



Review

Research Thesis for Undergraduate Engineering Programs in the Digitalization Era: Learning Strategies and Responsible Research Conduct Road to a University Education 4.0 Paradigm

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Abstract: Many university students have doubts about how or where to start writing their undergraduate thesis work; it is common not to be clear how to identify a research problem or even towards which topic their research is oriented, and there are doubts about how to process and systematize so much information available in the era of digitalization. This article presents learning strategies to formulate a research thesis for engineering undergraduate programs, with an emphasis on the use of information and communication technologies (ICTs) toward a University Education 4.0 paradigm. The main themes and issues discussed in this article, carried out through learning strategies for students based on the scientific method, are the following: (i) Recommendations for choosing a research topic, (ii) Guidelines for problem identification and question research, (iii) Suggestions for choosing a thesis advisor, (iv) Instructions for finding suitable sources of information, (v) Structure of the table of contents for writing the thesis manuscript, and (vi) Indications for preparing an oral defense of thesis research. This article highlights recommendations and precautions directed towards professors and students with the use of the chatbot-type artificial intelligence (AI) tool called ChatGPT for the formulation of the thesis under a responsible conduct approach in research. This article concludes that the application of tutoring/guidance strategies between professors and students requires an adequate ethical use of information and communication technologies (ICTs) during the development of a research thesis to generate a comprehensive educational environment that encourages research and develops a sustainable learning process in the context of the University Education 4.0 paradigm.

Keywords: thesis; research; university; undergraduate program; engineering; students; professors; ethical issues; information and communication technologies; ChatGPT; education 4.0



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1. Introduction

1.1. The Reality Faced by Undergraduate Engineering Students to Write a Thesis

The Sustainable Development Goals (SDGs) have been established by the United Nations (UN) as part of its global sustainable development agenda for the decade 2020–2030. Thus, one of the most important objectives is quality education, which is related to ensuring university education for all young people with abilities and talent, promoting higher education, promoting equal access for men and women, and reducing university desertion, among others [1,2]. For this, the use of active learning methodologies with the use of information and communication technologies (ICTs) is essential, for example, application

in educational areas like: Science, Technology, Engineering, and Mathematics (STEM) and Science, Technology, Engineering, Arts, and Mathematics (STEAM), since they improve the perception towards learning and facilitate the teaching process. In turn, technology makes it possible to reach all places, overcoming geographical barriers [3,4].

In this context, the engineering undergraduate programs of each specialty challenge students in their studies of both the basic sciences and the engineering sciences. During the early years, students focus on the study of basic sciences such as algebra, calculus, probability, statistics, chemistry, and physics, while, in the middle and final part of their studies, courses focus on the engineering sciences, applied to topics to learn how to solve problems specific to the specialty [5]. This is how engineering students spend much of their time in: (i) performing mathematical, statistical, chemical, and physical calculations, (ii) studying technical methodologies to solve certain problems, both theoretically and in the laboratory, (iii) developing skills to estimate costs, (iv) understanding the implementation of tools to formulate and manage investment projects, and (v) learning to use software for modeling real phenomena. Although engineering undergraduate programs offer humanistic courses, these are a minor percentage of the number of credits in the curricular plan and do not fully encourage students' writing and speaking skills, in comparison with students from Social Sciences, Languages, and Humanities (SSLH) scientific areas [6].

Today, in the era of digitalization of information, it is appreciated that university students tend to read and write less due to the use of digital platforms with videos where they learn new topics through tutorials or virtual classes [7,8]. University students rarely go to the library to look for printed books, but rather prefer to use digital books, for example. Recent studies have shown difficulties in reading and writing among university students due to the replacement by visual digital media of the traditional methods of reading printed texts and writing with pencil and paper in notebooks. For example, today some students attend classes and do not take notes in their notebooks because they prefer to later watch a video tutorial on the class theme on YouTube [9,10]. Another aspect related to information and communication technologies that has affected students' writing ability is mobile phone text messaging platforms, where people tend to write less and use images to communicate considering the use of instant message applications with mobile cell phones [11,12]. This has been accentuated at the time of the COVID-19 pandemic, mainly due to the implementation of virtual classes on internet platforms by universities, where the use of digital communication technologies allowed the continuity of the development of learning activities in a virtual mode without physical contact between people [13].

In this sense, undergraduate engineering students develop logical-mathematical problem-solving skills with great efficiency by applying formulas and methods, but they lack sufficient practice to write texts such as reports or theses linked with research and science scopes [14]. In addition, the following aspects have been evidenced: (i) a lack of clarity when identifying a topic of interest and projecting themselves developing their professional career in this area, and (ii) a lack of ideas on the part of the students when defining a potential topic for research [15–17]. There is a difficulty in defining a research problem and relating it to a certain methodology to solve the problem and find a possible solution. Another aspect that is quite noticeable to undergraduate students of engineering programs is the difficulty of applying the scientific method to study a problem applied to the resolution of an engineering topic. Finally, the lack of an adequate oratory capacity to defend and argue their ideas at the end of the investigation in front of a jury made up of professors makes engineering students vulnerable when arguing and supporting a research position [18–20].

For this reason, many universities in the curricular plan of undergraduate engineering programs have incorporated 1 or 2 courses, called, for example, (i) research seminar 1 and 2, (ii) research project 1 and 2, or (iii) thesis project 1 and 2. These courses have been implemented to help students and teach them how to plan and write a thesis investigation. In these courses, students learn to: (i) identify their topic of interest, (ii) formulate the problem/research question, (iii) design the structure of their thesis research, (iv) implement

a research methodology, (v) guide in the way of presenting results, findings, and solutions to the research problem, and (vi) finally develop speaking skills and techniques to support their research [21–23].

Another aspect, no less important, is that there is a percentage of desertion in the completion of the thesis research by a group of students who finish all their courses in the curricular plan and then prefer to start working in the labor field. There are many reasons why students decide to work first instead of finishing their thesis research; some reasons are, for example: (i) family need to generate income, (ii) need to pay debts that financed their undergraduate studies, (iii) interest from companies in the industry to hire young professionals at a salary below market value, (iv) lack of interest and motivation in carrying out the thesis, among others [24,25].

1.2. Digitalization Era and Education 4.0 Paradigm

University education has been quite traditional in the dissemination and generation of knowledge over time, but quick to change and update on issues of infrastructure, communication, data management, storage, and exchange of information and knowledge [26]. However, a fully integrated automated system is a challenge for universities in practice due to infrastructure limitations in communication, management, and data storage as of 2023 [27]. Currently, there is a trend in university education to promote new technologies different from traditional methods and to rely on innovative techniques that accelerate the progress of the teaching-learning process [28–30].

University Education 4.0 arises in the context of the “fourth industrial revolution”, referring to digital integration, artificial intelligence, automation, and the interconnection of technological devices in various social fields. It is based on the idea that educational institutions should take advantage of emerging technologies to improve the quality of teaching, research, and learning. In addition, prepare students for the future demands of the labor market in an industry 4.0 context with a focus on critical and creative thinking [31]. Unlike university education 3.0, 2.0, and 1.0, education 4.0 usually has greater capacity and scope. These last-mentioned paradigms are mainly characterized by the following: (i) University Education 1.0 is based on traditional teaching, passive learning, limited technology, and unidirectional learning, placing the teacher as the main source of information, (ii) University Education 2.0 is characterized by the beginning of the use of the Internet, more active participation, and the appearance of collaborative work tools with the promotion of participation and exchange of ideas between students and professors, and (iii) University Education 3.0 is defined as learning personalized, based on real activities, the integration of information and communication technologies (ICTs), and massive access to mobile devices [32].

It is in this context that education 4.0 is an educational trend where innovative teaching strategies and cutting-edge learning perspectives converge to develop talent capable of making creative and viable decisions [33–35]. Its eclectic educational approach encourages the use of disruptive technologies to optimize learning and, consequently, provide innovative solutions to real and complex problems [36–38].

It represents the ways in which smart and connected technology would be integrated into organizations, people, and assets and is marked by the emergence of technological capabilities such as massive sensor deployment, big data analysis, artificial intelligence (AI), machine learning, the Internet of Things (IoT), digital twins, cloud storage, 3D printing, virtual/augmented reality, 5G internet, automation, robotics, cybersecurity, nanotechnology, additive manufacturing, and advanced materials [27,39–41].

Its objective is to train an integral and multifunctional human being to achieve self-realization permanently. It is pragmatic since its inclination is to seek useful solutions for the productive sector and industry [42–44]. It adopts innovative methods for teaching and learning in line with the current and global technological context, which refers to:

- Human-machine learning, self-learning, and flexibility are promoted.
- Take advantage of disruptive technologies to offer educational opportunities different from those traditionally known.
- Strengthens the teaching-learning process based on the potential of technology developed in industries.

An important historical milestone that we must not forget to mention that accelerated the era of digitalization of education in the university was the global pandemic of COVID-19 [27,45–47]. This allowed the massive implementation of virtual classes through different digital platforms such as Zoom, Microsoft Teams, Google Meets, and Blackboard Collaborate, among others. Applications of both chairs and virtual evaluations were carried out during the time of the global pandemic, testing both professors, students, and technological platforms [48–51]. This has currently made it possible to have face-to-face, virtual, and blended (hybrid) classes and reduce educational gaps due to physical distance restrictions to educational centers, all thanks to improvements in internet connectivity and speed [52–57].

Addressing the challenges of future education in the context of climate change, people's demand for a pollution-free environment, and living in a complex and uncertain world requires the incorporation of information and communication technologies (ICTs) in order to encourage decision-making in a more responsible and proactive way with a more informed and participatory society [58,59].

In this context, the authors mention that the main learning perspectives implemented considering the paradigm of education 4.0 are based on information and communication technologies (ICTs) (Figure 1).



Figure 1. Learning perspectives in the Education 4.0 paradigm.

Within these learning perspectives, the following stands:

- **Problem-based learning:** Students in their research can solve real and everyday problems, such as environmental pollution or climate change [36,37,59].
- **Project-based learning:** Students in their research develop projects to address solutions to different problems, considering management projects, economic production projects, and nature conservation projects, among others [36,37,59].
- **Adaptive Learning:** Students today implement research techniques that are adaptive to changing times and are constantly learning new and emerging technologies [36,37,59].

- **Self-regulated learning:** Students could self-regulate their research, adopting a proactive and responsible attitude in the development of their studies [36,37,59].
- **Experiential learning:** Students develop experimentation skills through laboratory use, the development of pilot tests, or the implementation of advanced data processing techniques [36,37,59].
- **Active learning:** Today's students with access to various technological tools are active beings who take the lead in education and generate dissemination of their research experiences through social networks, such as YouTube, Facebook, Instagram, and Twitter, among others [36,37,59].
- **Collaborative learning:** Students work together with engineering partners from various disciplines, forming multidisciplinary teams that propose innovative, challenging, and holistic solutions [36,37,59].
- **Ubiquitous learning:** Students are very curious, and by their natural attitude, they want to witness, live, and experience everything, and they are in constant and continuous movement [36,37,59].
- **Rhizomatic learning:** Students have a resilient capacity for learning, and based on learning new knowledge, experiences, and tools, it allows them to continue opening up to new fields and acquiring new knowledge [36,37,59].

1.3. Aim of the Article

This article presents learning strategies to formulate a research thesis for engineering undergraduate programs, with an emphasis on the use of information and communication technologies (ICTs) toward a University Education 4.0 paradigm. The main themes and issues discussed in this article, carried out through a methodological guide for students based on the scientific method, are the following: (i) Recommendations for choosing a research topic, (ii) Guidelines for problem identification and question research, (iii) Suggestions for choosing a thesis advisor, (iv) Instructions for finding suitable sources of information, (v) Structure of the table of contents for writing the thesis manuscript, and (vi) Indications for preparing an oral defense of thesis research. Finally, this article highlights recommendations and precautions directed towards professors and students with the use of the chatbot-type artificial intelligence (AI) tool called ChatGPT for the formulation of the thesis under a responsible conduct approach in research.

2. Recommendations for Choosing a Research Topic

The first step for students when starting their thesis is to select a suitable research topic. In general, students do not have absolute clarity in this instance about what topic to investigate; in some cases, there is confusion and a lack of ideas, and in other cases there are many ideas and good intentions but a lack of coherence in how to approach the topic [60].

Therefore, the first recommendation is to identify in which area of their engineering program the students have knowledge and wish to continue developing ideas, knowledge, or experiences. As a main suggestion, it is proposed to students to choose a research topic of their liking and/or interest with a projection over time, both in the short and medium term, considering their professional/work field, due to the time that students will have to invest in development of the work, which can take between 6 and 12 months approximately. Each student, according to their personal motivations, preferences, and level of knowledge of a discipline within their engineering program, must choose a subject that is easy for them to understand and that allows them to enjoy learning [15].

As a second recommendation, students are suggested to analyze the access and amount of information available within their topics of interest or preference. This is a key aspect, since a student may have the best disposition to develop a research topic that may be very relevant and novel, but if there is not proper access to data and enough information, it will be impossible to develop the thesis research properly. It is important that students are informed of various alternative sources of access to information, for example, through: (i) the websites, (ii) scientific databases such as Scopus, Web of Science,

IEEE, Dialnet, ProQuest, EBSCO, or Springer, among others (iii) repositories from different universities, (iv) physical and virtual libraries from different universities, (v) conference papers proceedings, among others. This will improve the spectrum of access to information for students and help them choose a suitable topic for their research [61].

A third recommendation is to think about where, how, and when to obtain the research data. It is important to consider the types of data that will be obtained, whether qualitative, quantitative, or classified as categorical, discrete, or continuous data, as well as the correct identification of the variables to be used, their dimensions, indicators, and measurement units for each of them. Likewise, the data source can be field, laboratory, or information already available, either from an external source or the cloud. In addition, the effort to get the data must be considered in terms of time, availability of materials, technology, and monetary resources. After all this, it is necessary to consider the design, the number of representative samples for the investigation, and the statistical analysis to be carried out. Much depends on the quality of the thesis if all these aspects have already been evaluated [62]. For the latter, various statistical software can be used as tools, which can be paid or free open-source. In the case of paid software, the best-known in their different versions are SPSS, SAS, Stata, EViews, Minitab, Statgraphics, Infostat, Origin, Matlab, Primer-e, MS Excel, among others. In the case of free open-source software, for example Jamovi, JASP, R Studio, and Python are among the best-known. These last two, R Studio and Python, have been very relevant in the scientific and university communities due to their potential and versatility through ordered instructions (programming) for the analysis, management, processing, and visualization of large amounts of data in many fields of study [63].

R Studio and Python have outperformed many of the statistical tools because they go further. Their enormous computational capacity makes them a powerful tool in many respects for data analysis. They have specialized libraries according to the characteristics of the data. Many of them specialize in Machine Learning, which allows the generation of models from training data to make predictions, regressions, classifications, and groupings with greater precision than conventional statistics [64]. These tools have managed to group and apply Data Analysis, Machine Learning, and Domain Knowledge in the same space, contributing to the evolution and systematization of Data Science and artificial intelligence in recent times [65] (Figure 2).

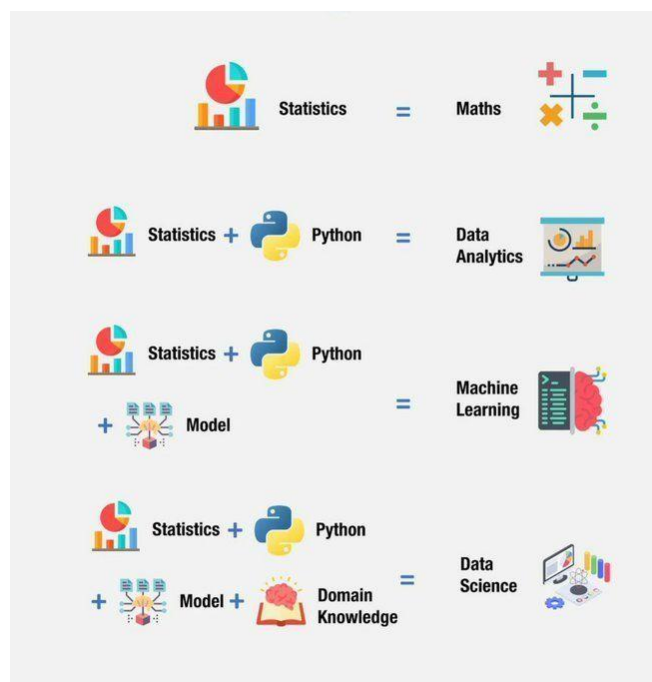


Figure 2. Evolution of data analysis and systematization from math's to data science.

As a fourth recommendation, students are advised to choose a research methodology, tool, or technique that has been validated by other researchers and is feasible to implement in their thesis. At the undergraduate level, thesis research does not require the creation of a novel work methodology, but it does require using an appropriate methodological tool recognized and validated through other research. Students should look for these reference methodologies in books, theses, and/or scientific articles [66].

A final recommendation is the adequate selection of the thesis advisor. This is key, as this person must have the right knowledge and experience to guide the entire thesis research process. It is key that students can access the curriculum of each of the professors at their school and understand the lines of research and expertise of the academics. More details about the choice of thesis advisor are listed below [67].

3. Suggestions for Choosing a Thesis Advisor

3.1. General Aspects focusing in the Students

As mentioned above, it is key that students are informed and know the professional profile and experience of the professors at the engineering school where they study. It is recommended that students begin this thesis advisor selection process well before reaching the stage of beginning the thesis research. It is important that the student begin to make contact with a professor during the development of the courses in his curriculum. In this instance, it is appropriate to know the research interests and experience of the professors. It is also key that the professor can meet potential thesis students, and it is a great opportunity for a student to demonstrate their interests and skills through participation in classes and standing out by obtaining good grades [68].

Another aspect to recommend to students in the thesis advisor selection process is to find out about the availability of time for student attention and guidance on their theses. It happens that, in some cases, there are professors with a large number of thesis students, which translates into a low availability of time to adequately attend to each of their thesis students. This can harm the student's teaching-learning process and extend the time of the research process [69].

In cases where an engineering school does not have enough professors for the thesis guidance of its students, there is a possibility that students turn to other schools or different universities to find a thesis advisor. It is possible that a student presents a professor from another university as her thesis advisor, and a commission from the engineering school of her university endorses and approves that candidacy. In other cases, it is also possible that two thesis advisors are assigned: a guide professor and a co-guide professor; in this way, in case one of the two professors does not have adequate time availability, the other professor can dedicate more time to guiding the student in his research work [70].

Finally, it is possible to mention that once a student has agreed to work under the guidance of a thesis advisor, it is important that the student follow the indications and instructions that his professor indicates. The student will not be able to make decisions for himself during the development of the research; it is key that any doubt, query, change, or modification in the thesis be communicated to the thesis advisor, who together will make the decisions that guide the development of the thesis research. It is relevant to mention that it is the thesis advisor who endorses the thesis research work developed by the student and who gives the final approval of the manuscript prior to evaluation by the thesis review committee [71].

3.2. Professor Skills for Educative Management Considering Information and Communication Technologies (ICTs) in an Education 4.0 Paradigm Context

Today, in the era of digitalization of information, professors must have certain skills for educational management considering the implementation of information and communication technologies in the context of the 4.0 education paradigm [34,35,38], which are the following:

- **Regarding the curriculum:** Know the graduation profile and recognize that your curricular unit contributes to this profile; adjust according to the current educational context in correspondence with student characteristics [34,35,38].
- **Regarding the virtual design:** Choose the strategies, media, and resources that best suit the educational intention and the student population; recognize the student context to access the selected resources or media [34,35,38].
- **Regarding the creation of digital educational content:** Have a virtual space to collect what is generated, build an accessible repertoire, and know how to create digital presentations [34,35,38].
- **Regarding the teaching action:** Network with other professors who share the same educational intention, and keep up-to-date with educational programs, applications, tools, and platforms [34,35,38].

It is important that the thesis advisors are updated and keep current with the new knowledge trends and technological tools that are appearing every day in the field of university education [34,35,38].

Just as students become more involved with new technologies every day, professors must share and interact with these experiences with their students so that everyone gains from the progress and development of knowledge, both in soft skills and hard skills [34,35,38].

4. Instructions for Seeking Appropriate Sources of Information and Data to Conduct Research

4.1. General Aspects Focusing on the Students

The form of access to information for the development of the thesis research, among other aspects, will depend on whether the thesis will be of the non-experimental or experimental type. In the first case, as previously indicated, there are several sources of public information that can be accessed using the Internet, such as scientific databases and free access for students provided by Higher Education Institutions (HEIs). In addition, it is possible for students to access these repositories from different universities, physical and virtual libraries from different universities, and conference papers proceedings, among others. On the other hand, in the second case, if the thesis is experimental and the use of laboratories is carried out, the access to the information may be different from that indicated above, requiring in some cases the collection of data with field samples. In this case, it is key to carry out a representative data collection process to avoid future errors in the systematization and processing of information [72].

Today, in the era of the digitalization of information, the amount of data available on the Internet is immense. It is possible to find different sources of information, different documents, or publications for the same subject, reaching hundreds or even thousands. This sometimes makes it a very difficult task to be able to systematize and process information for its understanding and comprehension. It is in these cases that it is important to have knowledge on the part of the students to resort to data analysis tools such as: (i) Data mining, (ii) Big data, (iii) Machine learning, and (iv) Artificial intelligence [12]. These tools allow the analysis of large amounts of information through intelligent algorithms, managing to systematize and process the information in short periods of time, facilitating research tasks. Another type of study that students need to be aware of when starting the search for information on a certain subject is literature review studies, carried out based on bibliometric analysis and systematic content analysis, where metrics are disclosed with tables and graphs on the most important aspects of a specific research topic, allowing access to the bibliographical references indicated by the authors. These studies are available in scientific databases as scientific articles and can be found in: Scopus, Web of Science, Science Direct, IEEE, Dialnet, ProQuest, EBSCO, Springer, Nature, MDPI, Scielo, among others. Another alternative to obtaining information to develop research by students is to access repositories from different universities and download undergraduate and graduate theses [8].

Another relevant aspect is the scientific information available, depending on the language. Most of the scientific information is in the English language. Considering the experience in countries that do not speak the English language, more than 90% of the references are in the student's native language. Therefore, the scientific information in English considered by the students may be limited in some cases. This problem may be due to a lack of command of the language or to a matter of ease and speed of reading scientific information. Currently, this is solved using translators that are included on the web pages or there are document translators on the web such as, for example: Google Translator, DeepL Translator, and El Mundo Translator, among others [73–76].

Finally, it is important to mention that any source of information considered in the thesis research must be correctly cited. This is relevant to recognizing other authors in their publications or research papers, creating a responsible and sustainable ecosystem. Students must apply different types of citations according to the handling of the information considered, whether direct citations or indirect citations. In the case of indirect citations, appropriate paraphrasing will be necessary for the text to be written to describe the idea that is to be conveyed. The thesis advisor must conduct an exhaustive review of the citations and creation of bibliographic references considered by the student in his thesis research, thus giving adequate scientific rigor to the work. It is the responsibility of each Higher Education Institution (HEI) to define the citation style to be used in thesis manuscripts by students, for example, some of the most commonly used citation styles are: APA, IEEE, Vancouver, Chicago, and Nature, among others [77].

4.2. Most Popular Platforms and Applications of Information and Communication Technologies (ICTs) Used by Professors and Students in a Thesis Context

In the era of the digitalization of information, many information and communication technologies (ICTs) applied in education have emerged. Both professors and students today handle and master them, which can be applied in developing thesis research [26,27,58]. Some examples include the following:

- Internet browser: Google Chrome, Firefox, Canaima, and Explorer, among others.
- Email: Gmail, Yahoo, Hotmail, Outlook, among others.
- Word processors: Microsoft Office 365 package, PDF, among others.
- Social Networks: WhatsApp, Instagram, Twitter, Telegram, Facebook, and Youtube, among others.
- Audio and video editing: Lightworks, Inshot, FilmoraGo, PowerDirector, among others.
- Development of virtual learning environments: Moodle, Chamilo, Google Class-room, and Blackboard Collaborate, among others.
- To manage virtual classes/meetings: Zoom, Google Meet, Youtube Live, and Blackboard Collaborate, among others.
- To create educational digital content: Canva, Geneally, Prezi, and Dolby On, among others.
- For mass storage and exchange of information: Dropbox, Google Drive, among others.

5. Different Uses of Artificial Intelligence (AI) Tools such as ChatGPT to Optimize Thesis Research Formulation

In the year 2023, the new freely accessible chatbot-type artificial intelligence (AI) tool called ChatGPT will cause a stir in society in general [78]. Many people worldwide have had the opportunity to experiment and interact on their own with this technology [79–81]. This is how, in universities around the world, both professors and students have begun to use this tool in classes, academic papers, debates, presentations, and thesis research, among others [82]. Much curiosity has been caused by this tool in the community in general, where both young people and adults have experimented with the use of the tool to ask questions and analyze the answers to those questions.

Below are some applications for the teaching-learning processes of the thesis research formulation considering the artificial intelligence (AI) tool ChatGPT:

- **Focus on students:** (i) information gathering and research, (ii) generation of summaries and reviews of texts, (iii) improvement of writing and style, and (iv) preparation for presentations/exhibitions and debates [83–86].
- **Focus on professors:** (i) Design of activities and exercises, (ii) evaluation of academic performance, (iii) creation of educational resources and materials, (iv) implementation of personalized learning strategies, (v) creating opportunities to develop skills such as critical thinking and co-creation [83–86].

In the following paragraphs, some applications focused on students will be presented to optimize the formulation of their thesis research through the use of the chatbot-like tool called ChatGPT:

- **Research and information gathering:** (i) Activity: Professors can assign students to research a specific topic using ChatGPT. Then the students must compare the information generated by the artificial intelligence (AI) model with other reliable sources and discuss the similarities and differences, (ii) Objective: Develop research and critical thinking skills, as well as foster the ability to assess the quality and reliability of information [83–86].
- **Generation of summaries and reviews of texts:** (i) Activity: Professors can ask students to use ChatGPT to generate summaries or reviews of academic texts. Students can then review and improve the generated text and present their final versions for discussion, (ii) Objective: Improve reading, comprehension, and writing skills, as well as develop the ability to synthesize information and evaluate texts from a critical perspective [83–86].
- **Help with writing and proofreading:** (i) Activity: Professors can encourage students to get suggestions on how to improve their writing and style in their thesis manuscripts. Students should reflect on the suggestions provided and apply them accordingly, (ii) Objective: To develop effective writing and communication skills and foster the ability for self-assessment and continuous improvement [83–86].
- **Preparation for presentations/lectures and discussions:** (i) Activity: Professors can assign students to use ChatGPT to get ideas and arguments on a specific topic for a presentation/lecture or discussion. Students can then investigate further and develop their own opinions, supported by information generated by the model and other sources, (ii) Objective: Foster research, oral communication, and critical thinking skills, as well as promote the ability to formulate and defend arguments effectively [83–86].

Although it is true that this tool can optimize time by being very helpful in various tasks where writing is used, within the thesis, it can only help to carry out some of them. The spaces in which it could contribute are in the introductory part (structuring and writing style), state-of-the-art, theoretical bases, and part of the methodology, such as in the analysis protocols, validation protocols, and the statistical analysis. However, all of them must be taken with great care and caution because the information may not be entirely correct. Reportedly, the claims made by artificial intelligence (AI) are not entirely true; they are often inaccurate, with invented sources, where the citations may sound legitimate and scholarly, but they are not real in some cases. For example, the ChatGPT information is based on past events before the year 2021, making it outdated and unreliable information. It is also necessary to consider that the language and writing are quite general. A person with little research experience might mention that everything is perfect. However, it still does not reach the level of consistency and precision of writing carried out by experienced scientists [87].

6. Recommendations to Define the General Scope of the Thesis Research

Some recommendations and suggestions are given to start the research process, mainly defining the topic to be investigated and identifying the research problem. The initial steps

that students must follow when addressing the need to develop a thesis research project will be described. Figure 3 shows the basic steps that students must follow in the development of his research.

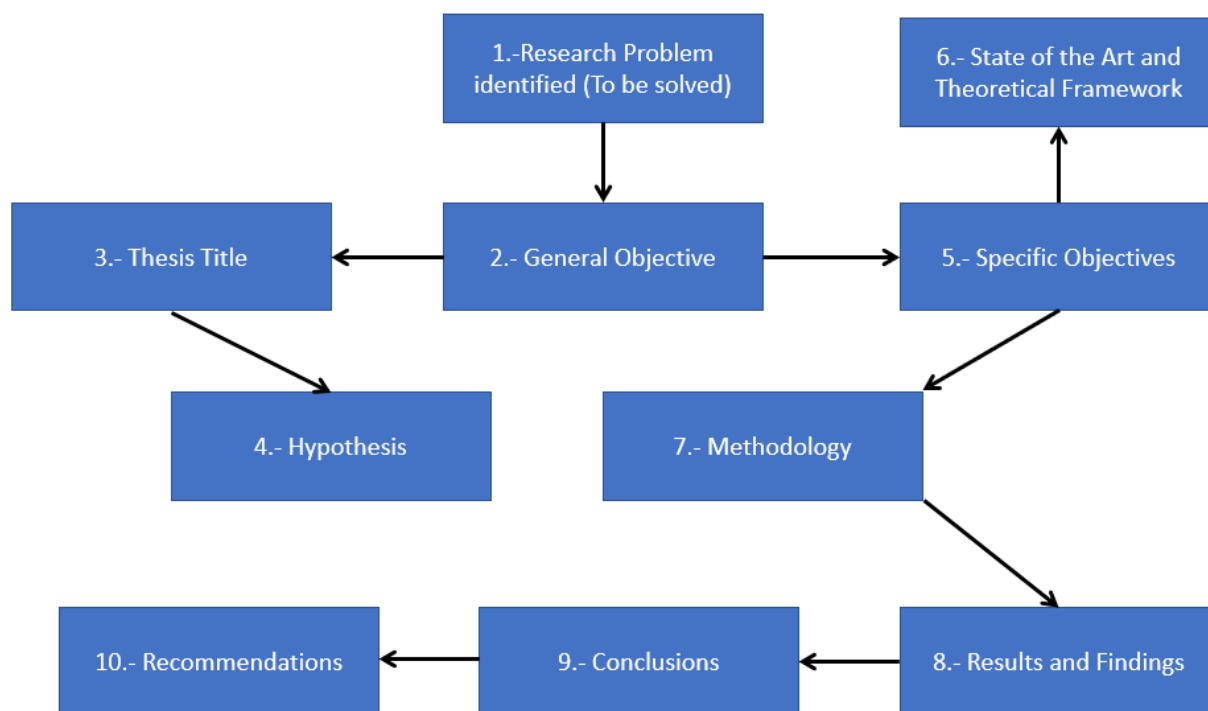


Figure 3. Schematical map to define the general scope of the thesis research.

The recommendation is to identify the initial topic depending on the engineering program; once the topic has been identified, the next step is to identify the research problem to be solved, then the general objective must be defined to later define a tentative title for the thesis. After that, a working hypothesis must be defined, and then the specific objectives of the investigation must be defined. In parallel, the state-of-the-art, theoretical framework, and methodology to be used in the investigation must be considered. Finally, is needed to have a notion of the results, conclusions, and recommendations to be obtained.

The engineering programs to which these recommendations apply include, among others, the list shown below in Table 1:

Table 1. Typical Undergraduate Engineering Programs.

Undergraduate Engineering Programs		
Civil engineering	Metallurgical engineering	Geological engineering
Environmental engineering	Electrical engineering	Business and Economics engineering
Mining engineering	Electronics engineering	Industrial engineering
Mechanical engineering	Computational engineering	Coastal engineering
Chemical engineering	Agricultural engineering	Biomedical engineering

6.1. Identification of Research Topic

The possible research topics are varied, and students must choose according to their affinity, experience in practices or work, or previously acquired knowledge; if, for example, select the Environmental Engineering Program, it is possible to show in Figure 4 some topics for analysis:

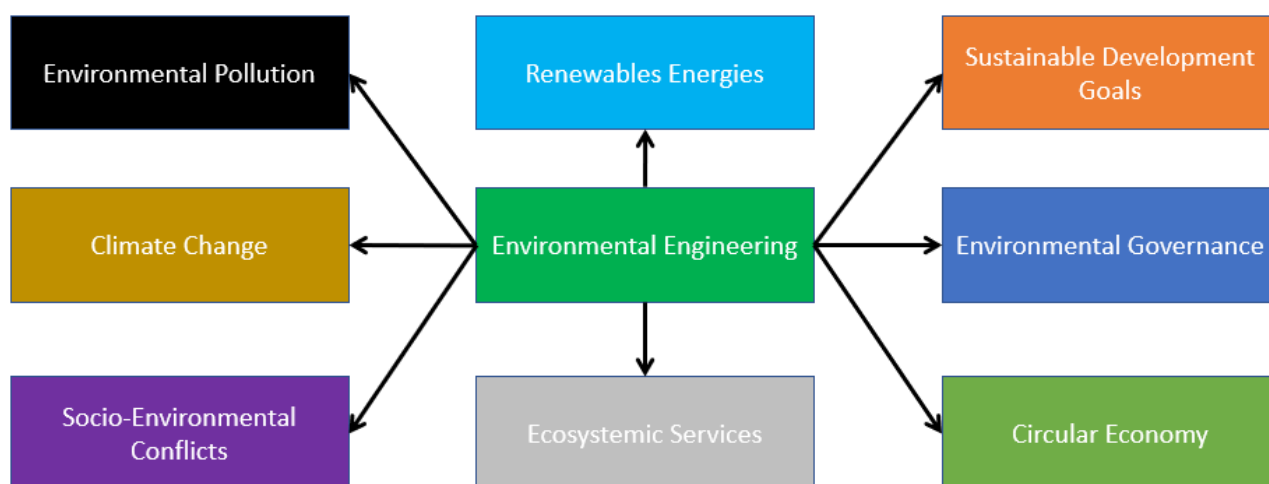


Figure 4. Example of Research Topic Selection for Environmental Engineering Undergraduate Program.

6.2. Identification of the Research Problem

Once the research topic has been selected, the next step is to identify all the research problems related to the topic. It is important to communicate to the students that they must select the research problem, considering two fundamental aspects: (i) choosing a topic of their interest, and (ii) the level of knowledge in the topic to be investigated. In addition, it is key to highlight that the research problem must be replicated in various scenarios and validated by information or scientific background. Figure 5 shows an example of the environmental engineering program on the choice of the research problem:

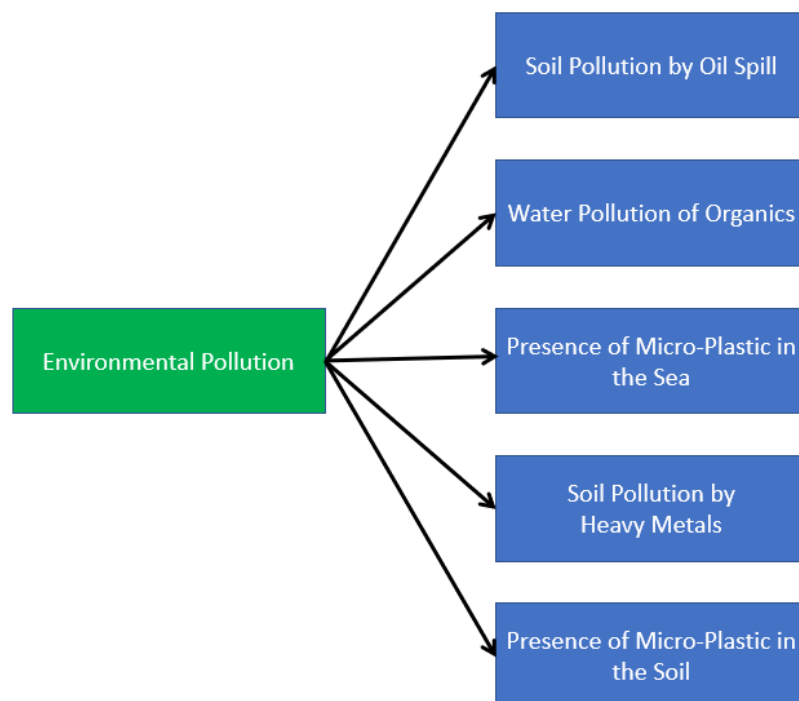


Figure 5. Example of Research Problem Selection for Environmental Engineering Program.

7. Table of Contents Structure Model to Write the Thesis Manuscript

This chapter of the article provides a methodological guide whose objective is to guide the undergraduate student in elaborating a research work corresponding to a thesis to obtain the professional title of engineer within engineering programs.

Figure 6 shows a basic and elementary structure to formulate a thesis investigation for an undergraduate engineering program. Every student must comprehend and understand the logical meaning of this structure before starting to write his thesis research manuscript [88–91].

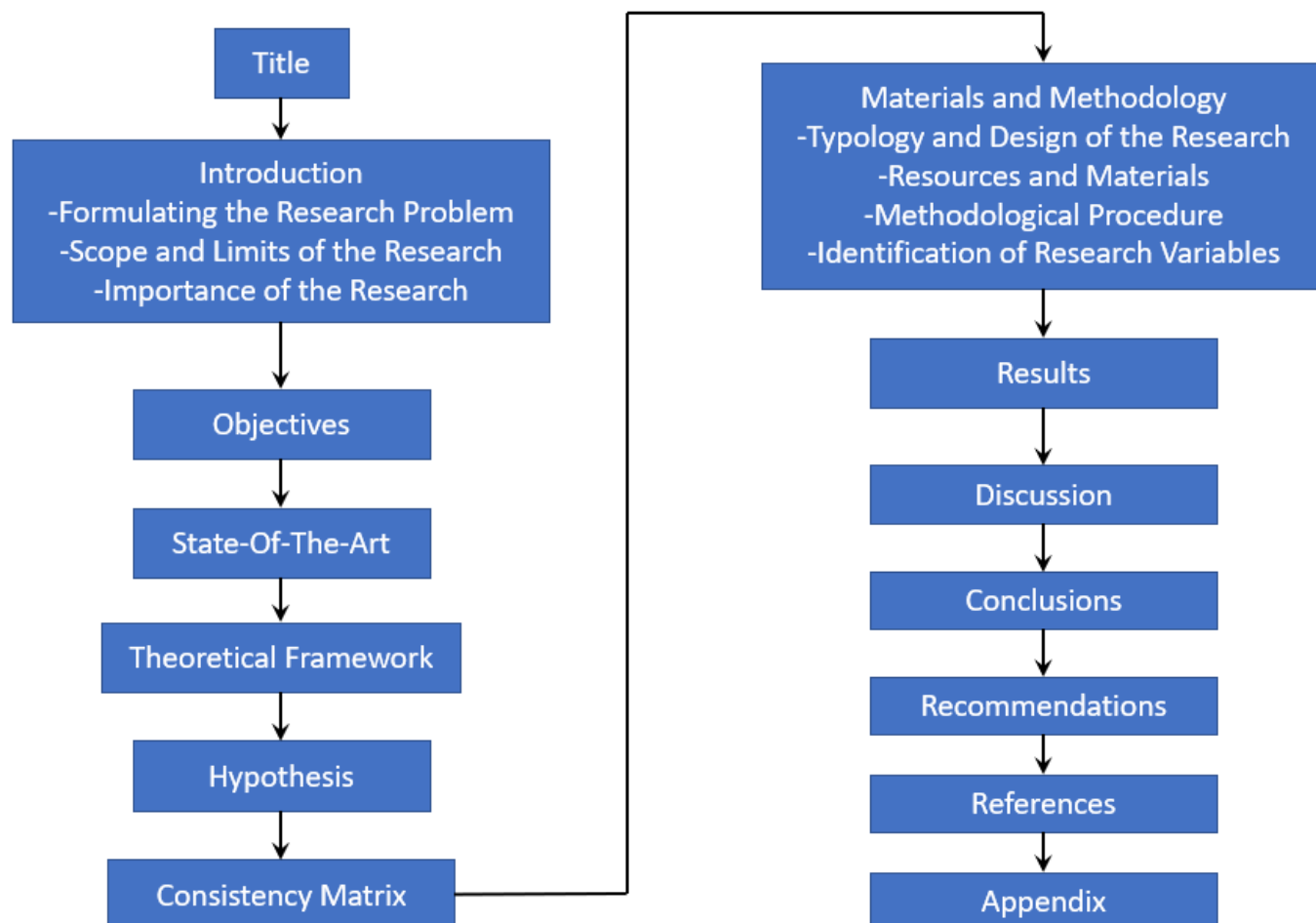


Figure 6. Example of Structure Model to Write the Thesis Manuscript.

The methodological guide that is explained below in this chapter has been created considering the requirements of engineering programs. It is essential that this thesis structure format be used by students in its entirety to comply with the substance and form requirements of the thesis research work.

It is also valid to mention that the specific topic of each thesis investigation may justify an adjustment of the design proposed in this chapter of the article.

7.1. Thesis Title

The title should be created to captivate or capture the attention of potential readers of the research thesis. Briefly and assertively, you must summarize and indicate the topics to be studied in the thesis research.

It is suggested that the title does not exceed 18 words in total and that the use of acronyms and company names should be suppressed/minimized. The title of the thesis is only mentioned on the thesis cover page of the thesis.

7.2. Thesis Content Index

The contents index must not contain consecutive points between the item name and the page numbers, and it is recommended to follow the indications for its elaboration as established by the APA 7th edition format (See Figure 7) [91].

THESIS TITLE	2
THESIS COVER	2
THESIS DEFENSE COMMITTEE	2
THESIS EPIGRAPH.....	2
THESIS CONTENT INDEX	3
THESIS TABLE INDEX.....	4
THESIS FIGURE INDEX.....	4
THESIS APPENDIX INDEX	4
THESIS DEDICATION	4
THESIS ACKNOWLEDGMENT.....	4
ABSTRACT IN LOCAL LANGUAGE	4
ABSTRACT IN ENGLISH LANGUAGE	4
1 INTRODUCTION.....	5
1.1 FORMULATING THE RESEARCH PROBLEM.....	5
1.2 SCOPE AND LIMITS OF THE RESEARCH.....	6
1.3 IMPORTANCE OF THE RESEARCH	7
2 OBJECTIVES.....	8
2.1 GENERAL OBJECTIVE.....	8
2.2 SPECIFIC OBJECTIVES	8
3 STATE-OF-THE-ART	9
4 THEORETICAL FRAMEWORK	11
5 HYPOTHESIS	12
6 CONSISTENCY MATRIX	13
7 MATERIALS AND METHODOLOGY.....	14
7.1 TYPOLOGY AND DESIGN OF THE RESEARCH.....	14
7.2 RESOURCES AND MATERIALS.....	14
7.3 METHODOLOGICAL PROCEDURE	14
7.4 ANALYSIS UNITS	14
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9.1 CONCLUSIONS	18
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Figure 7. Example of thesis content index.

7.3. Thesis Consistency Matrix

A double-entry table or matrix is prepared, preferably on a single page, in which all the thesis work is reflected in the most succinct way. This matrix can function as a kind of check form or checklist. There are various matrix models, but each model must be adapted to each thesis. Maximum $1\frac{1}{2}$ pages, it is recommended to use a small font size. This element is extremely important because it is possible to develop it at the beginning of the thesis research approach. His capacity for synthesis helps the student have a clearer picture of the research work. An example is shown in the following Table 2:

Table 2. Example of Thesis Consistency Matrix.

Thesis Consistency Matrix				
General Problem	Objectives	Hypothesis	Variables	Methodology
	General Objective	General Hypothesis	Dependent Variables	
1.-				Typology
				Design Method
Specific Problems	Specific Objectives	Specific Hypothesis	Independent Variables	
1.-				
2.-				
3.-				Resources and Materials

8. Directions for Preparing Oral Presentation of Research—Thesis Defense

In order to carry out the oral presentation of the thesis research in the support instance, it is necessary that the students have the security and sufficient empowerment of the subject of study in order to be able to support the results obtained. It is important that students, prior to this instance, prepare by practicing their oratory and argumentation skills to face the questions from the thesis committee. The use of technical and formal language is appropriate for this presentation; the use of idioms and colloquial language should be avoided. In addition, the personal presentation and formal dress are necessary to give due seriousness to this instance [92].

It is advisable to design the presentation through MS Power Point, Prezi, or other software, jointly between the thesis advisors and students, in such a way as to create a clear, attractive, and assertive presentation. In this presentation, emphasis should be given to showing mainly the objectives, methodology, results, and conclusions obtained in the research work. It is important to make it clear to the students that all the information indicated on the slides is fully mastered technically by them; they should avoid placing any type of information that is not mastered or unknown. All additional information complementary to the investigation must be placed in an annex chapter within the presentation and shown to the thesis jury if they request it [21].

Another relevant aspect that students must consider when preparing their presentation is the maximum duration of 45 min. Students must be careful not to exceed the time allowed, so as not to inconvenience the thesis jury and delay the thesis defense.

It is relevant to mention that the students, when answering the questions of the professors who are part of the thesis jury, must answer in the most precise, clear, and concise way possible, avoiding providing extensive and confusing answers. Students must demonstrate full mastery of the research topic and adequately argue, giving due support to their answers [18].

Finally, point out to the students that they can enjoy this important moment, an instance in which they are given the opportunity to teach the findings and results of their thesis research work, where the professors of the thesis jury have the objective of listening to the experience carried out by the students and generating a high-level technical discussion to endorse the research carried out.

9. Discussion

9.1. Advances and Lessons Learned

The current context of education implies recognizing that designing educational training means thinking that knowledge will be managed through smart mobile digital electronic devices such as cell phones, tablets, ipods [93], therefore:

- Links must be shared.
- The content must be brief and of quality.
- Consider different learning styles.
- Make the most of your time with clear purposes.

The current challenges for teaching consider an education 4.0 paradigm relevant to the new technological concept:

- The new reality post-COVID-19 pandemic: education is carried out at home or remotely, through hybrid education, teleworking, and self-employment connectivity [27,45,46].
- Prospects: Review our study programs and graduation adjusted to this reality, review new competencies and professional skills, train for new ways of working and undertaking, and identify the specific demands of professionals in the labor and productive sectors [26,38,58].

University professors have learned that they must keep up to date in this dizzying era of the digital information, where new applications and tools related to information and communication technologies (ICTs) appear every day [35,36,38].

In addition, authors can mention that in engineering undergraduate thesis research, one must act with principles of ethics and morality when using the ChatGPT tool due to [94]:

- Data privacy;
- Unequal access to information;
- Authenticity and plagiarism;
- Human responsibility:

As a lesson learned, each time new technologies appear, they must be handled and managed with care and caution, studying, and understanding the scope and limitations of their application to later validate and promote their massive use in society [94].

Another lesson learned is related to the promotion of the humanization of knowledge and avoiding falling into a dehumanization of knowledge considering the new information and communication technologies (ICTs) that could generate in certain cases some threats such as: less dialogue/discussion between people, operationalization/automation of activities, and non-application of critical thinking, among others. Considering this, the authors of this article highlight the essence of the teaching-learning process based on the relationship between epistemology, ontology, and axiology. In the context of the development of a thesis investigation, epistemology is related to the generation/construction of knowledge; on the other hand, ontology refers to the meaning/sense of knowledge; and finally, axiology refers to putting knowledge into practice for decision-making in everyday human life. This is how the thesis advisor should encourage and guide students in the relationship of “knowing”, “being”, and “doing” as a fundamental trilogy in knowledge management in thesis research with a human approach to a transcendent meaning. Furthermore, in the next subchapter, what refers to responsible conduct in undergraduate thesis research in engineering programs will be explained in more detail.

9.2. Implications of Sustainable Development Goals (SDGs) on Engineering Thesis Research

University approaches that promote research have gained importance by internalizing and promoting the sustainable development goals (SDGs) in engineering programs (IEA, 2021). The text issued by (IEA, 2021) mentions that “When students solve complex engineering problems, they analyze and evaluate the impacts on society, the economy and the environment” (sections WK1, WK5, and WK7). The engineer, with his level of

knowledge, mastery of technologies, and responsibility, contributes to the entire society as a whole and to sustainable development. Despite the advances in the promotion of the sustainable development goals (SDGs), some of these criteria still do not coincide with those considered in the formation of certain engineering schools [95]. Therefore, there are still challenges to meet to internalize the philosophy of the 17 sustainable development goals (SDGs) in academic training and in the development of research in engineering programs [96] (see Figure 8). In this same context, these aspects are addressed by the World Federation of Engineering Organizations (WFEO) in the WFEO Engineering Plan 2030 [97]. One of the 10 Principles mentions: “Ensure appropriate standards in engineering education that address the current and future needs of industry and society, including pedagogical teaching approaches, the use of technology, and graduate’s student outcomes”. In this way, compliance with sustainable development goal (SDG) number 4, called quality education, is promoted [98].



Figure 8. Agreements to meet the future challenges of engineering education of the International Engineering Alliance (IEA) in the context of the UN sustainable development goals (SDGs) [96].

Engineering research in a sustainable development context is essential. Undergraduate students in engineering programs can make it a reality by preparing their thesis research. Therefore, these investigations must fulfill their social role through science and knowledge with an emphasis on sustainability, the protection of peace and democracy, respecting cultural diversity and coexistence, and articulating a harmonious relationship between the academy, society, and the environment [98].

9.3. Ethical Aspects for a Responsible Research Conduct

According to the document Attributes of Graduates and Professional Competencies of the International Engineering Alliance (IEA) [99], one of the most important organizations for engineering education in the world, regarding the attributes of a graduate in terms of research (section WA4), a graduate “Carries out investigations of complex engineering problems using research methods, including knowledge based on research, design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions (section WK8)”. Considering the International Engineering Alliance (IEA), the thesis research is the means to accurately evaluate all this knowledge and do-

mains that a graduate must meet to best ensure good professional performance. Under this term, the elaboration of thesis research with sustainability criteria accompanied by ethical principles (section WK8) becomes a pertinent topic today in a highly technological context. Throughout its history, this document has undergone changes and improvements, motivated by the different constructive criticisms made, which have encouraged the application of accreditation criteria for engineering programs around the world [98,100,101].

To discuss ethical aspects of responsible conduct in research, it is necessary to define some concepts and answer the following question: What is scientific integrity? It corresponds to a framework of principles and values to ensure that research is conducted honestly and accurately [102,103]. This is how it is now possible to define what is responsible conduct in research, where it corresponds to the way of acting according to the principles and values of science, when an investigation is proposed, developed, evaluated, or reported, which contributes to this conduct yourself honestly and accurately [104,105].

Responsible conduct in research reflects the commitment and integrity of researchers (professors and students), who adhere to the norms of science when they propose, develop, evaluate, or report research results, contributing to the achievement a credible, accurate, valuable, and lasting scientific record [106].

In the current context of the digitalization of information, it is important to mention why we should be concerned with promoting responsible conduct in research:

- To maintain public confidence in researchers and research results: (i) promote the advancement of science, positive regulation, and new funding for scientific development, (ii) encourage the creation of new collaborations and opportunities for jobs, and valuable people are encouraged to take an interest in science and research [102,107].
- Inappropriate conduct in research can lead to bad decisions and cause serious damage at the individual and public levels [102,107].
- Inadequate conduct in research wastes resources such as funds, time, and effort and damages the prestige of the scientific community [102,107].

Additionally, it is possible to mention that education 4.0 paradigm should consider and encourage responsible conduct in research in both professors and students, which should be characterized by the following educational practices [26,28,41]:

- Honesty and impartiality in the proposal, realization, and presentation of research reports or publications.
- Recognition and disclosure of conflicts of interest.
- Accuracy and fairness in the representation of contributions to research proposals, reports, and publications.
- Fulfillment of mutual responsibilities between mentors and mentees.
- Competition and equity in peer review.
- Collegiality, collaboration in scientific interactions, communications, and resource sharing.

Regarding the use and implementation of artificial intelligence (AI) tools such as ChatGPT in education, for example in the formulation and development of thesis research, to date in the year 2023, it is possible to mention that it is an underdeveloped field and is in a full exploration stage, both for professors and students [94].

According to the experience of some professors, it has been possible to identify some restrictions and limitations of the artificial intelligence (AI) tool ChatGPT, which are:

- **Incorrect or inconsistent answers:** It has been noticed that on some occasions the answers given are incorrect or inconsistent, therefore, it is recommended that an expert professor in the subject to be investigated always validate the information provided by ChatGPT [78,80,86,108].
- **Sensitivity to the wording of the prompt:** It has been identified that the artificial intelligence tool is very sensitive to the formulation of the research question or prompt, for which reason it is recommended to test with a set of questions validated by an

expert professor in the thematic field that uses keywords recognized in the scientific literature in such a way to improve the precision in the answers [78,80,86,108].

- **Lack of in-depth contextual understanding:** A lack of in-depth contextual understanding of the topics consulted has been observed in the ChatGPT responses; this may be due to a lack of updating of the database, which requires expert support by a competent professor in the subject to be investigated with this tool [78,80,86,108].

Finally, according to the authors of this article, there are some threats to learning and teaching that must be considered, carefully analyzed, and discussed by university professors; these are the following:

- **Excessive dependence on artificial intelligence (AI):** It may happen that some students and professors become dependent on this tool, promoting a movement where the thinking and reasoning of people are not encouraged; this must be avoided.
- **Academic dishonesty:** This is dangerous and must be considered carefully, ensuring that students do not improperly cite or reference their thesis research papers, give due recognition to other authors, and avoid the practice of plagiarism.
- **Production of incorrect or inconsistent responses:** As mentioned earlier in this article, students should be advised by an expert professor in the research topic in order to validate and discuss the responses of artificial intelligence tools such as chatbots.
- **Trends and biases:** Due to their little experience using even chatbots, they may have trends or biases in their responses to their users; this should improve over time as these databases are fed with a greater amount of information and can self-learn more considering the use of many users worldwide.

Today, there are tools for the detection of improper use of ChatGPT; these tools are the following:

- Open-sourced GPT-Zero is an AI model with some mathematical formulation to determine if a particular text fed to it is written by AI or a human being.
- DetectGPT (ChatGPT Killer) is a tool created to identify texts written by ChatGPT or similar chatbots.

9.4. Future Directions

It is important to educate undergraduate engineering students that developing their thesis research is an important process in their professional training, which will allow them to learn to apply the scientific method to solve engineering problems and will also allow them to meet the requirements to obtain their professional license or professional title and thus practice their profession in the workplace [109].

It is key to promote students with an educational seal where recognition is given to the information and knowledge generated by other authors, thus eradicating negative research practices such as plagiarism. It is important that professors analyze and discuss with students the negative consequences of this activity in the field of research and knowledge creation. It is key that university professors create a culture where responsible writing techniques and procedures are taught that prevent plagiarism and facilitate the writing process for students. It is necessary that the thesis manuscripts be submitted to a similarity and plagiarism analysis by the thesis advisors, using the available software tools such as, for example, Safe Assign, Turnitin, iThenticate, Paper Rater, Plagium, Viper, and Grammarly, among others [110–113]. Thus, it is also important to define the maximum percentage of similarity that the manuscripts can have, with a valid range between 5% and 10%, a criterion defined by each university. In this context, it is relevant to teach students the different types of citations that exist and that they can use in their thesis manuscripts, considering direct and indirect citations. Technological software alternatives from bibliographic managers such as Mendeley, Zotero, EndNote, RefWorks, and others make it possible to properly cite and reference the bibliography in thesis manuscripts [12]. Nowadays, in the age of the internet, information technologies, and the application of artificial intelligence for the

development of tools that facilitate people's lives, it is important to promote clear ethical principles and responsible conduct in research among university students [7].

Thesis advisors should instill in their students' discipline in carrying out their thesis research, along with promoting their acquisition of frustration tolerance in case their progress is slower than what was considered in their expectations. Planning is a fundamental activity in the thesis work, where the student must be able to efficiently manage their resources: bibliographic, academic materials, economic, and time [114–119].

On the other hand, it is important that universities in their engineering programs at the undergraduate level clearly define the minimum content that thesis manuscripts must have through a protocol-type document that is public to students, generating a standard content structure of thesis research. This will make it possible to have clear rules between professors and students, facilitating the thesis research work for both parties [120].

Academic experience indicates that it is key to have an adequate number of professors who can advise a reasonable number of students in their thesis research so that professors can dedicate sufficient time to their students in the processes of reading, reviewing, and giving feedback in advising the thesis work [22].

A recurring observation by engineering students indicates that, although in the university most of the professors at engineering schools have a doctorate or master's degree, together with their professional experience in engineering projects, not all have adequate teaching capacity and sufficient pedagogical skills to teach content, being more engineers than teachers themselves. For this reason, it is key that the professors who teach thesis research courses develop adequate teaching skills to teach the contents to the students, applying clear, precise, motivating methodologies and, with the use of casuistry and technological tools, awakening the interest of learning by students. In this context, considering the demands of society, is very important to develop Teaching and Research (T&R) skills in the professors that have a job in the Higher Education Institutions (HEIs).

In some universities today, as a trend, the promotion of publishing their thesis research is being implemented not only in the repositories of the university but also in prestigious national and international journals. This has even, in some cases, meant the publication of scientific articles from some undergraduate research between students and professors in important journals indexed in the scientific databases of Scopus and Web of Science [121].

The evolution of the education 4.0 paradigm is still in the process of continuous improvement. The educational scope will depend on the speed of change and the social, educational, and political contexts in which the university institutions will develop. Currently, the world is facing a rapid and vertiginous growth of technology with influence in almost all fields of science and education, which must be used for the benefit of society, mainly respecting ethical aspects and the integrity of the human person [122,123]. The application of cutting-edge information and communication technologies (ICTs) in undergraduate engineering programs could be described as disruptive, scalable, and sustainable, with the possibility of promoting a sustainable university education in accordance with the UN sustainable development goals (SDGs) [31,124].

The impacts of learning, personal identity, and professional satisfaction are positively and closely related. The learning obtained and the professional satisfaction of achieving the professional title of engineer upon successful completion of the thesis research, can influence job opportunities as well as the human development of the person [122,125]. The fact of leaving a legacy, contributing, or generating knowledge, depending on the level or novelty of the contribution, can strongly influence the motivation of the human person since it transcends time and materializes a work of one's own authorship applying everything learned in university life. In this process, where a stage as a student ends and another stage as a professional begins, marks a milestone in the personal lives of students. This leads to valuing more extracurricular activities and knowledge in work contexts about what has been learned. Many times, the experience of preparing a thesis by solving a problem from a real case study gives professionals the tools and knowledge to better address difficult and complex situations in the world of work [124].

Finally, when this article mentions the concept of carrying out a sustainable university education, it refers to generating and updating knowledge based on learning from students' daily experiences, encouraging research, increasing know-how, and allowing the linkage with the national and international professional environment, both in the short, medium, and long term. This gives the possibility of creating an ecosystem of continuous learning over time considering different professional experiences in the field of engineering, which can transcend to multidisciplinary work fields where it is necessary to solve problems of society that are multidimensional, multiscale, and highly complex, such as the adaptation and mitigation of climate change [126–132].

10. Conclusions

To develop a sustainable university education in engineering programs at the undergraduate level, it is necessary to implement educational systems of continuous advice between professors and students in the formulation of a thesis investigation. It is necessary to encourage the writing ability of engineering students by not only teaching the writing of technical reports but also encouraging the development of creativity and innovation in a thesis research work. In the same way, it is relevant to educate engineering students in aspects of oratory with the use of appropriate technical language, with the objective that argumentation skills and the support of ideas are capacities that allow them to improve their professional future in aspects of leadership and work in multidisciplinary teams.

Engineering is a necessary profession for society in its different areas of specialization, and day by day, the preparation of professionals who adequately handle new technologies in a globalized world becomes more necessary. In this context, it is necessary to prepare engineering students at the undergraduate level with a holistic and comprehensive vision of the world, instilling the idea that the problems to be solved are complex in nature. This means that to achieve sustainability in the world, it is necessary to consider social, economic, and environmental dimensions in engineering projects. In addition, it is necessary to work in multidisciplinary teams where not only engineers but also other professionals from different areas of knowledge participate. This vision to face real complex global problems should be taught in undergraduate engineering programs through thesis research, allowing for adequate definition of the research problems, setting objectives, developing a methodological procedure, finding novel results, and conclusions, and thus forming in students the skills of critical thinking and complex problem solving.

Education 4.0 signifies the paradigm of a new educational revolution, one that unites advanced knowledge techniques with intelligent digital technologies to create digital models of teaching that would not only be interconnected and autonomous but could also communicate, analyze, and use data to drive more smart action back into the physical student world. It represents the ways in which smart and connected technology would be integrated into organizations, people, and assets and is marked by the emergence of technological capabilities such as massive sensor implementation, big data analysis, artificial intelligence (AI), machine learning, the internet of things (IoT), digital twins, cloud storage, 3D printers, virtual/augmented reality, 5G internet, automation, robotics, cybersecurity, nano-technology, additive manufacturing, and advanced materials.

Below are the main considerations for carrying out a professor 4.0 practice:

- Embracing 4.0 aptitude: Understanding the different perspectives of learning 4.0 and promoting them.
- Action Planning: Defining clear objectives, goals, and contents, which recognize the current context and the real educational possibilities.
- Incorporate 4.0 strategies: Developing activities with innovative purposes for the creation of new knowledge.
- Create valuable content: Socialize your own and/or collective production on the Web, constantly teaching topics in your area.
- Educate for today and for tomorrow by focusing on making creative, proactive, and viable decisions that solve real and complex problems by innovating.

- Link teaching with professionalization: Recognizing employment or entrepreneurial perspectives, their new contexts, and preparing to face them.
- Constant updating and training on trends, applications, programs, and tools according to your area.
- Networking: Participate and/or create professor networks to help each other, share materials, create content, and exchange knowledge and experiences.

It is important to strengthen the link with society and generate alliances between academy and industry to develop undergraduate thesis research in engineering that allows solving contingent problems of work. It is feasible to carry out an exchange of experiences, both between academics, students, and professional engineers from the industry, thus complementing theoretical and practical knowledge. In addition, these alliances can allow the partial or complete financing of undergraduate thesis research, thus allowing the investment of these economic resources in purchases of software licenses, supporting field trips, the acquisition of materials, and the purchase of books, among others.

Artificial intelligence (AI) tools of the chatbot type, such as ChatGPT, applied to the formulation and development of thesis research are in the exploration stage. It is recommended that professors and students use and handle it with adequate caution, always seeking advice from a person who is a specialist in the subject on which this tool is to be consulted to validate the answers given. The authors of this article recommend carrying out more studies and research on the use of this tool in the formulation of theses to improve and specify the scope, limits, and restrictions of its use, considering in the academy the development of responsible conduct in research.

It is important to humanize education, fostering the capacity for dialogue, debate, discussion, and critical thinking in students, and not fall into a dehumanization of education threatened by individualism, mastery of machines/robots, operation/automation of activities, and a lack of reasoning, among others, considering the implementation of information and communication technologies (ICTs) in this digital era. This means promoting the epistemology-ontology-axiology trilogy of knowledge management in a sustainable manner in the teaching-learning processes between professors and students, with the support of new technologies but with a sense of human transcendence in the daily tasks of life.

Finally, it is important to point out that the process of developing undergraduate thesis research in engineering programs can have a relevant impact on education, awakening interest in some students to continue a professional career related to university teaching or research and motivating the start of postgraduate studies for a master's or doctorate program. This opens the doors of students to the globalized world, allowing mobility to different universities in different countries, thus generating an exchange of human, technical, and cultural experiences.

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Abbreviations

APA	American Physiological Association
IEEE	Institute of Electrical and Electronics Engineers
SDGs	Sustainable Development Goals

UN	United Nations
ICTs	Information and Communication Technologies
STEM	Science, Technology, Engineering, and Mathematics, teaching and learning model
STEAM	Science, Technology, Engineering, Arts, and Mathematics, teaching and learning model
SSLH	Social Sciences, Languages and Humanities scientific areas
HEIs	Higher Educational Institutions
T&R	Teaching and Research
IEA	International Engineering Alliance

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