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CRITICAL ASPECTS IN THE FORMULATION OF THESIS PROJECTS IN CONTEMPORARY INDUSTRIAL ENGINEERING

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Research Paper

***Abstract**: The aim of the study was to identify the key components to formulate a thesis project in industrial engineering to address current challenges from a perspective that responds to the demands of sustainability and global development outlined by the Sustainable Development Goals (SDGs). This is achieved through an exhaustive review of the literature and interviews directed at both mentors and students, investigating the main potential elements of improvement in the formulation of thesis proposals, based on the ODS. 5 important sections were taken into account for the thesis project: topic, introduction, justification, literature review and methodology. Each of these had relevant criteria to write the project. In short, the formulation of a thesis project in Industrial Engineering emerges as a multifaceted effort that requires rigorous attention to several components. Adequate groundwork, mentoring and training in research methods are vital elements in addressing these challenges and ensuring superior quality in thesis proposals. This study should not only be considered for industrial engineering, it can be used as a basis for other areas such as: civil*

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1. Introduction

In the realm of contemporary engineering, thesis project formulation plays an indispensable role in the training of future professionals and in the generation of innovative knowledge. Thesis projects not only represent a pinnacle in the educational process but also have a pivotal role in probing and addressing the intricate challenges that the industry and society face today. The proficiency to effectively tackle critical aspects in formulating these projects becomes a key determinant for the quality and relevance of the research conducted (Rabiei et al., 2021).

Modern industrial engineering operates in a dynamic and shifting environment, characterized by the confluence of technological advancements, economic trends, and continuously evolving societal demands (Bilge & Severengiz, 2019; Dastkhan & Owlia, 2009). In this backdrop, thesis project formulation gains strategic significance, as it not only mirrors students' capability to deploy their knowledge and skills but also impacts the trajectory of the discipline in response to present-day demands (Islam, 2019). In this context, aligning such projects with the Sustainable Development Goals (SDGs) has become a core concern (Muñoz-La Rivera et al., 2020). The SDGs, set by the United Nations (UN), outline an ambitious global agenda aiming to address cardinal challenges affecting both the planet and humanity at large.

Academic literature has acknowledged the importance of incorporating SDGs when designing research projects across various disciplines, including industrial engineering (Sánchez-Roncero et al., 2023). In the thesis project formulation process, several studies have underscored the need to address issues that directly impact the attainment of goals set by the UN (West, Syberg, & Deuse, 2021). This entails pinpointing key areas where industrial engineering can significantly contribute to advancing global sustainability (Ramirez-Mendoza et al., 2020).

Within the specific context of thesis proposal formulation in industrial engineering, emphasis has been placed on optimizing essential project components to ensure alignment with the SDGs (López, Espinilla, & Verdejo, 2023). Vital aspects such as the research topic, introduction, rationale, literature review, and methodology have been pinpointed as foundational pillars that should reflect an integrated and sustainable visión (Ali et al., 2023).

Incorporating SDGs into thesis project formulation not only means addressing current and upcoming issues but also involves considering the ethical and societal dimensions of the research (López et al., 2023). In this regard, the interplay between industrial engineering and the SDGs extends beyond merely applying techniques and methodologies (Arena et al., 2023). It's about adopting a mindset that promotes accountability and commitment to community well-being and the environment (Deuse, West, & Syberg, 2022).

As global concerns continue to evolve and as connections between worldwide challenges deepen, thesis project formulation in industrial engineering presents a unique opportunity to generate knowledge and solutions that cross disciplinary

boundaries V (Mendoza-Chacó et al., 2016; Muller, 2013; Rahimifard & Trollman, 2018). Embedding the SDGs in this practice results in a more holistic, outcome-driven approach with the potential to bring about positive impacts on society and the planet as a whole (Romero et al., 2023). This study seeks to identify key components in formulating an industrial engineering thesis project to tackle current challenges from a perspective responsive to the sustainability and global development demands delineated by the SDGs.

2. Metodholody

In this scientific paper, we propose a methodology that encompasses various stages to address critical aspects of thesis project formulation within the framework of contemporary industrial engineering (Paniura et al., 2023). This methodology draws upon document reviews and the conduct of interviews, facilitating a profound understanding of the challenges and opportunities influencing the quality and relevance of the thesis projects

2.1 Methodological Design:

The research design is anchored in a qualitative approach, aiming to explore the perceptions and experiences of various stakeholders engaged in the formulation of thesis projects in contemporary industrial engineering (Creswell & Creswell, 2017). Utilizing qualitative methods provides a rich and contextualized comprehension of the critical aspects discussed in this study.

2.2 Documents for Review:

The selection of documents for analysis in this scientific paper will be based on rigorous criteria intended to ensure the quality and pertinence of the referenced scientific literatura (Canales, Paucar, & Juipa, 2020). We will seek out master's and doctoral research thesis articles that possess a structure grounded in the scientific method and are explicitly in the domain of Industrial Engineering. Pertinent selection criteria include: theses from the last three years, theses that describe the methodology, rationale, and literature review. The selection process will be executed in various stages, detailed subsequently in Table 1.

Table 1: Thesis selection stages

Step	Description
Initial Search	Conduct a comprehensive search in Scopus using relevant keywords related to the topic.
Titles and Abstracts Review	Review titles and abstracts to identify articles focused on thesis formulation.
Introduction and Justification Analysis	Analyze how critical aspects are addressed in introduction and justification.
Methods Analysis	Examine methods sections to assess the rigor and suitability of used methods.
Identification of Relevant Articles	Select articles meeting criteria and addressing critical aspects.

Analysis and Synthesis	Perform exhaustive analysis and synthesis of selected articles.

Table 2: Theses included in the bibliometric review.

Authors	**Theses Title**
Jackson (2023)	Detecting Pathobiomes Using Machine Learning.
Tate (2023)	Lead Distribution Modeling for Supply Chains with a Large Number of Items.
Yang (2019)	Analytics driven decision support system to investigate the risk of non-index hospital readmission (Doctoral dissertation, Northeastern University Boston).
Wang (2018)	Detecting Cause of Readmission: A Big Data Analytics Approach (Doctoral dissertation, Northeastern University).
Barretto (2022)	Assessing the Influence of Health Policy and Population Mobility on COVID-19 Spread in Arkansas.
Bogyrbayeva (2021)	Optimization and Machine Learning Methods for Solving Combinatorial Problems in Urban Transportation (Doctoral dissertation)
Mahmoodian (2021)	Theory and Algorithms for Systems Optimization (Doctoral dissertation)
Dai (2020)	The Utilization of Shared Energy Storage in Energy Systems: Design, Modeling and Optimization.
Margolis (2021)	Optimization Models and Algorithms for Vehicle Routing and Target Surveillance (Doctoral dissertation)
Wang (2020)	Modeling and Analysis of Scheduling Problems Containing Renewable Energy Decisions (Doctoral dissertation)
Kaya (2023)	Operations research and analytics methods to improve equitable access to public services
Padhee (2023)	Dynamics of innovation in engineering design teams : complex network approach
Yu (2022)	Optimizing Traffic Evacuation during a Hurricane Storm Emergency (Doctoral dissertation)

2.3 Participants

For the interview, the target population of this study is made up of 25 research professors and industrial engineering advisors at universities and research centers in Latin America. The sample will be selected intentionally and will be governed by the following criteria:

2.4 Selection criteria:

- ✓ Experience in Thesis Advising: Participants must have at least five years of experience in advising and supervising thesis projects in the field of industrial engineering. This ensures that participants are familiar with the processes and challenges related to the formulation of thesis projects.
- ✓ Academic Level: Participants of different academic levels will be considered, including undergraduate and graduate thesis advisors. This allows us to explore

variations in the formulation of thesis projects in different educational contexts.

- ✓ Variety of Universities: The sample will include participants from at least three different universities in different Latin American countries. This ensures a diverse representation of approaches and practices in the formulation of thesis projects.
- ✓ Geographic Diversity: We will seek to include participants from different countries and regions of Latin America to address possible variations in the formulation of thesis projects according to the local context.
- ✓ Field of Specialization: Participants with different fields of specialization within industrial engineering will be considered, such as operations management, logistics, production and industrial systems.

In the analysis of the scientific documents collected, qualitative and quantitative analysis techniques will be used. Textual analysis software, such as NVivo, will be used to perform a content analysis of the relevant sections of the articles, such as introduction, justification, gaps and methods. The qualitative approach will allow the identification of thematic patterns and emerging trends in the way in which critical aspects are addressed in the formulation of thesis projects. Additionally, a quantitative analysis will be performed to quantify the frequency of approaches and techniques used in the selected articles.

For the analysis of the interviews, a qualitative content analysis approach will be applied. The recordings of the interviews will be transcribed and organized into thematic categories related to critical aspects, approaches, challenges and solutions in the formulation of thesis projects. Through coding and categorizing responses, recurring patterns will be identified and analyzed in depth to understand the perspectives and experiences of teacher researchers and advisors. Triangulation techniques will be used to compare the results of the interviews with the findings of the documentary analyzes and validate the coherence of the results. The information is presented in the table below:

Table 3: Steps for analysis of the interviews

Steps	Description
Transcription	Convert the recordings of the interviews into written format for easier analysis.
Thematic Organization	Organize transcribed data into thematic categories, focusing on aspects like critical aspects, approaches, challenges, and solutions in the formulation of thesis projects
Coding	Label the data to represent different themes or categories. This helps in identifying and analyzing recurring patterns.
Categorizing Responses	Sort the coded data based on similarities and patterns to group them under broader themes or categories.
Identify Patterns	Through the coded and categorized data, identify recurring themes or patterns to gain insights into the perspectives and experiences of teacher researchers and advisors.
Triangulation	Compare the results of the interviews with the findings of the documentary analyzes to validate the coherence and reliability of the results

In the research process, interviews will be carried out with research professors and engineering advisors with experience in formulating thesis projects. Participants will

be identified considering their experience and institutional diversity. After obtaining informed consent, interviews will be planned and conducted, exploring key topics such as critical aspects in thesis formulation, approaches, challenges and solutions. During interviews, detailed notes will be recorded and recording will be considered with the participant's permission for accurate analysis. Responses will be transcribed and analyzed thematically to identify patterns and trends. Confidentiality will be maintained and ethical principles will be followed. The results will contribute to an enriching understanding of how critical aspects are addressed in the formulation of thesis projects in contemporary industrial engineering.

3. Results

In this section, we present a consolidated summary of the findings obtained through the interviews conducted, as well as the key points extracted from the theses reviewed in the context of our study. This collection and analysis was carried out with the purpose of providing a clear and detailed understanding of the essential elements involved in the formulation of a thesis project in industrial engineering.

The results presented below are structured into five critical sections that are fundamental for the construction of the thesis project:

3.1. Thesis topic

In the field of industrial engineering, the United Nations Sustainable Development Goals (SDGs) offer a unique perspective to address global challenges that are intertwined with the capabilities and skills of this discipline. When considering the selection of a thesis topic based on the SDGs, it is essential to consider the following points:

3.2 Alignment with Industrial Engineering:

Overview: Industrial engineering is grounded in the science of optimization, aiming to design, improve, and manage complex systems in diverse environments.

Connection to SDGs: With a robust toolbox of analytical and empirical methods, industrial engineering holds the potential to advance various Sustainable Development Goals (SDGs). By tapping into its intrinsic strengths—such as system efficiency, waste minimization, and resource allocation—industrial engineers can directly influence goals like SDG 9 and SDG 12.

Strategic Focus: However, the key lies in targeting those SDGs that seamlessly integrate with the core competencies and techniques of industrial engineering. Engaging in sectors like manufacturing, production, and logistics allows industrial engineers to make tangible impacts.

3.3 Precise Definition of the Topic:

Scope of SDGs: The SDGs encompass a vast range of topics, each with its sub-areas

of focus and challenges. A successful thesis necessitates drilling down into specific areas rather than adopting an overarching approach.

Importance of Specificity: A well-defined topic not only provides clarity but also ensures that the research remains focused and actionable. For instance, a niche study on waste reduction strategies in the food supply chain resonates more effectively with SDG 12, as opposed to a broad commentary on responsible production.

3.4 Relevance and Applicability:

Contextual Importance: While the SDGs are global, their implications and solutions are often local. A thesis should echo the unique challenges and opportunities of the regional or local landscape.

Solution-Oriented Approach: Building on the earlier example, if a region faces logistical hiccups, then a solution-centric thesis might revolve around infrastructural enhancements, dovetailing with SDG 9. Such a targeted approach ensures that the outcomes are both practical and impactful.

3.5 Multidisciplinary Approach:

Beyond Engineering: Tackling the SDGs requires more than just engineering prowess. It calls for an understanding of socio-economic nuances, environmental considerations, and sometimes, geopolitical underpinnings.

Collaborative Research: Engaging with experts from disciplines like economics, sociology, environmental science, or even anthropology can enrich the analysis, offering a holistic view of the challenges and potential solutions.

3.6 Impact and Contribution:

Beyond Identification: While recognizing problems is the first step, the essence of a thesis aligned with SDGs should be its contribution to resolving them.

Innovative Outcomes: The emphasis should be on devising innovative, scalable, and sustainable solutions that not only address the immediate concern but also have the potential for broader applications. In doing so, the research transitions from mere academic exercise to a blueprint for tangible change.

Industrial engineering, inherently rooted in the science of optimizing systems and resources, offers a promising avenue to address and advance the Sustainable Development Goals (SDGs). With its primary focus on enhancing efficiency and reducing waste, it's no surprise that certain SDGs, such as SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Production and Consumption), naturally align with the domain of industrial engineering. This synergy underscores the importance of strategically targeting these objectives to harness the unique competencies of industrial engineers. However, the breadth and depth of the SDGs also pose a challenge. Given their expansive nature, it's imperative for research endeavors, such as theses, to be precise and well-defined. A broad approach might risk superficiality, while a narrowed, specific focus—like exploring waste reduction strategies in the food supply chain—can yield actionable insights and solutions pertinent to goals like SDG 12.

Yet, while the importance of precision is undeniable, the relevance of the chosen topic to the local or regional landscape cannot be overstated. The SDGs, although global, manifest differently across regions, influenced by distinct socio-economic, cultural, and infrastructural contexts. Hence, a thesis that seeks to make a meaningful impact must resonate with these regional nuances, offering solutions tailored to local challenges. For instance, in regions plagued by logistical inefficiencies, research that delves into infrastructural enhancements can have far-reaching consequences, aligning seamlessly with SDG 9.

Table 3: Thesis topic selection criteria

Selection criteria	Specific feature
Alignment with Industrial Engineering	Contribute to SDGs related to industrial engineering skills
Precise definition of the topic	Focus on a specific aspect of an SDG
Relevance and applicability	Solve problems in the local or regional context with feasible solutions
Multidisciplinary approach	Incorporate economic, social or environmental aspects into the analysis
Impact and contribution	Propose innovative solutions that help achieve the SDGs

4. Introduction

The introduction is an essential part of any thesis, as it sets the context and justifies the relevance of the study. In industrial engineering, the introduction is expected to provide an overview of the problem from a global to a local perspective, identify gaps in the existing literature, and clearly define the empirical problem. Here is a step-by-step guide on how to address each component:

1. Preamble

Begin by providing an overview of the importance of industrial engineering and how it relates to the specific topic of your thesis. This serves as the starting point for contextualizing your research.

Example: "Industrial engineering plays a crucial role in process and system optimization, ensuring efficiency and sustainability in the production and operation of various sectors."

2. International Problem

Illustrate the magnitude and relevance of the problem in the global context. Show statistics, trends, and challenges faced by the international community regarding the topic.

Example: "Globally, industries are facing increasing challenges in waste management, with approximately 300 million tons of waste produced annually."

3. National Problem

Shift the focus from the international scene to your country or region. How does the problem manifest here? What specific challenges and opportunities does it present?

Example: "In [country name], local industries generate approximately [x] tons of

waste each year, raising serious environmental and economic concerns."

4. Local Problem

Further focus attention by addressing how the problem manifests in a specific local or regional context. This could refer to a city, a community, or a particular industry within the country.

Example: "In the city of [city name], manufacturing companies contribute to 40% of this waste, despite representing only 10% of the country's industries."

5. Literature Gaps

Review existing literature and highlight gaps or areas that have not been sufficiently researched. This justifies the need for your study.

Example: "Although numerous studies exist on national waste management, there is a shortage of research focused on specific solutions for manufacturing companies in [city name]."

6. Empirical Problem

Clearly define the specific problem your research addresses, based on observations or practical experiences.

Example: "Despite local regulations, many manufacturing companies in [city name] lack efficient waste management systems, resulting in inadequate disposal and high operational costs."

7. General Research Question

Finally, formulate the central research question that will guide your study.

Example: "How can manufacturing companies in [city name] implement more efficient waste management systems to reduce their environmental impact and improve profitability?"

With this structure, the introduction not only contextualizes the problem from a global to a local perspective but also establishes the relevance and necessity of the study, providing a solid foundation for the development of the thesis.

Industrial engineering's pivotal role in streamlining systems and processes forms the underpinning of numerous sectors, emphasizing its foundational significance in modern industries. As you embark on the journey of unraveling the intricacies of your thesis topic, it is paramount to first establish the broader framework within which it fits. By setting the stage with an understanding of the global scale of issues, as illustrated by the alarming 300 million tons of waste produced annually, the narrative is placed within a pressing international context that resonates with universal concerns.

However, to make the research pertinent and impactful, it is crucial to anchor these broad-scale challenges to the unique dynamics of one's country or region. By citing specific national data and statistics, such as the waste production figures for a particular country, the analysis shifts to a more intimate and immediate realm. Such a perspective not only resonates more profoundly with local stakeholders but also offers a lens through which national policies and strategies can be assessed and

critiqued. This localization becomes even more acute when zooming into specific cities or regions within a country. By emphasizing, for instance, the disproportionate contribution of manufacturing companies in a city to the waste output, the narrative unravels layers of complexity and specificity that are essential for targeted interventions.

Yet, while data-driven insights provide a quantifiable backdrop, the heart of research often beats in the silent gaps of existing literature. The areas yet uncharted, the questions yet unanswered, and the problems yet unsolved create a fertile ground for academic exploration. The absence of comprehensive studies, as noted in our example regarding waste management solutions for manufacturing companies in a specific city, underscores the urgency and relevance of the research at hand. By identifying these gaps, the researcher not only situates their study within the broader academic discourse but also carves out a niche that their research seeks to fill.

Empirical observations further reinforce the validity and immediacy of the study. Grounding the research in practical experiences and observations, like the inefficiencies observed in waste management practices of certain local companies, offers a tangible, real-world dimension to the analysis. This confluence of empirical insights and literature gaps culminates in the crystallization of the overarching research question, serving as the North Star guiding the entire research endeavor.

In essence, the proposed structure for introducing a research thesis beautifully choreographs the transition from the vast expanse of global issues to the intimate intricacies of localized challenges. In doing so, it not only lays down the context but also highlights the importance, relevance, and urgency of the study, paving the way for a robust and compelling research journey.

5. Justification of the study

The justification for research in Industrial Engineering is essential to establish the relevance and necessity of the study, especially in the context of the Sustainable Development Goals (SDGs). Below is a description of how to align the concepts of inclusive industrialization, sustainable industrialization, innovation, and technological progress with social, practical, methodological, and theoretical justification:

5.1 Social Justification (Inclusive Industrialization):

Definition: The social justification emphasizes the importance of the study from a societal perspective, examining how the research will contribute to the well-being and inclusive development of society.

Relation with Inclusive Industrialization: Inclusive industrialization focuses on ensuring that all members of society benefit equitably from industrial advancements, regardless of their socioeconomic origin.

Example: "As industrialization progresses, it's vital to ensure that it leaves no one behind. This research aims to develop methods that promote more inclusive participation in industrial processes, ensuring that marginalized communities have

equal access to the opportunities modern industry offers."

5.2 Practical Justification (Sustainable Industrialization):

Definition: This justification examines how the study's results can be applied in the real world to address specific challenges, focusing on the applicability and practical utility of the research.

Relation with Sustainable Industrialization: Sustainability in industrialization means adopting practices that do not compromise resources for future generations.

Example: "The world faces significant challenges in terms of resources and the environment. This research proposes sustainable industrial practices that not only address current demand but also preserve resources for the future."

5.3 Methodological Justification (Innovation):

Definition: Here, the focus is on introducing or improving methods, techniques, or tools used to conduct the research.

Relation with Innovation: Innovation, in this context, refers to introducing new methods or tools that can revolutionize or significantly enhance existing processes.

Example: "The current methodology in industrial engineering needs renewal. Through this research, we'll introduce innovative tools and techniques that can optimize and transform the way the industry operates."

5.4 Theoretical Justification (Technological Progress):

Definition: This justification centers on how the research contributes to the existing body of knowledge, filling gaps, or expanding existing theories.

Relation with Technological Progress: Technological progress refers to the development and evolution of technical and technological knowledge in the industry.

Example: "Technology is constantly evolving. This research delves into current theories and proposes new models based on the latest technological advancements, thereby enriching the theoretical corpus of industrial engineering."

Based on the SDGs, this multi-dimensional approach to justification provides a robust framework for addressing current challenges and opportunities in industrial engineering, ensuring that research is relevant, applicable, and progressive. Below is a table for more detail.

The interplay between Industrial Engineering and the Sustainable Development Goals (SDGs) underscores the importance of weaving together intricate threads of social, practical, methodological, and theoretical justifications. The first layer, social justification, gravitates towards the societal impacts of industrial engineering. By emphasizing inclusive industrialization, it addresses the quintessential challenge of ensuring equitable industrial growth. The narrative insists that industrial advancements must be an inclusive journey, ensuring that the benefits permeate through all layers of society. This sentiment resonates deeply, especially in a world rife with disparities. The study's intention to chart out methods promoting inclusivity in industrial processes embodies the essence of SDG targets that champion 'leaving no

one behind'.

Moving to the realm of practical justification, the focus sharpens on the tangible applicability of research in real-world scenarios. Here, the narrative aligns with sustainable industrialization, echoing the global clarion call for sustainable practices. The emphasis is on the present and the future - addressing today's demands without jeopardizing tomorrow's needs. This perspective is not just about conservation; it's a larger vision of conscientious industrial growth. Then, with methodological justification, there's an exciting pivot towards innovation. The essence here is transformation – reshaping traditional methodologies by infusing them with fresh, innovative tools and techniques that can redefine industrial operations. Lastly, the theoretical justification dives into the heart of academic enrichment, emphasizing how the study will enhance or expand the existing body of knowledge. This ties closely with the relentless march of technological progress, urging the academia to remain in step with the evolving technological landscape.

Table 4: Types of justification according to the SDGs

Category	Definition & Relation	Example
Social Justification (Inclusive Industrialization)	Emphasizes the importance of the study from a societal perspective. Relates to ensuring all members of society benefit equitably from industrial advancements.	"As industrialization progresses, it's vital to ensure that it leaves no one behind. This research aims to develop methods that promote inclusive participation in industrial processes."
Practical Justification (Sustainable Industrialization)	Examines applicability and practical utility of the research. Relates to adopting practices that don't compromise resources for future generations.	"The world faces challenges in terms of resources and environment. This research proposes sustainable practices that address current demand and preserve resources for the future."
Methodological Justification (Innovation)	Focuses on introducing or improving methods, techniques, or tools for research. Relates to the introduction of new methods or tools for the industry.	"The current methodology in industrial engineering needs renewal. This research introduces innovative tools and techniques to optimize and transform industry operations."
Theoretical Justification (Technological Progress)	Centers on how research contributes to existing knowledge, filling gaps or expanding theories. Relates to the development and evolution of technical knowledge.	"Technology is constantly evolving. This research delves into current theories and proposes new models based on the latest advancements, enriching the theoretical corpus of industrial engineering."

6. Literature review

Conducting a literature review for a thesis in industrial engineering is paramount for setting a strong theoretical foundation and justification for the proposed research. By laying out this framework, the researcher identifies and synthesizes relevant prior literature, comprehending current advancements, dominant theories, knowledge gaps, and methodologies employed in similar research. Here's a guide on how to

conduct a literature review for an industrial engineering thesis:

6.1 Scope Definition:

Prior to initiating your search, delineate the boundaries of your review. Which specific topics or subfields within industrial engineering are you interested in delving into?

6.2 Literature Search:

Leverage academic databases like IEEE Xplore, Google Scholar, Scopus, and Web of Science.

Employ keywords pertinent to your research subject. Fine-tune your search using Boolean operators (AND, OR, NOT).

6.3 Selection and Filtration:

Handpick articles and documents aligned with your research.

Aim for more recent literature unless referring to foundational theories or methods.

6.4 Organization and Structure:

Categorize literature based on themes, theories, chronology, methodologies, or a combination of these elements.

6.5 Critical Analysis and Synthesis:

Beyond summarizing, scrutinize the literature, pinpointing patterns, debates, consensus, dissent, and existing research gaps.

This section can unveil opportunities for your investigation.

6.6 Gap Identification:

Recognizing gaps in existing research that your study seeks to address is a primary motive behind a literature review.

6.74 Linkage to Your Research:

Conclude your literature review by connecting your findings with your investigation. How does your research fit within the broader landscape?

6.8 Citation:

Ensure proper citation of all sources, adhering to the requisite format (APA, MLA, Chicago, etc.)

6.9 Periodic Review:

Fields evolve; periodically update your literature review as your research progresses.

Clarity and Conciseness in Writing:

Maintain clear and structured writing. Avoid excessive technical jargon without elucidation, ensuring seamless flow from one section to another.

6.10 Theoretical and Conceptual Framework:

Differentiate between theories (generalizable principles explaining phenomena) and concepts (ideas or constructs derived from theories). Showcase how they influence your research.

6.11 Inclusion of Seminal Works:

Don't neglect foundational or seminal papers in the field. These often lay the groundwork for many subsequent studies and theories.

6.12 Comparison and Contrast:

Show differences and similarities between studies, bringing out unique contributions or corroborations of each work.

6. 13Use of Visual Aids:

Consider utilizing tables, charts, or diagrams to summarize and compare information or to illustrate complex concepts.

6.14 Address Conflicting Evidence:

Highlight any conflicting evidence or differing opinions in the field. This can underscore areas of contention and potential opportunities for further research.

By the end, your literature review should paint a comprehensive picture of the current research state in industrial engineering and how your study slots into this tapestry. Below is a summarized table for better understanding

Table 4: Steps to write a literature review

Steps	Description
1. Scope Definition	Define the boundaries of your review. Decide on specific topics or subfields within industrial engineering to explore.
2. Literature Search	Use academic databases. Employ keywords and Boolean operators for efficient searches.
3. Selection and Filtration	Choose relevant articles. Prioritize recent literature but consider foundational works.
4. Organization and Structure	Categorize literature based on themes, methodologies, chronology, etc.
5. Critical Analysis and Synthesis	Identify patterns, debates, consensus, and gaps. Engage in more than just summarizing.
6. Gap Identification	Highlight gaps in existing research that your study can address.
7. Linkage to Your Research	Conclude by connecting your review's findings with your study's aim and methodology.
8. Citation	Properly cite all sources following the required format.
9. Periodic Review	Update your literature review as your research progresses and as new relevant literature emerges.
10. Clarity and Conciseness in Writing	Ensure the writing is clear, structured, and free from excessive jargon.
11. Theoretical and Conceptual Framework	Differentiate between theories and concepts. Show their relevance to your research.
12. Inclusion of Seminal Works	Incorporate foundational papers that have significantly influenced the field.
13. Comparison and Contrast	Detail differences and similarities between various studies, showcasing their contributions.
14. Use of Visual Aids	Use tables, charts, or diagrams to illustrate complex concepts or summarize information.
15. Address Conflicting Evidence	Highlight areas of contention in the field, and note differing opinions and findings.

7. Methodology

Research Methodology in an Industrial Engineering thesis is a crucial section that defines the structural framework for addressing the research problem. It is the roadmap that guides the researcher in data collection, analysis, and presentation. Here, we present the possible methodological designs that can be used:

7.1 Research Design in Engineering: A Holistic Perspective

Engineering, as a discipline, is inherently practical and seeks to solve complex real-world problems. When considering research in engineering, it is essential to identify the most suitable research design based on the nature of the problem and the desired objective. Here, we will explore various research designs that serve as valuable tools for the engineering researcher.

7.2 Types of Research by Purpose and Nature:

Operational Research: This research aims to optimize operations and decisions through the use of mathematical techniques. It focuses on constructing and applying models that simulate real operational scenarios, allowing the analysis of multiple variables and providing optimal solutions to complex problems. It is especially relevant in areas such as logistics, production, and transportation systems.

Projective Research: Here, the focus is on proposing innovative solutions to specific problems. This design is predominant when seeking to design and plan new products, processes, or industrial systems. For example, when designing a new production system, the engineer could adopt this approach.

Applied Research: This research aims to apply theoretical knowledge to specific practical contexts. Its purpose is to solve specific problems through the development and application of emerging theories or technologies.

Prospective Research: Future-oriented, this research focuses on anticipating scenarios, trends, and challenges that may arise in the long term. It is highly useful in strategic planning and industrial trend analysis.

7.3 Types of Research by Depth or Scope:

Predictive Level: This research seeks to anticipate future events based on current data and trends. It is essential for early decision-making and preparation for possible scenarios.

Explanatory Level: Here, the goal is to understand the causes of a phenomenon or issue. Through this approach, an attempt is made to understand why something occurs and which factors are related.

7.4 Types of Research by Context:

Field Research: It is carried out in a natural and real environment. Here, the researcher interacts directly with the phenomenon or issue, collecting data where it occurs.

Laboratory Research: It is conducted in a controlled environment where specific variables can be manipulated to observe their effects.

Documentary Research: Based on the review of documents, literature, and

secondary sources. It is fundamental for building the theoretical framework and understanding previous research on the topic.

7.5 Types of Research by Manipulation:

Experimental Research: The researcher manipulates one or more variables to determine their effect on a dependent variable. It is structured and controlled.

Non-Experimental Research: The researcher observes phenomena as they occur in their natural context, without manipulating variables.

The choice of research design in engineering should be based on the problem to be addressed and the research objective. With an appropriate design, the engineering researcher can develop effective, innovative, and sustainable solutions that respond to the demands of the real world. Below is a detailed table:

Table 2: Methodological design to use:

Main Category	Subcategory	Description	Titles (examples)
Type of Research	Operational Research	Optimizes operations and decisions using mathematical techniques. Analyzes multiple variables to offer optimal solutions.	Optimization of Supply Chain Processes using Linear Programming in the Automotive Industry
	Projective Research	Proposes innovative solutions to specific problems. Used for designing and planning new industrial systems.	Designing a Green and Sustainable Manufacturing System for Electronics Production
	Applied Research	Applies theoretical knowledge to practical contexts. Addresses specific problems using emerging technologies.	Application of Industry 4.0 Technologies in Modern Warehousing Systems
	Prospective Research	Anticipates future scenarios. Used in strategic planning and trend analysis in industries.	Anticipating the Evolution of Green Manufacturing Practices by 2040
Depth Level	Predictive Level	Anticipates future events based on current data and trends. Useful for making forward-looking decisions.	Predictive Analysis of Energy Consumption Patterns in Steel Production
	Explanatory Level	Understands the causes of a phenomenon. Seeks to understand why something happens and which factors are involved.	Analyzing the Root Causes of Downtime in Automated Packaging Lines
Place of Research	Field Research	Occurs in a natural environment. Gathers data directly where the phenomenon takes place.	Evaluating the Real-time Performance of Smart Factory Implementations in Textile Mills
	Laboratory Research	Conducted in a controlled environment. Allows for manipulation of specific variables.	Investigating the Performance of New-age Robotics in Controlled Manufacturing Scenarios
	Documentary Research	Based on literature review and secondary sources. Fundamental for the theoretical framework.	A Comprehensive Literature Review on the Evolution of Six Sigma Methodologies
Degree of Manipulation	Experimental Research	Manipulates variables to determine their effect. Is structured and controlled.	Determining the Impact of Varying Humidity Levels on Electronics Assembly Lines

	Non-Experimental Research	Observes phenomena in their natural context without manipulation.	Observational Study on the Dynamics of Teamwork in Assembly Line Workers

From the outset, the categorization of research types by purpose and nature underscores the multifaceted objectives an engineering researcher might pursue. Operational Research, for example, exemplifies engineering's quantitative and problem-solving essence, utilizing mathematical models to achieve optimization in real-world scenarios. On the other hand, Projective Research embodies the innovative spirit of engineering, constantly pushing the boundaries of what's possible by proposing groundbreaking solutions. Applied Research and Prospective Research further reflect the balance between current applications and future-forward thinking, epitomizing the proactive nature of engineering that both addresses immediate challenges and anticipates future scenarios.

Moreover, the categorization based on depth or scope emphasizes the necessity of both predictive and explanatory approaches. While the former allows engineers to stay ahead of emerging challenges, the latter ensures a deep understanding of existing phenomena, laying the groundwork for innovative interventions.

The contextual categories highlight the varied environments in which engineering research occurs. Field Research underscores the importance of ground realities, Laboratory Research highlights controlled experimentation, and Documentary Research emphasizes the role of theoretical underpinnings and prior knowledge in guiding new inquiries.

Lastly, the distinction between Experimental and Non-Experimental Research, based on variable manipulation, underscores the spectrum of control a researcher might exert in different studies, reflecting the range between structured investigations and organic observations.

In sum, this holistic view of research design in engineering captures the discipline's depth and breadth. By aligning the problem's nature with the most fitting research approach, engineering researchers can pave the way for solutions that are not only innovative but also immensely impactful. The mentioned table, while not displayed here, likely offers a detailed breakdown, serving as a valuable reference for budding researchers and seasoned professionals alike.

8. Discussion

The domain of thesis project formulation in industrial engineering has undergone significant transformation in recent times, reflecting the discipline's evolution within the shifting landscape of global technological and societal change. This research underlines the imperative of aligning thesis project formulation with the broader sustainability concerns and mandates delineated by the Sustainable Development Goals (SDGs).

It's evident from the study that integrating SDGs within the thesis formulation process provides a structured pathway for students to tackle pressing global issues. When such a framework is in place, students can effectively leverage their engineering skills to propose solutions that have tangible and meaningful impacts. Thesis projects are no longer just academic exercises; they become instrumental platforms for driving

change and addressing global challenges.

A major highlight from our findings is the need for robust selection criteria when formulating thesis topics. As indicated in Table 3, a thesis topic needs to not only be aligned with industrial engineering concepts but also contribute significantly to relevant SDGs. The emphasis on having a multidisciplinary approach resonates with the broader global agenda, which recognizes that the challenges of today are interconnected and can't be addressed in silos.

The importance of the introduction in setting the context of a thesis cannot be understated. The step-by-step guide provided offers students a structured way to introduce their research topic and its relevance, both globally and locally. This approach ensures that the research is grounded in reality and speaks to current and pressing issues.

Furthermore, the categorization of justification according to the SDGs, as highlighted in Table 4, presents a nuanced understanding of how industrial engineering research can be framed. Whether it's from a societal, practical, methodological, or theoretical perspective, the emphasis is on aligning with the broader objective of sustainability and technological progress.

The comprehensive guide on literature review suggests that researchers should not only focus on what has been studied but also identify gaps, which are often the most fruitful areas for novel research. A rigorous literature review is essential for situating one's research within the broader academic landscape.

Regarding methodology, this research underscores the diversity of methodological designs that can be harnessed based on the nature and scope of the research problem. Engineering, being an applied discipline, requires a blend of theoretical and practical methodologies, tailored to address specific challenges.

9. Conclusion

The incorporation of the Sustainable Development Goals (SDGs) in the formulation of thesis projects in industrial engineering is a significant evolution in contemporary education and research. This adaptation reflects a proactive response to global challenges, ensuring that industrial engineering not only remains at the forefront of technical innovations, but also promotes sustainable and ethical solutions. As the world moves into an uncertain future, it is imperative that disciplines, such as industrial engineering, recognize and actively address their role in creating a more equitable and sustainable world. Alignment with the SDGs not only ensures the current relevance of research, but also prepares future engineers to be agents of positive change in society.

It is crucial to recognize the inherent limitations in integrating the SDGs in the formulation of thesis projects. Although the SDGs offer a broad and ambitious framework, they are not always perfectly adapted to the particularities and needs of each region or industrial sector. Furthermore, the vastness of the SDGs can be overwhelming for researchers, leading to the possibility of superficial or unfocused approaches. As these global goals are adopted, it will be essential to provide adequate

training and resources to students and professionals, ensuring that alignment with the SDGs is not only intentional but also effective and contextually relevant.

Future Guidelines

To consolidate this approach, educational and research institutions should prioritize training in methodologies aligned with the SDGs, promote interdisciplinary collaboration and ensure continuous evaluation of the impacts and relevance of research in the global context. Interaction with industry and civil society will also be essential to maintain the relevance and impact of industrial engineering research.

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