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Competencias técnicas en ingeniería renovable para el desarrollo de proyectos sostenibles

Technical competences in renewable energy for the development of sostenible projects

Competências técnicas em engenharia renovável para o desenvolvimento de projetos sustentáveis

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Resumen

La ocupación por combatir los efectos que conlleva el agotamiento de los recursos para la supervivencia de la humanidad han sido eje para la generación de planes que buscan disminuir sus efectos, después de múltiples acciones se ha generado la Agenda 2030 para el desarrollo sostenible, por esta razón, es necesario coadyuvar a las generaciones futuras para que cuenten con competencias para alcanzar los objetivos, posicionando a la educación como agente principal. Las competencias técnicas para el desarrollo de proyectos sostenibles permiten que los desarrolladores tomen decisiones para alcanzar el éxito, otorgando beneficios a todos los involucrados. En este estudio las competencias técnicas se evalúan en cuatro categorías: conocimiento técnico, atributos personales y profesionales, habilidades interpersonales y contexto sostenible en proyectos.

Este estudio realiza una evaluación sobre el nivel de dominio que poseen estudiantes de la Licenciatura en Ingeniería en Energías Renovables sobre las competencias técnicas para el desarrollo de proyectos sostenibles en dos momentos: previo y posterior a una intervención de reforzamiento. La metodología empleada en esta investigación plantea el desarrollo y aplicación de cuestionarios tipo Likert, analizando los resultados estadísticamente de manera descriptiva e inferencial, mostrando el avance en las categorías de estudio e identificando mediante el nivel de dominio los factores que permitan fortalecer estas competencias en estudiantes interesados en el área de desarrollo de proyectos en ingeniería, aportando una categorización de competencias técnicas y una metodología para su evaluación, que a futuro puedan servir para fortalecer currículos en ingeniería renovable.

Palabras clave: Competencias técnicas, desarrollo sostenible, energía renovable, desarrollo de proyectos.

Abstract

The occupation to combat the effects of resource depletion for the survival of humanity has been the axis for the generation of plans that seek to reduce its effects, after multiple actions the 2030 Agenda for sustainable development has been generated, for this reason, it is necessary to help future generations to have skills to achieve the objectives, positioning education as the main agent. Technical competencies for the development of sustainable projects allow developers to make decisions to achieve success, providing benefits to all involved. In this study, technical competencies are assessed in four categories: technical knowledge, personal and professional attributes, interpersonal skills, and sustainable project context.

This study evaluates the domain level of technical competencies for the development of sustainable projects by students of the Bachelor's Degree in Renewable Energy Engineering at two moments: before and after a reinforcement intervention. The methodology y used in this research proposes the development and application of Likert-type questionnaires, analyzing the results statistically in a descriptive and inferential way, showing the progress in the study categories and identifying through the domain level the factors that allow strengthening these competencies in students interested in the area of project development in engineering, providing a categorization of technical competencies and a methodology for their evaluation, which in the future can be used to strengthen renewable engineering curriculum.

Keywords: Technical competences, sustainable development, renewable energy, project development.

Resumo

A ocupação para combater os efeitos do esgotamento dos recursos para a sobrevivência da humanidade tem sido o eixo para a geração de planos que buscam reduzir seus efeitos, após múltiplas ações foi gerada a Agenda 2030 para o desenvolvimento sustentável, por este motivo , é necessário ajudar as gerações futuras para que tenham competências para atingir os objetivos, posicionando a educação como principal agente. As competências técnicas para o desenvolvimento de projetos sustentáveis permitem que os desenvolvedores tomem decisões para alcançar o sucesso, proporcionando benefícios a todos os envolvidos. Neste estudo, as competências técnicas são avaliadas em quatro categorias: conhecimento técnico, atributos pessoais e profissionais, habilidades interpessoais e contexto sustentável em projetos.

Este estudo realiza uma avaliação do nível de domínio que os alunos da Licenciatura em Engenharia de Energias Renováveis têm sobre as competências técnicas para o desenvolvimento de projetos sustentáveis em dois momentos: antes e depois de uma intervenção de reforço. A metodologia utilizada nesta pesquisa propõe o desenvolvimento e aplicação de questionários do tipo Likert, analisando os resultados estatisticamente de forma descritiva e inferencial, mostrando o progresso nas categorias de estudo e identificando através do nível de domínio os fatores que permitem fortalecer essas competências em alunos interessados na área de desenvolvimento de projetos de engenharia, fornecendo uma categorização de competências técnicas e uma metodologia para a sua avaliação, que no futuro poderá servir para fortalecer os currículos em engenharia renovável.

Palavras-chave: Competências técnicas, desenvolvimento sustentável, energias renováveis, desenvolvimento de projetos.

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Introduction

Today, electricity is the main source of energy used to make life more comfortable, and most technological innovations use it to function. Every year, the amount of electricity used in the different sectors: industrial, commercial and residential, is growing, so it is necessary to increase the number of power plants that produce it; however, the effects of the use of fossil fuels in energy generation have contributed to the problems caused by the greenhouse effect. For this reason, efforts have been made to include new technologies in the generation of energy based on renewable energy sources, complying with the sustainability guidelines set out in the 2030 Agenda.

The economic, environmental and social conditions of future generations depend on the current training that students are receiving. For this reason, it is important to assess whether engineers are being trained with a sufficient level of technical skills and also to understand their perception of these skills for the development of projects, so that they use education for sustainable development as the main axis of their knowledge, attitudes and values in favor of preserving adequate living conditions in their environment.

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2014), "education is a fundamental human right (…), it identifies education as an indispensable means for people to develop their capacity and made the completion of a full cycle of primary education a priority". In addition, it places education as a catalyst for development and considers it as a means to achieve the objectives set out in the Sustainable Development Agenda.

Competency-based education arises as a response to the demands of a society subject to exponential growth, where it is intended that individuals have the necessary skills to maintain this increase from various perspectives; from education it is intended that during the time that an individual remains in training, he or she acquires and develops basic skills that allow him or her to integrate and be part of society, acquired during compulsory education. On the other hand, when university studies are achieved and during this training, skills are acquired from a human perspective and another technical one aligned to the area of knowledge, these so-called generic or transversal skills are those that every graduate must possess and that therefore differentiate him or her from other individuals who did not reach this level of study. Finally, through the graduation profiles, which are formed from the needs of the industry, higher education based on competencies seeks that the student has specific skills, which are developed individually according to the application of knowledge (Bienzobas and Barderas, 2010).

In 2011, a study carried out in Peru and Spain called: Generic competencies in the area of engineering, a comparative study between Latin America and the European Union, through a comparison between the models developed by the Conceive Design Implement Operate Initiative (CDIO) and the International Project Management Association (IPMA) determined which competencies should be present in the curricula of Latin America. Based on the competencies established by the IPMA obtained from the Tuning project, in cooperation with the Spanish Agency for Project Engineering (AEIPRO) through the Project Certification Body (OCDP), they selected the necessary competencies that engineering students should have at the end of their education in project management, which they classified into three groups: contextual competencies that consider the theoretical knowledge necessary for project management; behavioural competencies that involve personal characteristics for good performance of engineers; and finally, technical competencies that consider practical knowledge. Seventeen technical competencies were considered, categorized into four groups: technical knowledge and reasoning, personal and professional skills and attributes, interpersonal skills and the last category, conception, design, implementation and operation in the company and the social context (Palma et al., 2011).

Technical skills in engineering

Competency-based training is a proposal that is based on meaningful learning and is aimed at developing comprehensive human training (Tobón, 2005). The role of the teacher must be considered within this sustainable education scheme. Due to the constant evolution of new technologies and challenges, this brings with it a necessary evolution within the classroom and therefore also in teaching functions, which brings with it a systematic evolution in teaching practice and in the educational theories used during this process of change (Fernández Muñoz, 2003). According to Escolano (1996), the teacher plays three basic roles: the technical role, the second role is linked to ethical and social aspects and the third is related to the satisfaction of the students' self-realization needs and their demands for well-being (Escolano, 1996 as cited in Fernández Muñoz, 2003).

Competencies must identify the way to respond to various problems that a person may face and through these identify what is necessary to respond to them. Therefore, competencies are immersed in all the different areas of life and are also related to the components in the dimensions of knowledge, attitudes and procedures that the individual uses in each context (Zabala and Arnau, 2008).

Incorporating the concept of competencies into higher education can be analyzed from a teaching perspective based on extremely complex and diverse approaches, which also involve an immeasurable number of purposes. However, three ways of approaching this teaching can be distinguished: competencies related to attitudes, competencies related to creative capacities and competencies associated with existential and ethical attitudes where the repercussions that one's own professional actions may present are identified (Zabalza, 2003).

Regarding competency-based education in Mexico, the *Official Journal of the Federation* published an agreement in October 2008 establishing the competencies that should be part of the common curricular framework for high school. These competencies are categorized into generic competencies, basic and extended disciplinary competencies, as well as basic and extended professional competencies. The former must be present in all students who graduate from this educational level; on the other hand, the basic disciplinary competencies, as well as the generic ones, must be present in all students upon graduation and are the basis of disciplinary training in all common academic contexts. As for the extended disciplinary competencies, they are not shared by all students; their purpose is to acquire greater depth than the basic ones, giving a specific meaning to the different educational models within the educational subsystems (SEP, 2008).

Finally, basic professional competencies provide students with useful elements in their basic training for work, technical-level capabilities that offer them opportunities to enter a professional practice (SEP, 2008). The formation of professional competencies is supported by national and international regulations and also concerns institutional ones according to the convenience of each one of them. Their construction is developed from the perspective of work, therefore, it is necessary to identify the knowledge, abilities, skills and attitudes that are required for a specific work activity.

Professional competencies in higher education seek the application of knowledge to reach a state of achievement within a work context. They are intended to be developed in accordance with the demands that govern that context. These programs meet specific standards subject to the definition of professional competencies according to each work sector. They are within the objectives of vocational training programs and must be a parameter for the evaluation and certification of said competencies (Bellocchio, 2010).

According to the National Association of Universities and Higher Education Institutions (ANUIES), due to the constant evolution that is taking place in professional careers, the competencies must follow the same rhythm, so higher education institutions will face the need for innovation within their academic processes, focusing mainly on the training of students, as well as on the continuous updating of graduates of these institutions (ANUIES, 2018). To this end, the vision for the year 2030 involves that upon graduation, higher education students have both emotional and intellectual competencies that allow them to have a better incorporation into the labor market, through the mastery of scientific and technical knowledge or so that they can develop entrepreneurial projects independently. In addition, it is intended that higher education institutions remain involved with the design and operation of projects that allow growth in social and economic development.

For the International Project Management Association (IPMA), competencies provide the possibility to make judgments through the right to an opinion on a particular point, being essential for the management of human resources in the industry and in the development of projects. The IPMA competencies are a collection of skills, personal attitudes, knowledge and experience that are necessary to achieve success in specific functions, which is why they are divided into three sectors: competencies in the technical range, competencies in the behavioral range and competencies in the contextual range. Technical competencies include essential competencies for project management, basically establishing how to develop a complete project, on the other hand, those related to behavioral aspects describe the skills and attitudes that must be possessed in project management that allow the increase in the number of participants, while contextual competencies are associated with aspects of the environment of the project itself and determine the relationship between organizations (IPMA , 2006).

Technical competencies depend on each of the specialties and are associated with the ability to achieve results and solve problems using technical models where the knowledge acquired during the stay in the university system is used and in addition to the application of skills and techniques to achieve effective results (Estudios Universitarios Y Superiores De Andalucía EUSA, 2017). From this perspective, it is important to emphasize that, in order to use the techniques and skills developed during university training, it is necessary to place these competencies within the specific disciplines; within these are elements associated with projects, such as: design, evaluation and development of projects, system calculations, management and optimization (Letelier et al., 2005). For this reason, technical competencies in engineering are applied to the development of projects, considering that the skills are associated with them being developed under sustainability standards that allow not only meeting the objectives of the project, but also promoting local and global benefits from an optimization perspective.

Technical competences in engineering comprise complex performance processes that involve knowing how to be, do, understand and live together, so that their integration allows solving problems from a perspective of metacognitive processes that generate ethical commitments and continuous improvement that contribute to personal, social, economic and sustainable development (Tobón, 2008). In this context, the proposal to build technical competences in engineering aims to contribute to the individual development of renewable energy engineering students and, in general, of individuals who are associated with the development of engineering projects and who also use renewable energy sources in them, considering the improvement of social, environmental and economic structures from a technical knowledge and reasoning processes (knowing how to know), which denote the personal and professional attributes that they must possess (knowing how to do), which demonstrate interpersonal skills during the exercise of project development (knowing how to be) and which involve a sustainable context in the development of projects that enhance direct and indirect benefits (knowing how to live together).

Based on these four areas of knowledge, the study variables proposed in this research work are established and the technical skills that must be part of the development of engineering projects with renewable energy sources are included, structured as follows:

I. Technical knowledge and reasoning.

This category is related to knowledge, that is, the knowledge that the graduate of the bachelor’s degree in engineering applied to renewable energy engineering must have and who will have to develop sustainable projects in his professional practice. Within these projects aligned with the international objectives of the 2030 agenda for sustainable development, they must consider that energy is through the use of clean energy and is affordable for the entire population, so that the proportion of energy from renewable sources grows in large proportion (UNESCO, 2015). Within this competence are the following parameters:

a) Project Identification
b) Project development
c) Project Management

d) Project execution

II. Personal and professional attributes.

The personal and professional attributes that the student must possess are related to aspects of the student's own personality and aptitudes within human formation and complex thinking (Tobón, 2004), they are the attributes of each student and the direct competencies associated with the project and those interested in it during its development and must be based on economic, social, cultural, historical, as well as environmental aspects (IPMA, 2006), and consider the following parameters:

a) Project management
b) Analysis and interpretation of results
c) Communication
d) Multidisciplinarity
e) Continuous learning

III. Interpersonal skills

Interpersonal skills are related to the capabilities that the student must have for a better interaction with other elements within a specific context, considering the adequate exchange of information in work centers, through critical acting and an ethical commitment (Pérez-Llantada, 2006) ; in this sense this competence within the development of projects allows the graduate to achieve efficiency in the management processes related to other parties involved and that facilitate the achievement of the objectives established in the different phases of the project and are independent in each specific situation, for this it is necessary to have the following parameters:

a) Efficiency in management
b) Teamwork
c) Professional ethics
d) Professional Responsibility

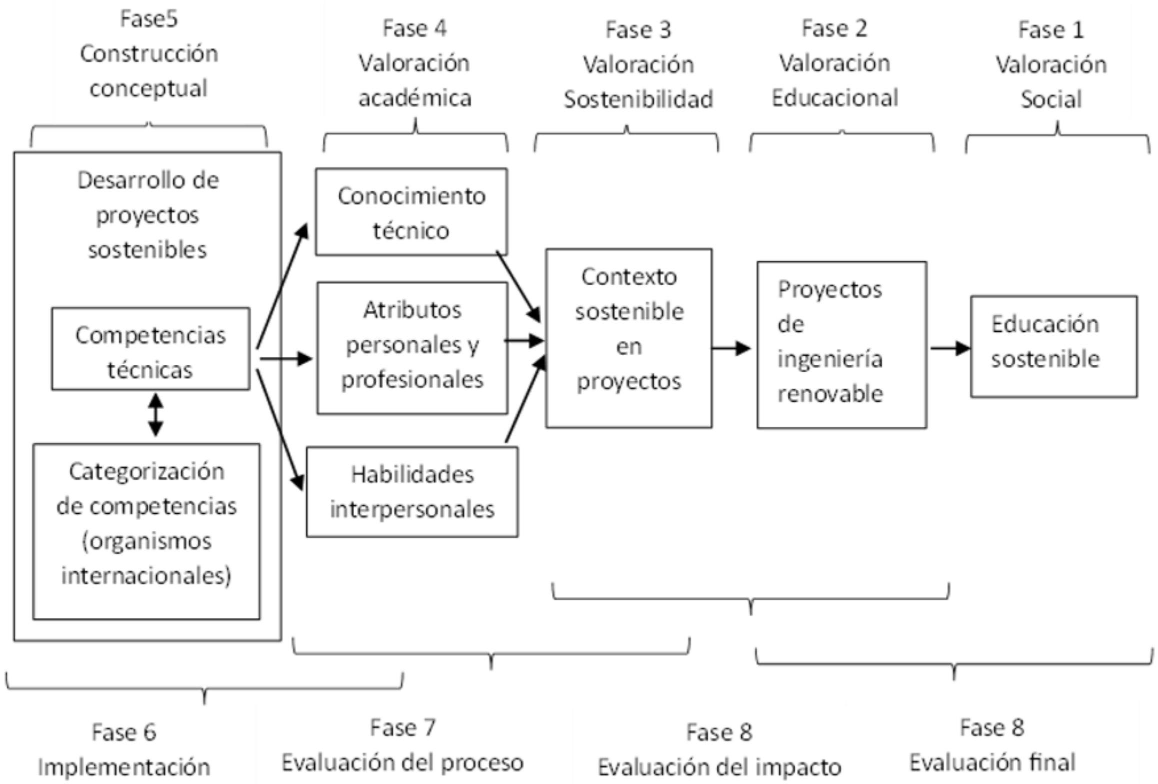
IV. Sustainable context in projects

By possessing competencies on sustainable development in the projects in which graduates of the Bachelor of Engineering are involved, either as participants or with directive and management functions within an energy development project, it is intended that they ensure compliance with the quality and safety aspects that have been associated with the project through the available and current regulations, visualizing each project through geopolitical tools that allow them to put social aspects before personal and/or commercial issues in the projects within the context of the project itself, within an evaluation of the sustainable aspects that have been considered that includes the assessment of social, economic and environmental impacts, within the local and global geographic region, and that the decisions and actions taken to raise these aspects are optimized to achieve better results (Federal Council of Deans in Engineering CONFEDI, 2016), within this competence the following parameters are considered:

a) Identification and mitigation of environmental impacts
b) Social management in project development
c) Local and global economic scope
d) Integration of sustainable aspects into project development

Figure 1 shows the diagram that allowed the conceptualization and categorization of technical competencies for the development of electric power generation projects, which is based on international studies and organizations. It is necessary to carry out an evaluation of these competencies to validate the level that students and future graduates have in the four categories from a sustainable perspective.

Figure 1. Conceptualization of the technical skills development model associated with the development of sustainable projects in renewable engineering.



Source: Adapted from (Classen et al., 2007).

This research work aims to evaluate the technical skills acquired by eighth and ninth semester students of the Bachelor of Renewable Energy Engineering (LIER) for the development of projects for the generation of energy based on renewable sources within a framework of sustainable development.

With the scope established in this research, we aim to identify the professional technical competencies for the development of energy generation projects based on renewable energy sources in Mexico, which serve as a basis for the design of quantitative instruments to evaluate the initial level of mastery that renewable engineering students have, and through an intervention to evaluate the improvement on these, in such a way that a global evaluation of each competence and category is allowed.

Methodology

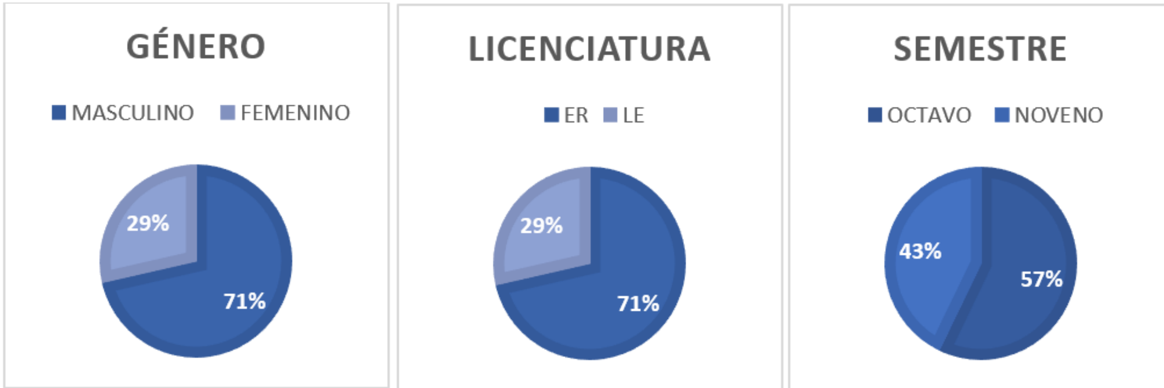
This study considers a quantitative approach with exploratory scope because the phenomenon of study has been little studied (Hernández et al., 2014), since the technical competences in engineering for the development of projects are within the competences that will be applied in the exercise of the profession and there are different perspectives around this area of study, in this sense from the bibliographic review and specialized studies in the development of projects, the construction of the technical competences necessary for an adequate performance of the students in real environments is considered. Regarding the design of the quantitative research, it was decided to use a quasi-experimental design, since it is intended to establish as the main variable in each technical competence the level of mastery that the students present with descriptive statistics, dividing this level into an initial stage and after an intervention, the level of mastery achieved is evaluated, establishing if there is a significant advance with the use of inferential statistical processes.

The quasi-experimental design used in this research process is due to the fact that the phenomenon of study is located within the social sciences, since it is intended to evaluate knowledge and aspects from qualitative and quantitative approaches, in addition to the fact that the study group was not selected randomly, but is part of the researcher's environment (Hernández et al., 2014), with this design it is intended to descriptively evaluate the behavior of the study variables.

Study subjects

The study considered a group of students who were taking courses in the Bachelor's Degree in Renewable Energy at a Public University in the state of Puebla, where they work with technical skills for the development of energy generation projects with renewable energy sources, who are currently studying between the seventh and eighth semester of the Bachelor's Degree in Renewable Energy Engineering, for this reason the selection of the study participants was made to a non-probabilistic sample, choosing a group of 25 students, 71% of these correspond to the male gender, and 29% to the female gender, on the other hand, the same percentage coincides with students of the Bachelor's Degree in Renewable Energy Engineering , and the rest to the Bachelor's Degree in Electronics, 57% studying the eighth semester and 43% the ninth semester.

Figure 2. Sample characteristics.



Source: Own elaboration.

Tools

The developed instrument is a Likert-type questionnaire with the purpose of knowing the favorable or unfavorable positioning before some assertions of key aspects (Hernández et al., 2014) of each technical competence. It was chosen to base the construction of the instrument on the Likert-type questionnaire because it allows interaction with the participants in the study before statements or judgments, choosing four scale levels: strongly agree (mA), agree (dA), disagree (eD), strongly disagree (mD). Through the operationalization of variables, the conceptual and operational definitions of each variable were established, generating for each indicator or technical competence three to four reagents with statements in positive or negative affirmation, this to avoid progressive tendencies in the answers, for example in the competence on the identification of projects, four reagents were generated with positive statements, such as, during the identification of the project the sustainable aspects of the project are considered, and the third item is with a negative statement, the decrease in the use of conventional energies triggers renewable energy projects. When considering negative statements, the order of the positions is also changed, which was also considered when analyzing the results with descriptive and inferential statistics. In total, sixty reagents were generated that were validated and piloted before being applied.

The application of the quantitative instrument was carried out at two moments, before and after the intervention, in order to determine whether there was an increase in the level of mastery, confirming the results with descriptive statistics on the mode of the participants' responses, and reaffirming the result with a hypothesis test, through inferential statistics on the scores achieved in each technical competence.

The instrument consists of 60 reagents distributed in the four study categories, considering between 4 and 5 reagents with positive and negative weights. The following table shows the operationalization of the variables.

Table 1. Operationalization of variables.

Dimension	Variables	Indicators	Items
Technical skills	Technical knowledge – Mastery level	Project Identification	1. (+), 2. (+), 3. (-), 4. (+)
		Project development	5. (+), 6. (-), 7. (+)
		Project Management	8. (+), 9. (+), 10, (-), 11. (+), 12. (-)
		Project execution	13. (+), 14. (-), 15. (+), 16. (-)
	Personal and professional attributes – Level of mastery	Project management	17. (+), 18. (-), 19. (+)
		Analysis and interpretation of results	20. (-), 21. (+), 22. (+)
		Communication	23. (-). 24. (+), 25. (-), 26. (+)
		Multidisciplinarity	27 (-), 28. (-), 29. (+)
		Continuous learning	30. (+), 31. (+), 32. (+)
	Interpersonal Skills – Mastery Level	Efficiency in management	33. (-), 34. (+), 35. (+)
		Teamwork	36. (+), 37. (+), 38. (+)
		Professional ethics	39. (-), 40. (+). 41. (-)
		Professional Responsibility	42. (+), 43. (-), 44. (+)
	Sustainable context in projects – Mastery level	Identification and mitigation of environmental impacts	45. (+), 46. (-), 47. (+), 48. (+)
		Social management in project development	49. (-), 50. (-), 51. (-), 52. (+)
		Local and global economic scope	53. (+), 54. (-), 55. (+), 56. (+)
		Integration of sustainable aspects into project development.	57. (-), 58. (+), 59. (+), 60(+)

Source: Own elaboration.

Procedure

The reliability, viability and pilot tests were carried out based on an expert review, applying a consistency test based on Cronbach's Alpha; this test is intended to measure how reliable the instrument is, considering the responses given by each of the participants in the pilot test. To carry out this analysis, a numerical scale was assigned to each response of the Likert-type questionnaire, such that, depending on whether the proposition is positive or negative, that is, it appears to scale with a positive proposition, the response corresponding to "strongly agree" was given a value of four points, while the response "strongly disagree" was given a value of one point.

In a first result, the Cronbach's Alpha resulted with an unacceptable value, this was with a percentage of fifty-two percent, however, when reviewing the literature and considering that there are negative positions, the items were exchanged so that the answers seemed to be all of a positive character, when making this modification and calculating Cronbach's Alpha again, a reliability percentage of seventy-seven point ninety-three percent was obtained, which is an indicator that the test is reliable and can be replicated to our control group.

As a result of the application of the pilot test, the initial results allowed us to visualize the understanding and structuring of each of the sixty propositions. With this, it was identified that of the sixty propositions, only two participants mentioned that one of the propositions was not understandable. The rest of the participants indicated that they are understandable and established a value position for each of them. With this review, it was found that the instrument is not susceptible to modifications in terms of the content of the structure of each of the propositions, so in this area it can be applied to the control group.

The research process begins with the participation of students in a pre-test, through which the initial levels of mastery were identified, classifying them according to the level of mastery found. Subsequently, an intervention was carried out, consisting of sessions where the theoretical aspects that govern the technical competencies for the development of sustainable projects were reinforced, to finally apply a post-test and, based on the findings found and with the application of the designed instruments, assess these technical competencies.

Table 2. Research methodology.

Design	Pre-experimental
Approach	Exploratory
Instrument	Likert type Questionary, Pretest – Post test
	60 items, 4 mastery levels
Variables	Dependent: Categories, technical competences
	Independent: Mastery level
Analysis	Descriptive Statistics – Measures of Central Tendency (Frequency)
	Inferential Statistics – Sudent T-Test (Total Scores)
Application	Pre-test – 1 initial session
	Intervention – 4 sessions
	Post-test – 1 final session
Subjects	25 participants LIER
	8th y 9th semester
	Non-probabilistic sample

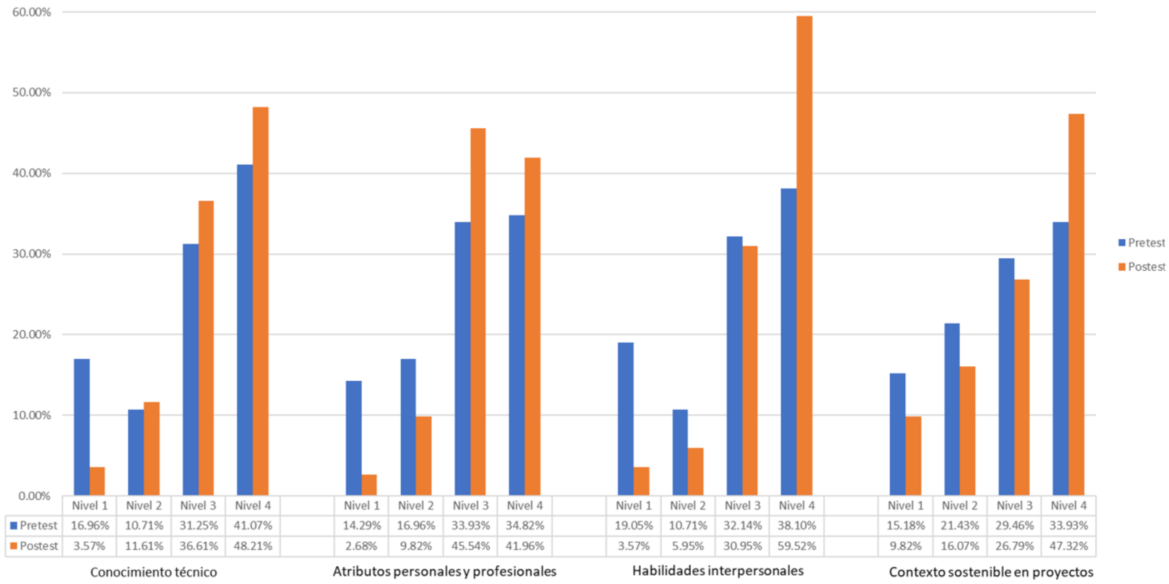
Source: Own elaboration.

The study considers the analysis of the data obtained from the use of descriptive statistics to identify the level of mastery, so that from the evaluation of the most frequent responses the level achieved in each competence is identified, subsequently inferential statistics was used through the Student T Test with paired samples that responds to the hypothesis that establishes that the increase in the level of mastery after an intervention is significant; With these results, a table was made considering the statistical results, identifying the P value, with which it is established if the increase was significant for each technical competence and study category.

Results

After applying the instruments, the results achieved are presented and analyzed, focusing on the initial and final level of mastery that students have regarding the technical skills for the development of energy projects involving renewable energy sources.

Figure 3. Pretest and posttest results.



Source: Own elaboration.

From the above figure we can see the general results for each study variable, considering the mastery levels achieved before and after the intervention. What is expected is a reduction in the initial mastery levels 1 and 2, and what is most desirable is an increase in levels 3 and 4, since this shows that the intervention allowed to increase the mastery levels. This initial analysis is based on descriptive statistics taking into account the frequency at each mastery level. Figure 3 shows that, in the study variables at the initial mastery level, there was a reduction in all of them. On the other hand, the second mastery level showed a reduction in all of the variables, except for technical knowledge. Mastery level three showed an increase in two of the four variables, while level 4 had an increase in all of the competencies presented, giving an initial conception about the usefulness of the intervention.

These results are complemented with the analysis of representativeness and frequency to identify the increases or decreases that each competence presented, subsequently carrying out a detailed review and analysis of each technical competence as well as statistical validation with inferential tools.

By performing an analysis of the results according to the study categories, the percentage representativeness is obtained considering the frequencies in the responses obtained, so that the percentages that represent the level of mastery achieved in each of the study categories can be seen and thus it is known if there is progress in the acquisition of knowledge after the intervention on the development of sustainable projects in renewable engineering. The following table shows the results achieved.

Table 3. Pretest vs Posttest comparison table.

		Pretest		Posttest	
Categories	Mastery level	Frequency	Representativeness [%]	Frequency	Representativeness [%]
Technical knowledge	1	19	16.96	4	3.57
	2	12	10.71	13	11.61
	3	35	31.25	41	36.61
	4	46	41.07	54	48.21
Personal and professional attributes	1	16	14.29	3	2.68
	2	19	16.96	10	8.93
	3	38	33.93	51	45.54
	4	39	34.82	48	41.86
Interpersonal skills	1	16	19.05	3	3.57
	2	9	10.71	5	5.9
	3	27	32.14	26	30.95
	4	32	38.10	50	59.52
Sustainable context in projects	1	17	15.18	11	9.82
	2	24	21.43	18	16.07
	3	33	29.46	30	26.79
	4	38	33.93	53	47.32

Source: Own elaboration.

From the results shown in the table above, it can be observed that the study category that reflects the greatest mastery by students prior to the intervention is technical knowledge, at this value it represents a representation of 41%, corresponding to the subjects who are at a maximum level of knowledge in accordance with the technical knowledge for the development of sustainable projects. On the other hand, the category that has the least representation is associated with the sustainable context in projects, with a total of 38 events located at mastery level four representing 34%. Regarding personal and professional attributes, 35% of the responses given by the quantitative instrument prior to the intervention are located at the maximum level of mastery, while interpersonal skills reached 38% at the same level.

The results of the post-test show a notable increase in interpersonal skills, with more than 21% of students reaching the highest level of mastery. In general, all study categories showed an increase in mastery levels after the intervention. Specifically, the technical knowledge category showed an increase of more than 7%, personal and professional attributes increased by 8%, and the category associated with the sustainable context in projects achieved an increase of 13%.

Evaluating the overall results of the pretest with inferential statistics, using the Student T Test, the main analysis parameters are shown in the following table.

Table 4. Statistical-descriptive: overall results.

Pretest		*Posttest*	
Average	2.89	Average	3.27
Typical error	0.1170	Typical error	0.0755
Standard deviation	0.9068	Standard deviation	0.5848
Sample variance	0.8222	Sample variance	0.3420
Kurtosis	-0.9592	Kurtosis	1.1957
Coefficient of asymmetry	-0.7468	Coefficient of asymmetry	-1.3611
Range	2.85	Range	2.42
Minimum	1.14	Minimum	1.57
Maximum	4	Maximum	4
Addition	173.57	Addition	196.71
Account	60	Account	60
Confidence level (95.0%)	0.2342	Confidence level (95.0%)	0.2848

Source: Own elaboration.

From the descriptive statistics associated with the quantitative instruments, it is initially observed the improvement that exists when carrying out the intervention going from an average of 2.89 to 3.27 in the level of mastery, also in the posttest it is observed that the standard deviation and therefore the variance decreases, which indicates that in the results the dispersion of these decreases, with respect to the mode and the median, which represent the most repeated values and the intermediate values and there is a slight variation in the results since there was an increase in the levels of mastery. In both instruments to obtain the descriptive statistical data, the means of each of the reagents were considered according to what was answered by the students. Below, the results are shown individually in each of the study categories, making a statistical analysis to show the results achieved.

By performing an analysis supported by inferential statistics, using a hypothesis test based on the Student T test for paired samples, posing as null hypothesis that there was no significant progress in the level of mastery identified after applying the pretest, or that the progress was maintained, leaving the null hypothesis as follows, $H_0: \mu_d \leq 0$. On the other hand, the alternative hypothesis indicates that there was progress in the level of mastery, through the difference of the results obtained after applying the posttest with the pretest, the statement of the alternative hypothesis was posed as follows $H_1: \mu_d > 0$, this test was carried out with a confidence level of 95% and a level of significance $\alpha = 0.05$.

The following table shows the results of the Student T test for the totals of the responses obtained from the different levels of mastery achieved, it is observed that the average obtained in the application of the post-test is higher than that obtained at the beginning of the intervention with the pre-test, through the results of the T test, it is observed that the critical value of one tail is 1.94, and the result of the T statistic of 7.83, when raising the hypothesis of one tail to the right, the result of the statistic is outside the acceptance of the null hypothesis, therefore this hypothesis is not accepted, and the statement of the alternative hypothesis is then accepted, confirming that with a confidence level of 95%, the application of the intervention reflects a significant positive difference in the progress of the level of mastery of the technical competencies for the development of projects in renewable engineering under a sustainable development framework.

Table 5. Inferential statistics: overall results.

Global results	*Posttest*	*Pretest*
Average	196.71	173.57
Variance	90.90	19.61
Observations	7	7
Pearson correlation coefficient	0.5846	
Hypothetical difference of the means	0	
Degrees of freedom	6	
t-statistic	7.8305	
P(T<=t) one tail	0.0001145	
Critical value of t (one-tailed)	1.9431	

Source: Own elaboration.

The results for each study category are shown below.

Technical knowledge

The assessment instrument proposed in this research study includes a total of 16 items for the technical knowledge category, divided into four technical competencies, which are: project identification, project development, project management and project execution. First, the results of the descriptive statistics are shown based on the mode presented by each item, with the purpose of identifying the most representative level of mastery in each of the study categories.

Table 6. Descriptive statistics: Technical knowledge.

Technical knowledge	*Pretest*	*Posttest*
Average	2.964	3.294
Typical error	0.1037	0.0767
Standard deviation	1.0981	0.8124
Sample variance	1.2059	0.6601
Kurtosis	-0.8191	0.4323
Coefficient of asymmetry	-0.7179	-1.0027
Range	3	3
Minimum	1	1
Maximum	4	4
Addition	332	369
Account	112	112
Confidence level (95.0%)	0.2056	0.1521
Mastery level		
Level 1	16.96%	3.57%
Level 2	10.71%	11.61%
Level 3	31.25%	36.61%
Level 4	41.07%	48.21%

Source: Own elaboration.

From the results in the table above, an increase is observed in the mean, moving to a mastery level of 3.29, while initially in the pretest the level was located at 2.96 points out of a maximum of 4 possible points. Descriptively, an advance is observed in the level of mastery after the application of the intervention, analyzing the increases in the different levels of mastery after the intervention, it is observed that the students are located with 48.21% at the maximum level of mastery, while with 36.61% at level 3, which is an acceptable level, and that, in a percentage less than 15% they are located in the lowest levels of mastery; When compared with the levels located in the pretest, a significant increase is observed in the response level 4 and 3, a significant decrease is seen in the mastery level 1 after the intervention, with these results it is evident that in the category of technical knowledge there was a significant increase in the acceptable and maximum mastery levels, this result was corroborated with the inferential statistics shown below.

Table 7. Inferential statistics: Technical knowledge.

Technical knowledge	*Posttest*	*Pretest*
Average	52.714	47.429
Variance	9.238	8.952
Observations	7	7
Pearson correlation coefficient	0.675	
Hypothetical difference of the means	0	
Degrees of freedom	6	
t-statistic	5.7551	
P(T<=t) one tail	0.0006	
Critical value of t (one-tailed)	1.9432	

Source: Own elaboration.

With a confidence level of 95%, the Student T test was applied to the technical knowledge category, finding that there is no significant difference in the progress of the level of mastery, on the other hand, the critical value was located at 1.94, while the statistical value T was 5.75, the value obtained is in the area where the null hypothesis is not accepted, therefore the alternative hypothesis is accepted indicating that there was a significant increase in the level of mastery associated with this category, which is reflected in the increase in the mean going from 47.42 points to 52.71 after the intervention.

Personal and professional attributes

The category of personal and professional attributes considers the qualities that students possess around their own personality and aptitudes for the development of projects in a sustainable environment and must be based on economic, social, cultural, historical and environmental aspects. This category considers project management, analysis and interpretation of results, communication, multidisciplinary and continuous learning. This category is made up of 16 total reagents.

Table 8. Descriptive statistics: Personal and professional attributes.

Personal and professional attributes	Pretest	Posttest
Average	2.8928	3.2678
Typical error	0.0985	0.0705
Standard deviation	1.0428	0.7471
Sample variance	1.0875	0.5582
Kurtosis	-0.8630	0.6262
Coefficient of asymmetry	-0.5585	-0.8784
Range	3	3
Minimum	1	1
Maximum	4	4
Addition	324	366
Account	112	112
level (95.0%)	0.1952	0.1398
Mastery level		
Level 1	14.29%	2.68%
Level 2	16.96%	9.82%
Level 3	33.93%	45.54%
Level 4	34.82%	41.96%

Source: Own elaboration.

In this study category it is observed that the value of the mean in the pretest was located at 2.89 while in the posttest it was 3.26, which shows an advance in the level of mastery. On the other hand, when reviewing how the mastery levels one and 2 were formed, associated with a minimum level of mastery and a deficient level, going from 14.29% to 2.68% in level one and from 16.96% to 9.82% in level 2, while in levels 3 and 4 corresponding to acceptable and maximum mastery levels an increase is observed, the most representative is associated with level 3 going from 33.93% in the pretest to 45.54% in the posttest and level 4 going from 34.82 to 41.96; From these results it is observed that there is an increase in the level of mastery in this study category, which is corroborated by the inferential analysis shown below.

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Table 9. Inferential statistics: Personal and professional attributes.

Personal and professional attributes	Posttest	Pretest
Average	52.571	46.286
Variance	17.286	8.905
Observations	7	7
Pearson correlation coefficient	0.267	
Hypothetical difference of the means	0	
Degrees of freedom	6	
t-statistic	3.759	
P(T<=t) one tail	0.005	
Critical value of t (one-tailed)	1.943	

Source: Own elaboration.

The inferential analysis shows that the critical value T with a right tail is 1.94, while the result of the statistical value of is 3.75, located outside the acceptance value of the null hypothesis, therefore, the alternative hypothesis is accepted, indicating that there is significant progress in this category of study.

Interpersonal skills

This category of study considers the skills associated with the capacities that the student must have to achieve a better interaction with other elements associated with a specific context that allow adequate communication and exchange of information in the different work centers, considering critical action and ethical commitment, and allows students to achieve efficiency in the management processes involved in the project, facilitating the achievement of objectives in each of the activities and phases, also allowing the integration of sustainable aspects in a tangible way. The formation of this category within the evaluation instrument considers a total of 12 reagents and four competencies: efficiency in management, teamwork, ethics and professional responsibility.

Table 10. Descriptive statistics Interpersonal skills.

Interpersonal skills	*Pretest*	*Posttest*
Average	2.8929	3.4643
Typical error	0.1222	0.0837
Standard deviation	1.1196	0.7675
Sample variance	1.2534	0.5891
Kurtosis	-0.9749	2.0744
Coefficient of asymmetry	-0.6285	-1.5153
Range	3	3
Minimum	1	1
Maximum	4	4
Addition	243	291
Account	84	84
Confidence level (95.0%)	0.2429	0.1665
Mastery level		
Level 1	19.05%	3.57%
Level 2	10.71%	5.95%
Level 3	32.14%	30.95%
Level 4	38.10%	59.52%

Source: Own elaboration.

The statistical results associated with this category of study show that there is an increase in the mean of the modes in the students' responses after the intervention, going from 2.89 to 3.46. A decrease is observed in the standard deviation and the variance, evidencing a lower dispersion in the data and consequently the responses given by the students. On the other hand, regarding the levels of mastery, a decrease is observed in level one, associated with the minimum level of mastery, going from 19 points zero 5 to 3.57%, regarding level 2 a decrease is observed in the post-test reaching a total of 5.95%, at level 3, considered as an acceptable level, a decrease is observed from 3.14 to 30.95%, finally at level 4 is where the greatest increase is shown, this level is associated with the maximum possible level to reach, and the result shows that it went from 38.10% to 59.52%, these results show that there is an increase in the levels of mastery associated with this category.

Table 11. Inferential statistics: Interpersonal skills.

Interpersonal skills	*Posttest*	*Pretest*
Average	41,571	34.714
Variance	5.619	3.905
Observations	7	7
Pearson correlation coefficient	0.041	
Hypothetical difference of the means	0	
Degrees of freedom	6	
t-statistic	6	
P(T<=t) one tail	0.0005	
Critical value of t (one-tailed)	1.9432	

Source: Own elaboration.

As a result, an increase is observed in the total score after the intervention, going from 34.71 to 41.57 points, evaluating the critical value of T for a tail to the right, it is observed that it is located at 1.94, while the T statistic is located at 6, so this value is outside the acceptance region of the null hypothesis and consequently the alternative hypothesis is accepted, indicating that there was an increase in the level of mastery for this study category and that this is significant, in addition it is observed that the P value is lower than the alpha value of 0.05, associated with the level of confidence, corroborating the result.

Sustainable context in projects

The competence associated with the sustainable context in projects considers that students who are in management or directive roles consider compliance with the quality and safety aspects that are considered in current regulations, in order to allow putting social, economic and environmental aspects first in projects at a local and global level, optimizing the results in a way that they do naturally integrate the sustainable aspects of project development.

Table 12. Descriptive statistics: Sustainable context in projects.

Sustainable context in projects	*Pretest*	*Posttest*
Average	2.8214	3.1161
Typical error	0.1008	0.0955
Standard deviation	1.0672	1.0112
Sample variance	1.1390	1.0224
Kurtosis	-1.0935	-0.5281
Coefficient of asymmetry	-0.4047	-0.8224
Range	3	3
Minimum	1	1
Maximum	4	4
Addition	316	349
Account	112	112
Confidence level (95.0%)	0.1998	0.1893
Mastery level		
Level 1	15.18%	9.82%
Level 2	21.43%	16.07%
Level 3	29.46%	26.79%
Level 4	33.93%	47.32%

Source: Own elaboration.

Carrying out the descriptive analysis for this category, which is shown in the table above, it is observed that after the application of the intervention there was an increase in the mean, going from 2.82 points to 3.11 points in the level of mastery associated with this category. Analyzing individually the levels of mastery presented in each of the tests, a reduction is observed in mastery level 1 as well as in mastery level 2, similarly in domain level 3 there was a slight decrease, going from 29.46% to 26.79% in the reagents associated with this category, in domain level four there was a significant increase, this associated with the maximum possible level, going from 33.93% to 47.32%, with this it is observed that descriptively the level of mastery was improved in this study category.

Table 13. Inferential statistics: Sustainable context in projects.

Sustainable context in projects	*Posttest*	*Pretest*
Average	49,857	45.143
*Variance	12.476	4.143
Observations	7	7
Pearson correlation coefficient	0.212	
Hypothetical difference of the means	0	
Degrees of freedom	6	
t-statistic	3.3857	
P(T<=t) one tail	0.0074	
Critical value of t (one-tailed)	1.9432	

Source: Own elaboration.

The inferential analysis carried out on this category detailed in the table above shows a slight increase after the intervention evidenced by a reach of 49.85 points, and that, initially, 45.14 points were reached, these data associated with the responses of the reagents associated with this category, on the other hand, when performing the Student T test for paired samples, considering a hypothesis statement associated with statistically evidencing a significant increase in the level of mastery after the intervention, in this test the critical value is 1.94, while the T statistic is 3.38, this value is located in the acceptance region of the alternative hypothesis, in addition to the fact that the value is lower than the alpha value associated with the level of significance, this shows a significant increase in this study category.

Similarly, individual analyses of each technical competency were carried out ~~,~~ which are shown in the following table, where the important elements that statistically show the evaluation of the levels of mastery are highlighted.

Table 14. Quantitative results.

Dependent variable	Representative level of mastery		Increase in the average	P-Value
	Pretest	Posttest		
Technical knowledge	N4 41.07%	N4 48.21%	11.14%	<0.001
Project Identification	N4 35.71%	N4 64.29%	24.39%	<0.001
Project development	N4 42.68%	N4 61.90%	22.58%	<0.001
Project Management	N3 28.57%	N3 42.86%	15.78%	0.0017
Project execution	N3 35.717%	N3 28.57%	-12.90%	0.015
Personal and professional attributes	N3 33.93%	N3 45.54%	12.96%	0.005
Project management	N4 33.33%	N4 52.38%	15.87%	0.031
Analysis and interpretation of results	N3 33.33%	N3 52.38%	7.93%	0.155
Communication	N3 21.43%	N3 39.29%	6.09%	0.127
Multidisciplinarity	N4 0.00%	N4 33.33%	57.14%	0.001
Continuous learning	N3 47.62%	N3 47.62%	-17.90%	0.229
Interpersonal skills	N4 38.10%	N4 59.52%	19.75%	<0.001
Efficiency in management	N4 33.33%	N4 47.52%	24.13%	0.013
Teamwork	N3 33.33%	N3 38.10%	-9.09%	0.160
Professional ethics	N4 33.33%	N4 71.43%	55.31%	<0.001
Professional Responsibility	N4 19.05%	N4 61.90%	24.59%	0.002
Sustainable context in projects	N4 33.93%	N4 47.32%	10.44%	0.007
Identification and mitigation of environmental impacts	N4 35.71%	N4 50.00%	7.31%	0.099
Social management in project development	N4 25.00%	N4 28.57%	7.24%	0.278
Local and global economic scope	N3 25.00%	N3 35.71%	7.69%	0.099
Integration of sustainable aspects into project development	N4 35.71%	N4 71.43%	18.39%	0.023

Source: Own elaboration.

The table above presents a summary of the most representative results for each competency, ranging from descriptive to inferential assessment. It shows the most significant level of mastery at the beginning and end of the intervention, considering the frequency of responses. It also includes the percentage increase in the mean of the total scores and the P-value obtained through the inferential statistics test, which is associated with the level of significance for the hypothesis test, demonstrating that there was progress after the intervention in the different levels of mastery.

Discussion

Since the instruments, methodology and results were designed specifically for this study, there is no evidence of similar studies with which they can be compared, so the discussion focuses on the results and the analysis of the study variables.

After applying the instruments, Figure 2 shows the general results of the pretest and posttest, which show the progress in the levels of mastery of the study categories, given that the intervention intended to strengthen the mastery of these competencies through an academic intervention, the results show that there was indeed progress in the level of mastery in each category, increasing the percentage values in the high mastery levels, corresponding to levels 3 and 4.

These results also show that students already have technical skills in mind as a tool for the development of renewable energy projects, and that the intervention fulfilled its main purpose. It is also worth mentioning that the study group is in the last semester of the Renewable Energy Engineering degree, so it is important to mention the presence of these skills at the beginning of the research work. The results also coincide with the general results shown in Table 4, where the statistical analysis shows that this study group showed progress in the level of mastery, reaching 3.27, which corresponds to a wide level. The value reached in the standard deviation shows a greater dispersion of values in the pretest, so that after the intervention, the general knowledge of the skills was more homogeneous in the participants.

Regarding the global inferential statistical analysis, the hypothesis test delivers a P value greater than 1.9, which indicates a rejection of the null hypothesis and consequently an acceptance of the alternative, showing that the increase in the level of mastery is significant. This result was achieved considering seven observations that correspond to the students who satisfactorily completed the research exercise and therefore are limited to the number of participants, but with acceptable results.

Performing an individual analysis of each study category, in the technical competencies corresponding to the technical knowledge that includes the knowledge that students must possess so that the developed projects have a greater probability of success in each of its stages, it shows a significant advance in the hypothesis test; as well as in the descriptive analysis with increases in the levels of mastery, these results show that despite having knowledge at an average level, these were reinforced during the academic intervention, like the global results, the sample size for this analysis considered seven observations that correspond to the students who completed the study satisfactorily.

The results corresponding to the category of personal and professional attributes, being those technical competences that allow students to correctly apply knowledge in their professional practice, also show a significant increase in the level of mastery of the technical competences that comprise them, the descriptive values show an advance in each study parameter, when comparing the descriptive and inferential values, in both cases there is an improvement in the levels of mastery that, as in the previous cases, seven observations were considered.

The category corresponding to interpersonal skills, which includes technical competencies that allow for adequate professional development in the application of competencies, also shows an increase in the levels of mastery both descriptively and inferentially, with seven observations in the latter. Finally, in the category that includes technical competencies that allow for achieving a sustainable context for engineering projects, significant increases are also shown in this category of study because of the descriptive and inferential analysis.

It is worth mentioning that within the study categories in the inferential analysis, technical competencies were presented where the progress achieved was not significant, these correspond to the analysis and interpretation of results, communication, continuous learning within personal and professional attributes, as well as teamwork within interpersonal skills, and teamwork for the sustainable context in projects, which are competencies that involve professional practice in the field, which being an academic study does not allow practice in these competencies, so it would be worth considering a practice exercise where the application of these competencies is allowed.

Based on the results of this study, it is worth mentioning that there were deficiencies in student participation as a result of the study being conducted in a pandemic context and online. However, the exercise demonstrated that it is possible to categorize and measure the levels of mastery of technical skills for the development of engineering projects that consider renewable sources of energy aligned with sustainable development, which is of utmost importance to strengthen energy generation sources while preserving resources and promoting a sustainable future.

Comparison with similar studies

When comparing the results with other similar studies, reference is made to the theoretical construction of technical skills in engineering. The study carried out by Bienzobas and Barderas (2010) based on a bibliographic review describes the levels of skills to be developed within the Mexican curriculum, which are important since they show the level of skills that are necessary for the professional practice of students, giving meaning to the learning acquired during the school career through problem solving or the construction of projects. In this research work, the levels of skills in the university environment are introduced, emphasizing the specific skills generated from professional profiles and contrasted with the requirements of the productive sector, classifying them into disciplinary and professional, categorizing technical skills within professional skills, considering exclusively the development or construction of projects when carrying out evaluations to determine a level of skills for a specific professional practice, which is part of the main objective of this research.

On the other hand, in 2011 a study carried out in Peru and Spain called: Generic competencies in the area of engineering, a comparative study between Latin America and the European Union (Palma et al., 2011), resumed research work where the necessary professional competencies in engineering were determined, which were classified into three groups: contextual competencies, behavioral competencies and finally, technical competencies that consider practical knowledge. This work contributes to the present research to establish the classification and categorization of technical competencies for the development of engineering projects based on specialized international organizations.

A study based on a literature review, which used Likert-type surveys to engineering professionals in the industry through a quantitative approach, identified the professional skills that engineering graduates in the industry must possess (Shamshina, 2014). The conclusions of this work show that: on the one hand, the link between sustainable development and construction was made only through literature and it was evident that there are multiple interpretations and definitions, which, however, in sustainable construction leadership plays an important role since it will be able to carry out sustainable projects reaching In addition, higher productivity. As evidenced by this study, in the evaluation of competencies associated with the development and management of projects with respect to the functionality of a project, there is a marked lack of this category, considering also that in this study sustainability aspects were not taken into account, so the contribution that is made about this lack is important, which is addressed in the present research work, especially based on the technical competencies of students about to graduate from an engineering degree.

Finally, a mixed study evaluating population-based health promotion for the safety of older drivers considers two main phases, a systematic evaluation of the causes and on the other hand, the political and bureaucratic factors (Classen et al., 2007). In this study, the interrelation between the causal factors of car accidents is evaluated from a socio-ecological perspective, considering a statistical multivariate analysis. As a conclusion of this study, the multi-causal factors for the safety of older drivers and their interaction with behavioral and health factors were determined.

The methodology of this study served as a reference for the construction and evaluation of technical competencies, as well as the statistical validation of the intervention. The results obtained with inferential analysis were taken up in this research work, however, they were applied to the area of education and evaluation of technical competencies for the development of projects.

Limitations of the study

This study was carried out in a context where academic activities were carried out online, so the application of instruments and intervention were carried out completely online, where physical interaction with the participants was null, this is reflected in the continuous participation of the students and in the possible results, therefore, it is expected that by replicating this study in a context free of health threats it may present more favorable results, taking into account that in essence the results and objectives were met, it is expected that more favorable results may be presented. Similarly, the number of initial and final participants in the intervention was different, therefore, it was necessary to adjust the statistical analysis to the final number. It is intended that by carrying out the study in person, there may be greater participation and with more generalized results. The results achieved and the methodology used allow this study to be replicated in other areas, however, the theoretical construction of the competencies is an important contribution that must be adjusted to each context where it is intended to be replicated.

The relevance of this study is notable in the context of the need to have specialists in the development of projects that naturally adopt the criteria of sustainable development to procure resources and continue with technological development in various areas of renewable engineering.

Conclusion

The inferential and descriptive statistical analysis carried out on the results of the research exercise were possible due to the creation, validation and reliability of the instruments designed from a theoretical review of the main aspects that govern technical competencies from a professionalizing approach, taking as reference seventeen technical competencies, classified into four categories: technical knowledge, personal and professional attributes, interpersonal skills and sustainable context in projects. In addition, the initial application of the instruments provides an approach to the level that eighth and ninth semester students of the LIER have on technical competencies for project evaluation.

The quantitative analysis carried out before and after the intervention established the level of mastery in each category and technical competence. The level of mastery was obtained from a descriptive statistical analysis based on the frequency of the responses of each reagent that make up the different competencies, finding the level of mastery achieved before and after the intervention. To strengthen the analysis, a hypothesis test was carried out that aims to evaluate whether the level of mastery achieved was significant. This test was based on the Student T test, reinforcing the quantitative results under an inferential analysis process. The results found allowed to show, according to the level of mastery of each technical competence, the degree of progress presented before and after the intervention, as well as the verification through an inferential evaluation on the level of significance of the progress presented.

The results found by combining the level of mastery and the Student T test, show the competencies with the greatest increase in the level of mastery after an intervention, obtaining that interpersonal skills are those that presented a greater inferentially validated increase, initially found at 38%, reaching 60% after the intervention, on the other hand, personal attributes and the sustainable context in projects, are those that presented a lower initial level, while technical knowledge is the competency with the highest initial level.

On the other hand, when reviewing the technical competencies that make up each category, the largest increases in the means after the intervention show the competencies that had the greatest development in this exercise, highlighting multidisciplinarity and professional ethics, which showed an increase greater than 50%, finding that there was a lack of knowledge of these at the beginning and that the intervention managed to reinforce it. Some competencies were identified that after the intervention show a decrease, among them are the execution of projects, continuous learning and teamwork. These competencies are associated with professional practice, for this reason is that after the intervention aspects were identified that were not taken into account and that in the final evaluation were recognized as deficient.

Finally, there are inferential statistics that after the T test show that the growth is not significant, since the variation in its increase is less than 10%, these correspond to analysis and interpretation of results, communication, continuous learning, teamwork, identification and mitigation of environmental impacts, social management in the development of projects and local and global economic scope, in these competencies the results show variations in the means; However, from the inferential statistics there are no conclusive results, so it is necessary to investigate the factors that yield these results.

From the findings found in this research work, it was identified that the intervention helped to improve the levels of mastery of the technical competencies for the development of sustainable projects in renewable engineering, highlighting the creation of instruments for their measurement and identification, as well as the specific aspects necessary to strengthen these competencies in renewable engineering students, which will help future project developers have technical tools, knowledge, skills and practices that improve the conditions of the projects in which they are related, thus contributing to the fulfillment of sustainable objectives set in the 2030 agenda, which can also be integrated as academic strategies today to strengthen these competencies.

Future lines of research

It is necessary to consider the assessment of qualitative aspects within the research so that the way in which students perceive technical skills can be investigated and it can be assessed whether it is aligned with sustainable development criteria that allow contributing to the achievement of objectives; in this sense, it is essential to consider carrying out a mixed study, to triangulate the results of this study concurrently with the qualitative ones and to allow the assessment of the presence of technical skills in renewable engineering students, their perception and alignment with sustainability criteria.

Since the proposal for categorizing technical competencies is aligned with the development of engineering projects, its study can be extended to projects outside the field of renewable energy. Likewise, the methodology used can be applied to the evaluation of other professional competencies, so it is suggested to replicate this study in another area of engineering or some other field of study that involves competencies in the professional field.

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