

## Environmental education and ethics in Civil Engineering study programs in the Puno region, Peru

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### Abstract

The objective of the study is to analyze the level of environmental education and ethics in civil engineering programs in order to propose transversal contents within the curriculum. To evaluate the presence of environmental issues, a Likert scale questionnaire was applied to 260 students and a dichotomous scale to 42 professors and directors of universities in the Puno region. The results indicate that the students have a medium level of environmental ethics in knowledge and skills, while in attitudes and values they have a high level. Regarding the application of the environmental theme by the professors, there is a medium level in the physical, pedagogical and didactic areas and a high level in the academic area; consequently, it is necessary to establish environmental policies explicitly in the strategic plans and study curricula so that future professionals assume their environmental commitment at the time of executing civil infrastructure projects.

*Keywords:* curriculum; education; ethics; engineering; environment.

## Educación y ética ambiental en programas de estudio de Ingeniería Civil en la región Puno, Perú

### Resumen

El objetivo del estudio es analizar el nivel de educación y ética ambiental en los programas de ingeniería civil para proponer contenidos transversales dentro del currículo. Para evaluar la presencia del tema ambiental se aplicó un cuestionario con escala Likert a 260 estudiantes y escala dicotómica a 42 profesores y directivos de las universidades de la región Puno. Los resultados indican que los estudiantes presentan un nivel ético ambiental medio en conocimientos y habilidades mientras que en actitudes y valores se ha presentado un nivel alto. Respecto a la aplicación del tema ambiental por parte de los profesores se presenta un nivel medio en los ámbitos físico, pedagógico y didáctico y un nivel alto en el ámbito académico; en consecuencia, es necesario establecer políticas ambientales de manera explícita en los planes estratégicos y los currículos de estudio para que el futuro profesional asuma su compromiso ambiental al momento de ejecutar proyectos de infraestructura civil.

*Palabras clave:* currículo; educación; ética; ingeniería; medioambiente.

### 1. Introduction

The development of societies advances in accordance with the construction industry which has a great impact on the environment, in that sense sustainability is becoming a key factor in the decision-making process of infrastructure projects throughout their life cycles [1]. This process must be

respectful with the environment in such a way that allows those responsible to choose alternatives in accordance with nature and that the construction of civil works bets on the preservation of the natural environment, with professionals committed to the application of certain construction materials that do not cause negative environmental impacts and with low energy consumption or use of renewable energies, hence

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the essence of the concept of sustainable development coincides with the categorical imperative of environmental ethics and this imperative can be expressed in one word: "Responsibility" [2].

Historically, those responsible for the construction of civil works have not acted with environmental values and responsibility when designing and executing civil projects, thus, environmental education and training arises from the need to mitigate or solve problems related to the environment and one of the main tasks is to seek strategies to develop environmental awareness in human beings, which is reflected in their attitudes and behaviors [3] which have to be formed and made aware from university education, with the inclusion of cross-cutting themes of environmental education in the curricula of civil engineering studies and projected responsibly to society. Thus in an era of increasing pressure from stakeholders to implement sustainable environmental management practices in the workplace, organizations should adopt and apply environmental ethics to achieve a perfect synergy between the needs of business, society and the planet [4].

Likewise, at present the lack of proper education, awareness, knowledge and approach of people towards the environment degrades nature and its resources. There is a need to develop a strong environmental education system with human responsiveness towards nature for sustainability and environmental security [5]. Therefore, it is possible to highlight some aspects that characterize the real problems and development prospects of Education for Sustainable Development [6] that should be taken into account by the university in the curricula and educational process, among which are mentioned: change of curricula that is supported by emotional cognitive skills and abilities of students and their value endowment ecological integrity and equitable welfare, skills and values to students for the formation of a sustainable world, participation of all strata, multifaceted and interdisciplinary education planning and the needs of all groups.

In this sense, the objective of this study is to analyze the environmental ethical level of civil engineering students, to evaluate the level of application of environmental education by the professors involved and to analyze the environmental theme established in the guidelines of academic documents such as the mission, strategic objectives and graduate profile of the Civil Engineering study programs.

### ***1.1 University environmental education***

Since the environment is the set of physical, chemical, biological and social factors capable of causing direct or indirect effects, in the short or long term, on living beings and human activities [7], environmental education is necessary to provide community groups, public officials, companies and industries, and private citizens in general, with the awareness, knowledge and techniques to solve environmental problems, elements necessary to respond to the challenges in an active and successful way, and to guarantee a healthy and sustainable environment for present and future generations [8].

Universities contemplate three basic pillars: teaching, research and social projection or extension, and it is in this

last pillar that university management considers environmental education which should be articulated to all actions in favor of environmental protection [9], thus, environmental education should be transversal in the training of future engineering professionals for the sustainable development of a country, taking into account that it is not an independent discipline, nor an isolated subject of the curriculum, but that it should include everything, i.e. be introduced as a generic theme in the professional training; It should consider local customs and cultures, be linked to experiential situations or coordination with other sectors to promote activities in favor of the environment, and respond to institutional policies contemplated by governmental, non-governmental and non-formal education organizations [10].

In addition, in the case of Peru, universities must take into account the National Environmental Education Policy that establishes the educational process with an environmental focus, which is oriented towards the formation of a new type of citizen, with new values and sense of life based on: respecting and protecting all forms of life (principle of biospheric equity); assuming the environmental impacts and costs of their activity (principle of responsibility); valuing all ancestral knowledge that is an expression of a better environmental relationship between human beings and nature (principle of interculturality); respect the lifestyles of other social groups and cultures, encouraging those that seek harmony with the environment (principle of coexistence); work for present and future human well-being and security, based on respect for the heritage of past generations (principle of intergenerational solidarity) [11].

### ***1.2 Environmental ethics in the curriculum***

Environmental ethics is understood as the philosophical discipline that specifies appropriate human relationships with the natural world [12], in that sense the appropriate level of biodiversity protection is a moral consideration, we adopt an environmental ethics perspective to explain how different levels of protection are associated with different ethical positions on a spectrum ranging from anthropocentrism (where only humans have intrinsic rights) to ecocentrism (where all individuals of all species have intrinsic rights) [13].

Some scholars in the field also call environmental ethics as ecoethics, defining it as the systematic study of human behavior in the area of environmental sciences and it faces two trends: a) The introduction of ecoethical principles in the professional deontologies that directly affect the care or devastation of the environment (environmentalists, engineers, architects, chemists, biologists and other professions offered by universities); b) The introduction of ecoethical principles in the sectorial legislations on environment that at national or international level try to protect and palliate environmental damage [14], the same that should be transversal themes in the curricula of university studies.

In this sense, environmental ethics, as a subdiscipline that addresses the problems arising from the relationship between human productive activities and those that protect the environment and at the same time the human being [15] should

be included in university engineering curricula, mainstreaming the environmental axis in the curriculum with the participation of professors, coordinators and educational authorities, is the best strategy for students to have a training relevant to current needs and requirements, oriented to sustainability [16].

### 1.3 Professional skills and environmental education

Competencies are complex processes of performance with suitability in certain contexts, integrating different knowledge (knowing how to be, knowing how to do, knowing how to know and knowing how to live together), to perform activities and/or solve problems with a sense of challenge, motivation, flexibility, creativity, understanding and entrepreneurship, within a perspective of metacognitive processing, continuous improvement and ethical commitment, with the goal of contributing to personal development, the construction and strengthening of the social fabric, the continuous search for sustainable economic and business development, and the care and protection of the environment and living species [17].

It is common to disaggregate professional engineering competencies into generic and specific competencies. Generic competences are the fundamental competences to achieve personal fulfillment, manage projects, contribute to the ecological balance and act in any occupation, job and/or profession. They are responsible for a large part of the success in life and in the professional world, so it is necessary that they are formed from the family, to basic and higher education in which the environmental theme is integrated. On the other hand, specific competencies are specific to a given profession, have a high degree of specialization, as well as specific educational processes, generally carried out in technical programs, job training and higher education [18].

For the case of Civil Engineering, the Tuning Project proposes a series of specific competencies among which those related to the environmental issue are mentioned: evaluating the environmental and social impact of civil works and proposing solutions that contribute to sustainable development [19]; therefore, the graduate profiles should include these competencies in a transversal manner and should materialize in generic or and specific or professional competencies [20] in which the environmental issue is involved, so as to have future professionals with a critical sense and a culture of environmental sustainability at the time of executing civil engineering projects.

Thus, the graduate profile should not only focus on the work environment, but implies a comprehensive definition of the professional that is expected to be trained, especially in environmental issues. Thus, the graduate profile (as a definition of identity and as a training commitment) is conceived as an instrument that gives meaning to training programs [21] and is the formal statement that the curriculum of a particular profession of the university makes to society.

## 2. Methods and materials

The study was carried out in the department of Puno, Peru. The area has two distinct geographical regions, the highlands and the jungle with a total of 13 provinces and 110

districts, where the study population comes from, Civil Engineering students from three universities present in the research which are: Universidad Nacional del Altiplano Puno (UNAP) based in Puno, Universidad Peruana Unión (UPeU) with a branch in Juliaca and Universidad Andina Néstor Cáceres Velásquez (UANCV) based in Juliaca.

The study sample is made up of 260 students from the last four cycles of studies, distributed as follows: 80 students belong to UNAP, 70 to UPeU and 110 to UANCV. In the case of professors and directors, there is a sample of 42 professionals from the three Professional Civil Engineering programs considered in the research.

A questionnaire with a Likert-type scale of five levels was applied to the students for each indicator, coded as follows: never (0), almost never (1), sometimes (2), almost always (3) and always (4). The questionnaire evaluates the environmental ethical level in the criteria of knowledge, skills, attitudes and values; for which the reliability obtained by applying Cronbach's Alpha coefficient obtained the following values: 0.848 for knowledge (good), 0.729 for skills (good) and 0.913 (excellent) for values and attitudes.

To verify the level of implementation of the teaching and learning of environmental education by teachers, a dichotomous scale questionnaire was applied as instruments, which is divided into the following criteria: physical, pedagogical, didactic and academic, corresponding to the curriculum and syllabus. The survey was validated by means of the  $K_{R20}$  indicator, obtaining a value of 0.874, which is qualified as good.

To evaluate the level in environmental ethics, the survey technique was applied, whose instruments are the questionnaires applied to students and teachers and the criteria is taken as established by a study on "Methodology to evaluate the ethical level in organizations" [22], in which the proposed scale was adjusted to the environmental ethical level (Ne) as follows:  $0.00 \leq Ne \leq 0.35$  very low,  $0.35 < Ne \leq 0.50$  low,  $0.50 < Ne \leq 0.75$  medium,  $0.75 < Ne \leq 0.90$  high and  $0.90 < Ne \leq 1.00$  very high.

In the case of the analysis of academic documents, the documentary analysis technique was applied in which the systematic observation form was used as an instrument to

Table 1.

Indicators to evaluate the presence of environmental issues in the academic documents of the Civil Engineering programs, 2021.

| Dimension   | Indicator  | Scale   | Technical        |
|---|--|---|------------------|
| Presence of the environmental dimension in the Institutional Mission. | The Institutional Strategic Plan considers the environmental dimension in its Mission. | -Good (B): if it is explicit in the document.<br>-Regular (R): if it is implicit but not mentioned.<br>-Bad (M): if it is not included in the document. | Content analysis |
| Presence of the environmental dimension in the strategic objectives.  | The environmental dimension is considered in the strategic objectives.                 |   |                  |
| Presence of the environmental dimension in the graduate's profile.    | The environmental dimension is considered in the graduate profile.                     |   |                  |

Source: The authors.

2record the inclusion of environmental criteria in the mission, strategic objectives and graduate profiles of the professional programs of Civil Engineering, using the "criterion of presence" [23] in order to evaluate the environmental dimension present in the pedagogical and administrative management documents such as the mission and strategic objectives in the strategic plan and the graduate profile in the curricula of the civil engineering programs, which are rated according to the indicators and techniques established in Table 1.

### 3. Results and discussion

The results of the research are grouped into three aspects: analysis of the environmental ethical level of civil engineering students, level of application of environmental education by civil engineering professors and analysis of the environmental theme established in academic documents, considering that environmental education and ethics should be applied at a high and very high level, to meet the criterion of environmental sustainability in the study programs. These constituent aspects helped the realization of a proposal for the development of environmental contents to be developed in the civil engineering curricula of the universities at the level of the Puno region.

#### 3.1 Analysis of the environmental ethical level of civil engineering students

The results on the environmental ethical level presented by civil engineering students are shown in Table 2, which is grouped into the following criteria: knowledge, skills and attitudes and values with seven, four and eight indicators respectively. Each indicator has been evaluated on a scale from 0.00 to 1.00 and a qualitative assessment has been made per indicator and for each criterion considered.

From Table 2 in the knowledge criterion, it can be observed that the indicators on firm position and the transversality of environmental ethics have a high level of valuation, which means that the students have knowledge about the importance of this topic, the other indicators have reached a medium level, and in the average a qualification of 0.73 that is valued as a medium level of knowledge in environmental ethics, situation that represents the need to include topics in environmental ethics in their professional formation. In the skills criterion, only the indicator on contribution to environmental mitigation and repair in works reached the valuation of high, which implies that students have the potential to mitigate and also repair environmental damage if any, in the other cases the medium level is reached, and in the average a score of 0.69 that is valued as a medium level in environmental skills, therefore, there is a need for students to be more practical in caring for the environment. Finally, for the case of attitudes and values, only two indicators, justification of environmental deterioration and proactivity in initiatives, reached the medium level of valuation; however, in the global, a qualification of 0.78 is reached, which is valued as a high level in attitudes and values regarding environmental ethics; consequently, civil engineering students are aware of the conservation and care of the environment.

Table 2.

Environmental ethical level of civil engineering students, 2021

| N°                          | Indicator   | Nei  | Val.   | Nec  | Val.   |
|-----------------------------|---|------|--------|------|--------|
| <b>Knowledge</b>            |   |      |        |      |        |
| 1                           | Strong stance on the environment.   | 0.78 | High   |      |        |
| 2                           | Environmental education at the university.                                    | 0.58 | Medium |      |        |
| 3                           | Identification of environmental problems.                                     | 0.68 | Medium |      |        |
| 4                           | Knowledge of ethical behavior.  | 0.72 | Medium |      |        |
| 5                           | Importance of environmental ethics in the execution of works.                 | 0.72 | Medium | 0.73 | Medium |
| 6                           | Ability to solve environmental problems.                                      | 0.74 | Medium |      |        |
| 7                           | Transversality of environmental ethics in the teaching of Civil Engineering.  | 0.87 | High   |      |        |
| <b>Skills</b>               |   |      |        |      |        |
| 8                           | Contribute to environmental mitigation and remediation at construction sites. | 0.83 | High   |      |        |
| 9                           | Participation to maintain a healthy environment.                              | 0.67 | Medium | 0.69 | Medium |
| 10                          | Participation in environmental collectives.                                   | 0.55 | Medium |      |        |
| 11                          | Critical observation and environmental solution.                              | 0.73 | Medium |      |        |
| <b>Attitudes and values</b> |   |      |        |      |        |
| 12                          | Ethical behavior  | 0.80 | High   |      |        |
| 13                          | Environmental ethics and moral conscience in the execution of works.          | 0.84 | High   |      |        |
| 14                          | Awareness of the harmful effects of construction works on the environment.    | 0.84 | High   |      |        |
| 15                          | Justification of environmental deterioration due to the execution of works.   | 0.59 | Medium | 0.78 | High   |
| 16                          | Respect for the environment.  | 0.81 | High   |      |        |
| 17                          | Valuation of biodiversity.  | 0.85 | High   |      |        |
| 18                          | Proactivity in environmental initiatives.                                     | 0.71 | Medium |      |        |
| 19                          | Self-assessment of actions.   | 0.80 | High   |      |        |

Note. Nei = environmental ethical level by indicator, Nec = environmental ethical level by criterion and Val = valuation.

Source: The authors.

From the previous analysis, it can be inferred that students understand the principles of environmental ethics as a social value, since they can guarantee a good coexistence with the natural environment, due to the fact that they have a high level of valuation in attitudes and values. However, social values begin to function when they pass to the category of professional values [24] that is, when the future professional passes to the field of action of his profession and must put into practice his learned knowledge, skills and attitudes. Therefore, values are predictive sources of environmental responsibility among young people and have a direct impact on their development [25] which should be exploited as it is a potential that civil engineering students have.

In addition, students will be the main actors in environmental decision making in the future, therefore, there must be a greater understanding of their capabilities, knowledge, skills, values and attitudes towards sustainable development. In a study conducted in Portugal, it was

determined that most students who are more concerned about climate change, actively contribute to sustainable development with reuse, reduction and recycling practices, and participate in organized activities to promote the protection of the environment or society [26], similar but limited situation is presented with students in the Puno region, lacking awareness programs so that they can actively participate in environmental collectives and maintain a healthy environment.

### 3.2 Level of implementation of environmental education by civil engineering professors.

The level of application of environmental education presented by civil engineering professors is shown in Table 3, in which four criteria are presented: physical, pedagogical, didactic and academic with two, six, four and three indicators respectively. Each indicator has been evaluated on a scale from 0.00 to 1.00 and a qualitative assessment has been made per indicator and criterion.

Analyzing Table 3 in the physical criterion, both indicators have a medium level of valuation, as well as in the global with 0.68, which implies that the natural environment is not entirely present in the student's learning. From the pedagogical criterion, it is inferred that the descriptive charts of the courses do not include the environmental ethical theme because it had a low level of valuation; however, the indicator of analysis of situations related to environmental deterioration in the execution of works, presented a high valuation, in the global it has a medium level of 0.67. In the didactic criterion, it is observed that there is no active participation by teachers in positive activities for the environment, since it obtained a low level of valuation, in the global it has an average level of 0.57, in this sense it is necessary to implement projects of community participation in environmental issues. Of the academic criteria, only the indicator on the inclusion of environmental ethics in teaching has a low valuation, which means the lack of presence of the environmental ethics theme in the curriculum. Therefore, teachers should actively participate in environmental projects that consolidate the values of care and conservation of the environment in students, for which environmental policies should be established in a transversal manner.

From what has been analyzed above, it is observed that in the pedagogical and didactic criteria there is a medium level of environmental education, which should be improved by working from the university classrooms, motivating individual actors and starting from a liberating perspective to have a positive impact on the knowledge of environmental problems and their solutions, this knowledge leads to personal attention, willingness to participate and environmental action to ensure clean production in the future [27].

In fact, environmental education should not be understood as a unidirectional transfer of information, but as a tool that develops and improves environmental attitudes, values and knowledge, as well as skills that prepare individuals and communities to undertake positive environmental actions in collaboration [28] with university students in favor of the environment; and it is here where civil engineering

Table 3. Level of implementation of environmental education by civil engineering professors, 2021.

| N°                         | Indicator  | N <sub>ei</sub> | Val.      | N <sub>ec</sub>  | Val.   |
|----------------------------|--|-----------------|-----------|------------------|--------|
| <b>Physical</b>            |  |                 |           |                  |        |
| 1                          | Contact or view of the teaching and learning classrooms with nature.   | 0.62            | Medium    | 0.68             | Medium |
| 2                          | Courses that are developed in direct contact with the environment.   | 0.74            | Medium    |                  |        |
| <b>Pedagogical</b>         |  |                 |           |                  |        |
| 3                          | Course descriptive charts contain environmental ethics topics.   | 0.43            | Low       | 0.67             | Medium |
| 4                          | Teaching-learning methods related to the environment.  | 0.74            | Medium    |                  |        |
| 5                          | Construction of knowledge about the interrelationship of the environment.  | 0.71            | Medium    |                  |        |
| 6                          | Construction of knowledge in relation to causes and effects of environmental problems in the construction of works.  | 0.71            | Medium    |                  |        |
| 7                          | Analysis of situations related to environmental deterioration in the execution of works.   | 0.79            | High      | 0.57             | Medium |
| 8                          | Socialization of the use of clean technologies as an option to reduce pollution and environmental damage in construction processes.  | 0.67            | Medium    |                  |        |
| 9                          | Creativity and scientific rigor in the solution of environmental problems in the practice of the courses.  | 0.52            | Medium    |                  |        |
| 10                         | Interest in raising awareness on environmental ethics applied to construction works.   | 0.69            | Medium    | 0.50             | Low    |
| 11                         | Active participation in activities that benefit the environment.   | 0.50            | Low       |                  |        |
| 12                         | Promotion of formative research applying ethics in environmental problems produced by construction processes.  | 0.57            | Medium    | <b>Academic:</b> |        |
| <b>Syllabus/Curriculum</b> |  |                 |           |                  |        |
| 13                         | Graduation profile of the Civil Engineering student with a solid formation in environmental ethics to avoid, reduce and/or restore environmental damages caused by construction works. | 0.86            | High      | 0.77             | High   |
| 14                         | Syllabus of the professional civil engineering programs that contemplates the teaching of environmental ethics.  | 0.5             | Low       |                  |        |
| 15                         | Transversality of environmental ethics as an educational proposal that consolidates values, achieving a change of attitude in the care and conservation of the environment.            | 0.95            | Very High |                  |        |

Note: N<sub>ei</sub> = ethical level per indicator, N<sub>ec</sub> = ethical level per criterion and Val. = valuation.

Source: The authors.

professors should intervene with relevant teaching and learning methods that help the construction of knowledge in interaction with the environment, the socialization of the use of sustainable technologies and materials for the solution of environmental problems, and the full participation in activities of social responsibility and research for the benefit of the care and conservation of the environment.

On the other hand, a study conducted in Brazil on environmental practices in higher education indicates that the presence of more motivations and fewer barriers leads to a more successful adoption of environmental management system practices and confirms that governmental directives coercively drive the adoption of these practices, stakeholders such as students, faculty and staff drive the development of environmental projects, and that the combination of top-down and participatory approaches is essential to maintain environmental management system practices, with bureaucracy being a major obstacle [29]. In this sense, if the environmental theme is not explicitly contemplated in the curricula, as the present study shows in part, the motivation of these environmental management practices should start at the initiative of the actors involved in the process such as: authorities, teachers and students.

Consequently, higher education institutions, as the place where future leaders are prepared, should provide an understanding of environmental issues and sustainable development for stakeholders and decision makers, both at a theoretical and practical level [30], therefore it is necessary that university professors of civil engineering are trained to involve the student in the environmental issue, due to the fact that they possess an average level of application of didactic techniques, in that sense the authorities and managers should foresee awareness programs to all their staff on the subject, since they have not been trained as such in the past.

### 3.3 The environmental theme established in academic papers

The analysis of the environmental theme established in the academic documents such as the strategic plan of the universities and the curricular structure of the civil engineering study programs are presented in Table 4. The study carried out analyzes explicitly or implicitly the inclusion of the environmental theme established in the mission and strategic objectives of the university and the graduate profile of the civil engineering study programs. Each academic guideline established in the indicated documents has been evaluated based on the scale established in Table 1, in which B is rated as good, R regular and M bad.

As can be seen in Table 4, in the case of the mission established by the UNAP, the environmental theme is indirectly made explicit within the term of sustainability and is valued as good; on the other hand, in the other universities it could be inferred that it is found within the concept of development of the region for the UANCV and for the UPeU within the term people of integrity and is valued at a regular level. Regarding the strategic objectives, in the UNAP the environmental theme is implicitly presented in the concept of social responsibility, in the same way as in the UANCV, in the concept of projection and university extension actions,

which is valued at a regular level; on the other hand, in the UPeU the environmental theme is explicit and is valued at a good level. Regarding the graduation profile of the civil engineering programs, in the three universities the environmental theme is clearly expressed in a concrete and explicit way, being valued at a good level. As can be seen, there is no uniform alignment of the environmental theme in the mission, strategic objectives and graduate profile.

Table 4. Analysis of the environmental theme present in the mission and strategic objectives of universities and the graduate profile of study programs, 2021.

| Institution | Academic guidelines established in documents  | Val. |
|-------------|---|------|
| UNAP        | <b>Strategic plan: Mission</b><br>To train qualified and competitive professionals and postgraduates; contributing to society the results of scientific, technological and humanistic research, with cultural identity and social responsibility, contributing to the sustainable development of the region and the country.                                      | B    |
|             | <b>Related strategic objective</b><br>Strengthen the activities of social responsibility, cultural extension and social projection to the university community.   | R    |
|             | <b>Profile of graduates</b><br>Applies environmental concepts in civil engineering projects to contribute to sustainable development.   | B    |
| UPeU        | <b>Strategic plan: Mission</b><br>We are a university community of the Seventh-day Adventist Church that models people to be integral, missionary and innovative based on the biblical-Christian worldview to serve God and humanity.   | R    |
|             | <b>Related strategic objective</b><br>Contribute to sustainable development, linking with the environment, to improve their quality of life.  | B    |
|             | <b>Profile of graduates</b><br>Commitment to environmental preservation, social responsibility and citizen commitment.  | B    |
| UANCV       | <b>Strategic plan: Mission</b><br>Provides comprehensive quality higher education through academic and administrative management, focused on excellence and social relevance of professional and graduate careers, research and responsible exercise of university leadership, linked to the development of the region and the world.                             | R    |
|             | <b>Related strategic objective</b><br>Develop and promote the linkage and interaction of the University with civil society, business and the state from policies and actions of projection and university extension of the university, and contribute to its integral development in an ethical framework of teaching management of academic and ethical quality. | R    |
|             | <b>Profile of graduates</b><br>Knows the interaction of environmental components, practicing the culture of sustainable development.  | B    |

Note: Val. = valuation, B = good, R = fair and M = poor.  
Source: The authors.

Education related to environmental engineering has mainly focused on pollution prevention, environmental sustainability and sustainable development, consequently there should be the commitment of higher education institutions to prepare engineering graduates to be environmentally educated [31], making planners make effective decisions on the development of pro-environmental behaviors in different social groups, particularly in university students [32], providing young people with a clear vision and definite goals about their behavior in modern society; therefore, it is necessary to redesign the curriculum, objectives and outcomes, as well as teaching techniques in engineering programs, so that environmental education can effectively influence the formation of environmental values and responsibility [25]. In this sense, the graduate profiles analyzed present the environmental theme in a transversal and explicit manner; however, the environmental focus has yet to be specified and consolidated in the mission and strategic objectives established in the universities' strategic plans.

From the above, there is also a need to discuss the design of specialized strategic environmental assessment courses that respond to the needs of society in civil engineering curricula. The integration of this assessment tool into the curricula could have significant implications for the improvement of higher education practices for sustainable development [33], with environmental attitudes being important determinants of pro-environmental behaviors, to raise awareness of the need for environmental protection, the right to life of animals and plants, the impact of environmental degradation on personal health and social well-being, and the increasing responsibility of companies to comply with environmental principles that will help to improve environmental behavior [32].

In addition, the graduate profile of civil engineering programs should be based on intentionality, ethics, responsibility, creativity and inclusion to develop and implement plans that impact environmental quality and preservation, incorporating action projects in programs in local natural areas and the design of conservation initiatives based on the needs of the community [28]. From this, the main lines of research in the environmental area can be deduced and are in agreement with: sustainable development, environmental impact, economy, education and recycling, which allow establishing evaluation indicators for managers and officials of academic institutions of higher education and, in addition, establishing protocols to evaluate the economic dimension of sustainability [34].

In accordance with the graduate profile and lines of research in environmental education, the following topics are proposed to be developed in the training of competent professionals who have a vision of sustainability: natural catastrophes, endangered species, natural events, space pollution, use of natural resources, environmental issues, environmental pollution, environmental awareness, environmental cleanup, meteorological phenomena, erosion, fossils, ecology, among others [35].

Table 5.

Proposal of the graduate profile, competencies, courses and contents of environmental education in university students of civil engineering, 2021.

| Related competencies  | Required courses                  | Scope of environmental issues   |
|---|-----------------------------------|---|
| <b>Graduate profile:</b> The civil engineering graduate assumes responsibility and ethical environmental commitment for the preservation and conservation of the environment in civil engineering projects with a critical sense. |                                   |   |
| C 1: Performs basic engineering studies for civil infrastructure projects with environmental responsibility and critical sense.   | Introduction to civil engineering | Incidence of works on environmental deterioration.                    |
|   | Applied geology                   | Geomorphology and environmental risk.                                 |
|   | Construction materials            | Eco-sustainable materials and reuse.                                  |
| C 2: Formulates infrastructure projects in the different areas of civil engineering with environmental ethics, critical sense and social responsibility.  | Constructions                     | Eco-efficient construction processes and bio-construction.            |
|   | Hydrology                         | Climate change and greenhouse effect.                                 |
|   | Roads                             | Environmental impact of road projects.                                |
|   | Environmental geotechnics         | Subsoil contamination and waste treatment.                            |
| C 3: Performs the project management process planning, executing, controlling, evaluating and rehabilitating civil infrastructure respecting the natural environment with critical sense and social responsibility.               | Irrigation                        | Environmental assessment in irrigation and drainage works.            |
|   | Buildings                         | Sustainable buildings, bioclimatic architecture.                      |
|   | Environmental management          | Deterioration, restoration, mitigation and environmental remediation. |
|   | Contract administration           | Management systems, auditing and environmental responsibility.        |
|   | Pavement design                   | Environmental control of inputs used.                                 |
|   | Reservoir dam engineering         | Environmental impact of reservoir and diversion dams.                 |
|   | Water supply and sewerage         | Surface and groundwater quality assessment.                           |
|   | Wastewater treatment              | Treatment plants and air quality.                                     |

Source: The authors, based on the curricula of study.

The topics mentioned in the previous section can form a general course, an elective course or be included transversally in other courses within the civil engineering curriculum as suggested in Table 5, where a contextualized graduate profile, related competencies, courses and environmental topics to be included in the curriculum are proposed.

From what has been analyzed, there is a need to redesign the Civil Engineering curricula under an environmental approach as shown in Fig. 1, for which a methodology is proposed whose starting point is the environmental diagnosis of the context. In the first stage, based on the environmental diagnosis, the guidelines are proposed, which are sequentially embodied in the mission, vision, educational objectives, graduate profile and professional competencies that will guide curriculum development. In the second stage, the curriculum with an environmental approach is formulated, establishing the curriculum, course charts and syllabi, environmental contents according to Table 5 and teaching and learning strategies. In a third stage, the

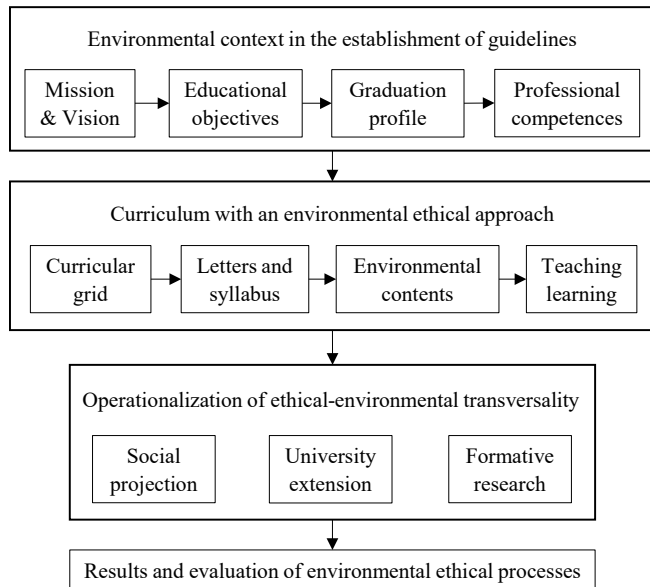


Figure 1. Methodology for the redesign of the curriculum with an environmental approach in civil engineering.

Source: The authors.

transversality of the environmental ethical theme is considered in actions such as social projection and university extension to link academic activities and projects with the natural and social reality, taking care of the environment, as well as to promote formative research in the university classrooms with a critical sense in the different courses of civil engineering. The results of this process should be evaluated in order to make decisions for environmental improvement.

Finally, the results suggest that universities and more specifically civil engineering study programs establish policies on environmental issues such as: commitment to social and economic sustainability in strategic plans and sustainability plans, variety of policy instruments to assess and ensure sustainability, and promote collaboration in national/international networks with other countries to establish a common framework and share practices [36] for the benefit of the environment.

#### 4. Conclusions

The level of environmental ethics presented by civil engineering students is assessed at a medium level in knowledge and skills, and at a high level in attitudes and values; therefore, it is necessary to implement environmental and sustainable development policies in the study programs so that students can participate in activities and projects that promote the protection and conservation of the environment in order to develop capacities, knowledge, skills, values and positive attitudes towards the environment.

Regarding the environmental education given by professors of the civil engineering study program, a medium level of valuation is reached in the physical, pedagogical and didactic criteria and a high valuation level

in the academic criterion, which implies the existence of a positive attitude on the part of the university professor to impart environmental actions in the teaching-learning process that helps students to assume an ethical environmental responsibility during their professional training and to put it into practice in the field of action of the profession.

Regarding the inclusion of environmental issues in pedagogical-administrative documents, the presence of environmental criteria in the graduate profile of civil engineering programs of study is good, but not specifically in the institutional mission and strategic objectives; therefore, it is necessary to establish environmental policies explicitly in the strategic plans of the universities, which should be aligned to the graduate profile and lines of research of the curricula of the civil engineering programs, in order to have a collective practice of environmental education by the entire educational community and to establish awareness and training activities that include the participation of the entire university community.

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