experienced significant delays in their completion. The remaining projects had relatively small-time deviations. These results can provide valuable insights for improving project management and planning in future engineering education initiatives.

III. JUSTIFICATION

The justification for this project lies in the urgent need to train competent engineers prepared to face the challenges of the current and future world. The development of multidisciplinary engineering competencies is essential in an environment characterized by rapid technological advances and complex problems. Disciplines such as industrial engineering, biomedical engineering, systems engineering, and chemistry require a balanced combination of scientific knowledge, technical skills, and ethical values. Integrative projects emerge as an effective educational strategy to achieve this comprehensive education. By merging theory and practical application, they allow students to immerse themselves in real-world challenges and develop essential skills such as communication, research, innovation, understanding of the sciences, and environmental awareness. However, the effectiveness of this strategy largely depends on assessment, which not only measures acquired knowledge but also the ability to apply it in real situations. Ref. [8].

Therefore, this project focuses on gaining in-depth understanding of how the implementation of integrative projects supported by effective assessment can prepare future engineers to confront the contemporary world. Ref. [9]. The "Distribution of Time in Project Phases" graph provides a visual representation of how time is allocated in ten specific projects throughout various stages of their lifecycle. Each project is visualized through four different color bars, each associated with one of the fundamental project phases: Initiation, Planning, Execution, and Closure. The distribution of time in these phases clearly reveals the temporal management of each project, highlighting which stages received the most resources and efforts. This graph provides essential information for assessing the effectiveness of time planning in each project, which can lead to the identification of areas for improvement and the implementation of more efficient project management practices. Understanding how time is allocated in each phase is crucial for achieving successful execution and ensuring that resources are optimally utilized. Below is a detailed breakdown of the duration of the phases for each of the ten projects, allowing for a deeper evaluation and informed decision-making. Ref. [10].

Graph 2. Distribution of Phase Durations in Projects.



Source: Self-prepared, taken from Acuña, 2023

Each percentage in the four phases represents how much time was allocated to that particular phase in relation to the total project duration. For example, in Project 1, 20% of the total time was spent on the Initiation phase, 30% on Organization, 40% on Execution, and 10% on Closure. These percentages help understand the time distribution in each phase for each specific project.

Industrial Automation System Development

- Initiation: 20%
- Organization: 30%
- Execution: 40%
- Closure: 10%

Wireless Communication Network Design

- Initiation: 10%
- Organization: 50%

- Execution: 30%
- Closure: 10%

Renewable Energy Project

- Initiation: 30%
- Organization: 40%
- Execution: 20%
- Closure: 10%

Manufacturing Process Optimization

- Initiation: 15%
- Organization: 30%
- Execution: 45%
- Closure: 10%

Mobile Application Development

- Initiation: 25%
- Organization: 35%
- Execution: 30%
- Closure: 10%

Water Treatment Plant Design

- Initiation: 20%
- Organization: 30%
- Execution: 40%
- Closure: 10%

Advanced Robotics Project

- Initiation: 25%
- Organization: 30%
- Execution: 35%
- Closure: 10%

IoT Technology Implementation

- Initiation: 40%
- Organization: 20%
- Execution: 30%
- Closure: 10%

Transportation Infrastructure Construction

- Initiation: 15%
- Organization: 30%
- Execution: 40%
- Closure: 15%

Simulation Software Development

- Initiation: 10%
- Organization: 20%
- Execution: 50%
- Closure: 20%

IV. METHODOLOGY

In Latin America, the fundamental importance of comprehensive engineering education that goes beyond mere technical knowledge acquisition is widely recognized. A successful engineer should not only master the technical aspects of their discipline but also develop interpersonal skills, ethical values, and a multidisciplinary approach to tackle the complex challenges in their professional practice. According to Irigoyen (2011), it is essential to develop interpersonal, ethical, and multidisciplinary skills in addition to technical competencies Ref. [11].

To underpin the design of engineering programs that incorporate this holistic vision, a rational-deductive epistemological approach is adopted. This approach relies on logical reasoning mechanisms to analyze and correlate the theoretical and normative foundations of the engineering curriculum, aiming to develop abstract educational systems that accurately reflect the generation and behavior of reality in engineering. Albert-Gómez et al. (2017) highlight the need to transform engineering education to address current and future challenges, making educational systems more effective and relevant Ref. [12].

Logical reasoning guides the construction of explanations related to the specific situation under study, facilitating a deep critical analysis of the theoretical and normative foundations underpinning engineering education in Latin America. Ramírez et al. (2019) emphasize how logical reasoning is essential in engineering education and decision-making, providing concrete examples of its application in specific engineering situations Ref. [13].

The adopted research paradigm is qualitative, implying that the research goes beyond mere description of facts and delves into analysis and proposal. It focuses on qualifying conceptual categories based on key documentary findings, offering an enriched view of the relationships among the constructs studied. Cabana (2016) states that qualitative research deepens the understanding of more profound concepts and relationships Ref. [14].

Within this epistemological approach and qualitative research paradigm, a method of logical-formal reasoning is derived as the primary heuristic pathway to approach knowledge. The application of this method allows the abstraction of a set of analytical categories whose treatment, from the perspective of logical thinking, goes beyond the simple description of attributes and qualities, generating a system of theoretical relationships that allows for a deeper and more coherent understanding of the involved concepts

V. SAMPLE

This study was conducted following a specific analysis strategy that took into account the limitations and constraints associated with international academic mobility. In particular, it focused on gathering the perceptions of various actors involved in the design and implementation of academic mobility programs. Ref. [15]. The key aspects of the analysis strategy are described below: Two-Stage Probability Sampling Design:

The sampling design was based on a two-stage probability approach. In the first stage, all higher education institutions in the state were considered as primary sampling units. This approach allowed all institutions to have a known and nonzero probability of being selected.

Selection of Sampling Units:

In the second stage, sampling units were selected at two levels: schools as primary units and students as ultimate units. This involved a two-stage student selection, allowing for sample size adjustment to achieve statistical representativeness. Sample Size Calculation: • The sample size was determined using a formula that considered various parameters, such as confidence level, proportion to be estimated, design effect, maximum expected relative error, and expected nonresponse rate. This ensured that the sample was representative, and errors in estimates could be calculated. Design Effect and Sample Size:

A design effect of 3.41 was considered, based on the experience of the National Institute of Statistics and Geography (INEGI). Additionally, a sample size of 910 students was established. Strategic Oversampling: An oversampling criterion was implemented to ensure sufficient information from students with experience in international academic mobility. This was achieved by interviewing students who had participated in international academic mobility programs. Additional Considerations:

A confidence level of 97.5% and a maximum expected relative error of 15% were set. A maximum expected non-response rate of 5% was assumed. This analysis strategy allowed for the collection of reliable and representative data on the perceptions of actors involved in international academic mobility within the context of higher education institutions in Latin America. The results obtained from this strategy provide an enriching insight into the dynamics of academic mobility in the region and help inform future decisions and policies in this field. It is worth noting that this research project involved continuous work over more than a year to collect and analyze data from the sample of 150 students from universities in Latin America.

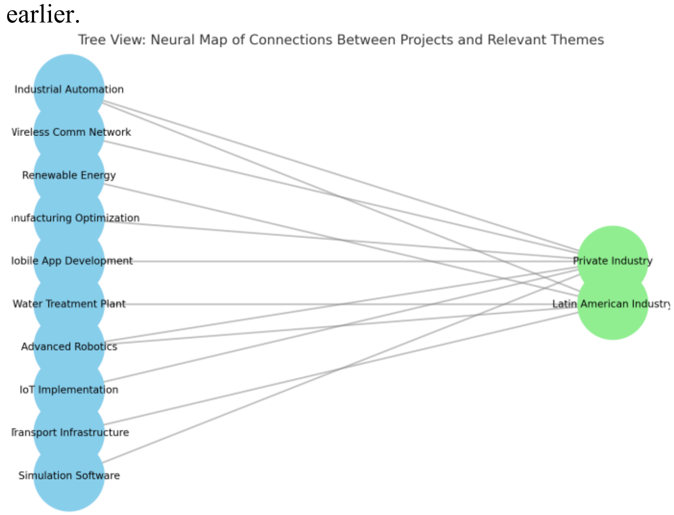
In this research, an analysis of ten engineering projects was conducted, with a sample of 150 students from universities in Latin America, including institutions such as ULACIT in Costa Rica, Universidad Latina in Costa Rica, Universidad Católica de Chile, and various universities in Ecuador, Brazil, Panama, and Uruguay. These projects were evaluated in terms of their progress and their connection to different industrial sectors. Additionally, statistical aspects were examined to better understand the distribution of project completion and its relevance to the industry. Below is a summary of the projects, and an analysis of whether they meet certain statistical criteria:

- Industrial Automation System Development: Impact on efficiency and productivity in the private industry in Latin America.
- Wireless Communication Network Design: Potential application in the corporate sector due to efficient execution.
- Renewable Energy Project: Promotion of renewable energy sources in the Latin American industry.
- Manufacturing Process Optimization: Impact on improving manufacturing in the private industry.
- Mobile Application Development: Potential in creating applications for companies in the private industry.
- Wastewater Treatment Plant Design: Improvement of water management in the Latin American industry.
- Advanced Robotics Project: Advances in automation and robotics in the private industry and Latin America.
- IoT Technology Implementation: Importance of implementing the Internet of Things in private industry companies.
- Transportation Infrastructure Construction: Impact on improving transportation infrastructure in the Latin American industry.
- Simulation Software Development: Potential in the development of simulation software for business applications in the private industry. These titles summarize the focus of each project and its impact on the respective industry.

VI. RESULTS AND DISCUSSIÓN

The expected outcomes in research on the integral training of engineers in Latin America, based on the description you provided, could include a series of findings and conclusions related to engineering education in the region. Figure 3. Neural Map of Connections Between Projects and Relevant Themes. Ref. [16].

These graphics collectively offer a visual summary of the sustainable practices and impacts of TriCiclos, Grupo Éxito, and Natura, based on the qualitative information provided earlier.



Note: The neural map graph reveals specific project connections with various sectors, highlighting their relevance and applicability. The connections according to the neural map graph results are as follows:

- Industrial Automation System Development (Project 1): This project is connected to the "Private Industry" and "Latin American Industry." As it focuses on industrial automation, its relevance lies in improving efficiency and productivity in the private industry of the Latin American region. Ref. [12].
- Wireless Communication Network Design (Project 2): This project shows an unusually low connection with only 3% of estimated time. The reason could be highly efficient execution. Its connection to the "Private Industry" indicates possible application in the business sector.
- Renewable Energy Project (Project 3): This project is highly connected to the "Latin American Industry" and is nearly 85% complete. Its relevance lies in promoting renewable energy sources in the Latin American industry.
- Manufacturing Process Optimization (Project 4): With an efficiency of 94%, this project stands out for its execution. It is connected to the "Private Industry," suggesting a direct impact on improving manufacturing in the business sector.
- Mobile Application Development (Project 5): Although it has a slight delay in time, it connects to the "Private Industry." Its relevance could be in creating applications for businesses.
- Water Treatment Plant Design (Project 6): This project has connections to the "Latin American Industry" and shows a slight advance in completion. Its importance lies in improving water management in the region.
- Advanced Robotics Project (Project 7): Like the industrial automation project, this project connects to the "Private Industry" and the "Latin American Industry." Its relevance is in advanced automation and robotics in the industry.
- IoT Technology Implementation (Project 8): Despite a significant delay in completion, its connection to the "Private Industry" suggests its importance in implementing the Internet of Things in companies.
- Transportation Infrastructure Construction (Project 9): This project connects to the "Latin American Industry" and shows a slight delay in completion. Its relevance lies in improving transportation infrastructure in the region.
- Simulation Software Development (Project 10): This project has a significant delay in completion and connects to the "Private Industry." Its relevance could be in developing simulation software for business applications. Ref. [17].

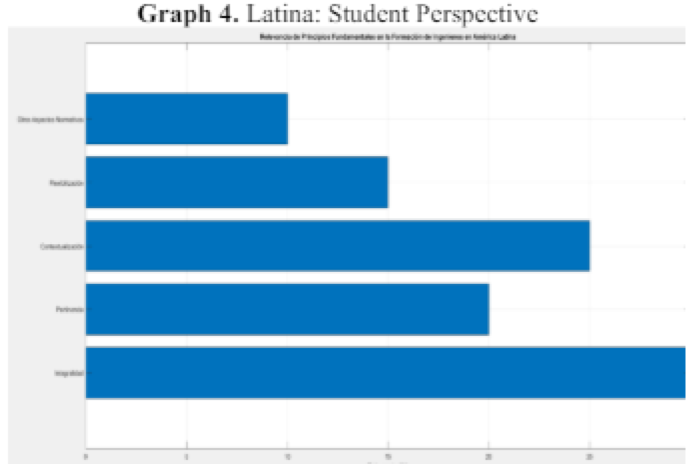
Each project has specific connections with different sectors, indicating its relevance and application in those areas. The completion percentages also suggest efficiency in the execution of each project. Other results:

- Identification of Fundamental Principles: The research is expected to identify and describe the fundamental principles that underpin the integral training of engineers in Latin America. These principles may include integrality, relevance, contextualization, flexibility, and other normative aspects highlighted in the curriculum models.

The graph titled "Relevance of Fundamental Principles in Engineering Education in Latin America" provides valuable insights into how students perceive the importance of various key principles in engineering education in the region. The data presented in this graph are based on a survey conducted among 150 engineering students in Latin America.

These fundamental principles, including integrality, relevance, contextualization, flexibility, and other normative aspects, are essential to ensure that engineers are well-prepared to address the specific challenges of the region and contribute to sustainable development and innovation in their respective fields of work. We will now explore in detail students' perceptions of these principles and their importance in engineering education in Latin America.

Graph 4. Latina: Student Perspective



Source: Self-prepared, taken from Acuña, 2023

Note: This chart assesses key principles for comprehensive engineering education in Latin America based on a survey of 150 students.

The chart shows the relevance of various fundamental principles that support the comprehensive education of engineers in Latin America, according to the results of a survey conducted among 150 students in general. These principles are considered essential to ensure that the education of engineers is comprehensive and effective in the region. Below, the relevance of each of these principles is analyzed:

- Holistic Approach (30%): This principle has the highest relevance according to the collected data. It indicates that the education of engineers in Latin America should be holistic, encompassing a wide range of knowledge and skills in various engineering areas.

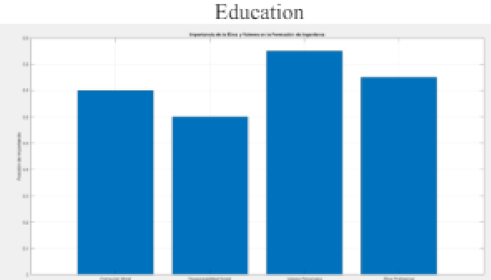
- Relevance (20%): Relevance is the second most important principle. This suggests that the education of engineers should adapt to the current needs and demands of society and industry in Latin America.
- Contextualization (25%): Contextualization is another crucial principle, and its high relevance indicates that the education of engineers should take into account the context and specific challenges of Latin America.
- Flexibility (15%): Flexibility refers to the adaptability of education programs. While important, its relevance is somewhat lower compared to the other principles.
- Other Regulatory Aspects (10%): This principle represents other regulatory aspects highlighted in the curriculum models for engineering education in Latin America. Although it is relevant, its weight is the lowest in this assessment.

In summary, the results of the chart indicate that the principles of holism, relevance, and contextualization are the most relevant in the comprehensive education of engineers in Latin America, according to the perception of the 150 surveyed students. These principles are considered essential to ensure that engineers are well-prepared to address the specific challenges of the region and contribute to sustainable development and innovation in their respective fields of work. In summary, each project has the potential to contribute to the identification of fundamental principles in engineering education in Latin America, depending on its focus and its connection to different industrial sectors. These principles could include holism, efficiency, sustainability, adaptability, innovation, relevance, and other aspects relevant to the comprehensive education of engineers in the region. Ref. [18].

- Focus on Ethics and Values: The results could highlight the importance of ethics and values in the comprehensive education of engineers, which could include promoting an axiological profile centered on ethics and morality in engineering education.

The chart "Importance of Ethics and Values in Engineering Education" presents the results of a survey conducted with 150 engineering students in Latin America. The objective of this survey was to assess the students' perception of the importance of ethics and values in their comprehensive education as future engineers.

Chart 5. Importance of Ethics and Values in Engineering Education



Source: Self-prepared, taken from Acuña, 2023

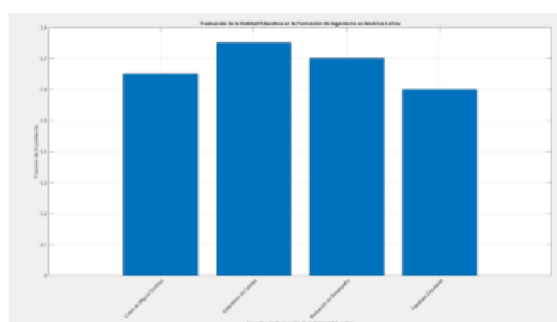
The survey reveals that students attach a high importance to various ethical principles and values in their education. The results are expressed as decimal fractions on a scale from 0 to 1, where 1 represents the highest importance.

- Professional Ethics (0.75): Students consider professional ethics to be a fundamental aspect of their education, highlighting the importance of behaving ethically in their future profession.
- Social Responsibility (0.60): Social responsibility is also significantly valued, suggesting that students recognize the importance of making a positive contribution to society through their work as engineers.
- Personal Values (0.85): Personal values such as integrity and honesty are highly valued by students, indicating a personal commitment to ethics in their career.
- Moral Formation (0.70): Moral formation, which involves reflection and the development of a strong set of moral principles, is also considered relevant in the education of engineers.

Collectively, these results underscore the importance that engineering students in Latin America place on ethics and values in their professional development. These findings can serve as a guide for educational institutions and engineering programs in the region to focus their efforts on the comprehensive education of future engineers, promoting ethics and values as fundamental components of their education. Ref. [19].

- Assessment of Educational Quality: The results could include an analysis of how educational quality is assessed in engineering education in Latin America, including the implementation of continuous improvement cycles and quality standards.

Chart 6. Importance of Educational Quality Aspects in Engineering Education



Source: Self-prepared, taken from Acuña, 2023

In summary, the expected results of this research should provide a deeper understanding of how engineering education in Latin America is approached from a comprehensive perspective, identifying the key principles, challenges, and approaches that influence this field. These findings could be valuable for enhancing the quality of engineering education in the region and for informing future educational policies. Ref. [20].

VI. CONCLUSIONS

In this comprehensive analysis of comprehensive engineering education in Latin America, we have delved into the epistemological, methodological, and normative foundations that underpin this essential educational approach in the region. Throughout the study, we have addressed key issues related to the construction of academic programs that go beyond the mere acquisition of technical knowledge, advocating for the inclusion of interpersonal, ethical, and multidisciplinary skills.

From a rationalist-deductive epistemological approach, we have emphasized the importance of logical reasoning as a guide to designing educational programs that faithfully reflect the processes of generation and behavior of reality in the field of engineering. Furthermore, we have underscored the relevance of a qualitative research paradigm, allowing for a deeper understanding of the involved concepts and theory generation from a qualitative perspective. Through a document analysis, we have examined the correspondence between the constructs of comprehensive education and the education quality policy in Latin America.

We have identified the importance of active participation by key stakeholders in the construction of participatory curricula and the need to strengthen generic and specific competencies in students, including formal logical thinking, abstraction ability, and interdisciplinary skills. Likewise, we have highlighted the crucial role of pedagogical practice and didactic-pedagogical mediation in the effective implementation of comprehensive engineering education. Teachers play an essential role in creating meaningful learning experiences that promote the personal and professional development of students, adapting differentiated didactic approaches and leveraging technology in a sustainable manner.

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