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Training Proposal in Ethical Principles for Systems Engineering Students

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***Abstract*– Training in ethics faces various challenges, due to the presence of unethical acts, greatly affecting the economy, safety, health, and well-being of human beings. Engineering ethics can affect people's lives and bring about change in the community, so there is a great responsibility for engineers who craft solutions that affect people's rights and freedoms. The objective of this study was to identify training actions within the systems engineering curriculum, establishing good practices for each ethical principle based on student evaluation. The results obtained show that the use of ethics case studies managed to identify that the ethical principles: "use of resources", "professional secrecy", "quality" and "loyalty" require greater attention for their effective training. It concluded with a proposal of actions for the formation and strengthening of each ethical principle.**

***Keywords*— Ethics, Ethical Principles, Ethical Proposal**

I. Introduction

The teaching of ethics to develop better human beings and better professionals has been facing various challenges, since society continues to witness unethical acts that often exceed imagination, situations that greatly affect the economy, safety, health, and well-being of human beings.

Etymologically, ethics comes from the Greek *ethikós,* which derives from *ethos*, which means custom or habit; it also deals with the morals and obligations of man. It is very important to differentiate that ethics and morals are not the same. So much so that ethics is a philosophical thought, it is theoretical, abstract, it seeks universality, it provides descriptions and general explanations about moral problems; While morality is the object of study of ethical science, a set of norms, principles and values with which human conduct is regulated, it is practical and modifies life itself [1].

Sabbi and Herrán [2] indicated that, despite the advance of technology and science, there is still concern about questioning the values, the pattern of thoughts, actions and consequences of the reactions of human beings that have changed since the beginning of humanity. But we must not fail to analyze that ethics must continue to contribute to the general good of humanity and therefore work must be done on the education of conscience.

Shemelkes [3] identified the need to evidence the evolution in the formation of ethical values based on everyday situations that arose in the academic environment and close environment, scenarios of reflection that allowed students to know the exemplary way to act in a coherent and prudent way when reacting to an event.

The teaching of ethics in a university academic program is the core of the practice of ethics in the profession. One of the techniques that has the greatest impact on engineering students is "embedded ethics", which provides the opportunity to see ethics in action and not just from a philosophical perspective. Thus, the need to teach ethics from the contexts in which ethical problems arise, focusing on how to make ethical decisions correctly is evident [4].

Previous research recommends asking questions such as: when (in what part of the curriculum), who (should teach), where (in what part of the curriculum), and what is the degree of applied ethical training of the teacher's engineering.

Something similar was proposed by Colombian researchers, who proposed to contribute to the teaching of ethics in engineering from the practical dimension, that after including ethics as part of the curriculum, case studies, moral dilemmas and problems contextualized to reality were worked on that allowed learning to respond ethically to real cases [5].

Likewise, it is evident that not only can ethics be taught in career courses, but also in general contexts such as the study of mathematics, since in order to explain them, real casuistry is always conceived for their application and being able to include ethics in these spaces of reflection is also considered significant in the training of engineers [6].

Engineering ethics as well as health ethics have the same impact, since they can affect people's lives and generate changes in the community, which is often evidenced in the role of civil, environmental, forestry, mining engineers, among others; But ethics is no stranger to the world of software engineering and the process of creating algorithms. Studies show risks that amoral algorithms can generate, not only producing ethical damage but also going against basic principles and values. This impact can be classified as: 1.Social discrimination, 2.Economic discrimination, 3.Discrimination against free access to information and deprivation of liberty and 4.Discrimination and abuse of control [7]. That is why there is a great responsibility of engineers who develop solutions where computers decide for human beings, where they affect people's rights and freedoms.

While it is true that society expects ethical professionals, today there are accreditation models that promote the training of professionals with ethical principles. But it is not enough to just offer the content of ethics as a stand-alone module, but its learning and practice must be considered throughout the curriculum. To this end, academic institutions must evaluate the development of content, evaluation and demonstration of competence throughout the entire training period [8].

Behaving responsibly is a complex reality to analyze, especially because there are different beliefs that often guide human behavior. Human and social values have been impacted from all social spheres, in some regions more than in others; Therefore, the opportunity to educate in systems engineering based on ethical principles that allow students to learn to make ethical decisions like those they will have to make in the exercise of the profession is evaluated. Research concluded that it is possible to define deontological and ethical rules that guide the actions of a systems engineer, which are based on virtues such as: honesty, sense of fairness, ability to put the general interest before the particular and ability to solve problems taking into account the impact of solutions in an honest way [9].

Application studies allowed students to demonstrate the importance of case studies to measure the level of achievement of ethical competence in systems engineering. These case studies were aligned with definitions of ethical capacity, such as: professional secrecy, loyalty, general interest versus private interest, appropriate use of resources, use of true information, responsibility, caution, justice, honesty and quality [9], [10].

The university participating in the study has an educational model based on general competencies and specific competencies of each career. At the level of general competencies, there are: (1) Creative and critical thinking, (2) Problem solving, (3) digital systemic mindset, (4) social intelligence and (5) social responsibility and sustainability. While, at the level of specific competencies, the Faculty of Engineering has declared eleven competencies: (1) The professional and the world, (2) Ethics, (3) Individual and Team work, (4) Communication, (5) Project Management, (6) Lifelong Learning, (7) Engineering knowledge, (8) Problem analysis, (9) Design and development of solutions, (10) Inquiry and (11) Use of tools.

At the level of the academic program, the professional career expects that, at the end of the ten cycles of studies, students will apply the professional ethical principles and the norms of engineering practice, adhering to the relevant legal framework, respecting the diversity of human groups.

The objective of this study was to identify training actions within the systems engineering curriculum, establishing patterns that allow promoting the practice of ethical principles from academic activities in the classroom.

II. METHOD

The study included the evaluation and analysis of the results obtained through a non-experimental, descriptive post-facto design; the population and sample consisted of 192 students in the last cycles of the Systems Engineering career, of which 14% were women and 86% were men. Data collection was carried out in the second semester of 2022, using the ethical principle assessment questionnaire, which has been used by the university, which was validated in the last 5 years.

Taking as a reference the methodological process of Plasencia et al. [11], the methodological phases developed for this evaluation of the ethical principle in students are shown in Fig. 1. The process began with the planning phase, which included the selection of subjects from the 2020 curriculum, choosing and selecting the resources that academic actors would use to improve the teaching-learning experience that included ethical principles. In addition, the measurement instrument was reviewed and updated with the participation of teachers and specialists. Then, in the awareness-raising phase, the selected subjects were socialized, and in each of them the moments of development of both the code of ethics and the Cybersecurity course were identified, as well as their alignment with the graduate profile. The evaluation phase continued, applying the measurement instrument through an online questionnaire, downloading the data for statistical (descriptive) analysis and interpretation. Finally, in the proposal phase, the subjects were identified and classified by ethical principle, establishing actions to strengthen the specific ethical principles.

Once the results have been obtained, new opportunities for improvement are registered that will be considered for the next academic cycle in their development, application and measurement of ethical principles, forming a process of continuous improvement.

The instrument consisted of ten ethics cases, taking into account the ethical principles that included [9], [12]: (a) Professional secrecy, (b) loyalty, (c) interest, (d) use of resources, (e) truthful information, (f) responsibility, (g) caution, (h) fairness, (i) honesty and (j) quality. The items considered for evaluation were dichotomous options (Ethical/Unethical). This instrument was validated in previous studies with the KR-20 statistic, obtaining a value of 0.802 of good consistency [10] and taking into account the case study methodology through the adaptation of the steps: 1) Case presentation, 2) Reaction to cases, 3) Fact analysis, and 4) Decision making and assessment (ethical/unethical) [13]. The questionnaire was administered through an electronic form,

prior to the participation of the socialization of the engineer's code of professional ethics [14] and the ethics chapter of the Cisco Academy's "Introduction to Cybersecurity" course [15], following the evaluation data sheet (Table I).

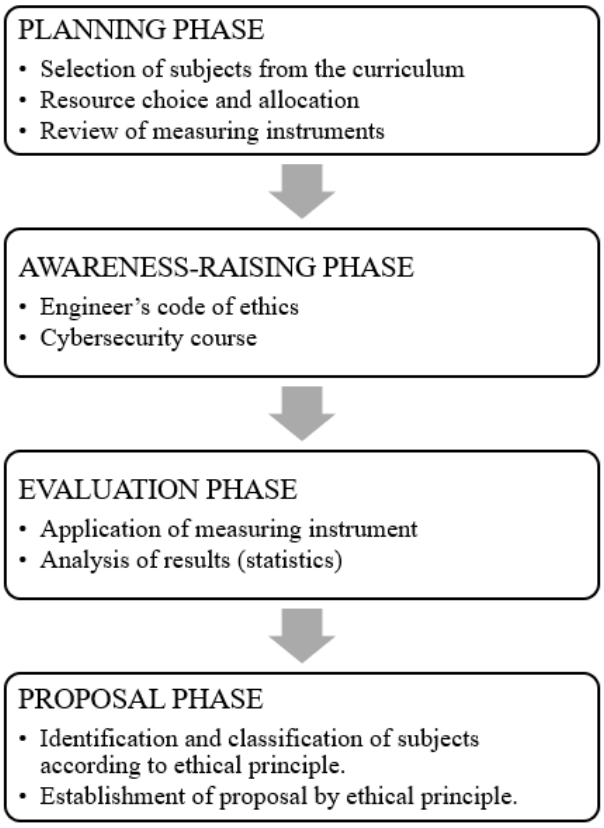

Fig. 1. Methodology for the Evaluation of the Ethical Principle

TABLE I. EVALUATION DATA SHEET

EVALUATION	ETHICAL PRINCIPLE
1. Application	Individual
2. Strategy	Case Studies
3. Duration	30 minutes
4. Structure	- Professional Implications - Professional Liability - Code of Ethics
5. Material	- Code of Ethics - Course "Introduction to Cybersecurity" – Ethics chapter - Online Questionnaire
6. Scale	- To improve (<14) - Good (>=14 and <=16) - Outstanding (>16)

After the analysis of ethical principles, some challenges were established that must be considered when training and ethical evaluation.

III. Results And Discussion

The evaluations carried out were made by students who participated in the remote subjects of: Database Workshop and Capstone Project. Below are the results obtained for each ethical principle using case studies selected for assessment as ethical or unethical, verifying the percentage of correct answers (Fig. 2).

a) **The case of professional secrecy,** 83% of students considered it unethical not to keep information related to their work confidential.
b) **The case for loyalty**, 84% of students considered it unethical to take advantage of trust for personal gain.
c) **The case of interest**, 93% of students who considered it unethical to perform professionally, with personal interest prevailing over general interest.
d) **The resource use case**, 70% of students who considered it unethical to respond to personal needs using the organization's resources.
e) **The case for true information**, 96% of students who considered it ethical to honor the truth based on viable information.
f) **The responsibility case**, 94% of students considered actions that are carried out with competence and capacity to be ethical.
g) **The case for caution**, 94% of students who considered it unethical not to recognize limits and foresight when making a decision.
h) **The case for justice**, 97% of students who considered it unethical to act impartially in the equitable distribution.
i) **The case for honesty,** 96% of students who considered it unethical not to act with rectitude and integrity in coherence of doing what is said.
j) **The quality case**, 83% of students who considered it ethical to seek excellence and follow what was requested.

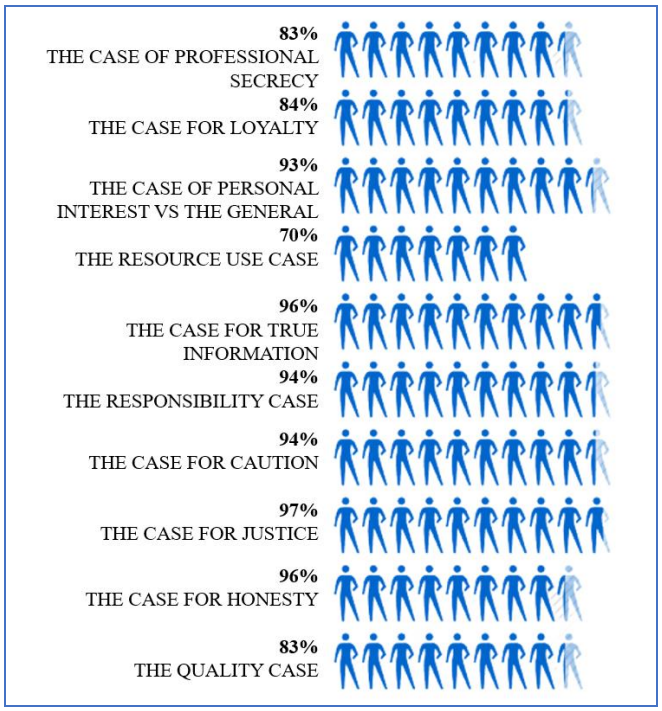

Fig. 2. Evaluation of ethical principles

In short, effective ethics training translates into the correct identification of the case as ethical or unethical; According to the principle evaluated and in descending order of success, it was possible to identify in Table II the prioritized outcomes, to later give attention and proposals for improvement in the training with the highest percentage of error.

TABLE II. PRIORITIZED OUTCOMES

Priority	Ethical Principle	% of correct identification	% errors
1	Justice	97	3
2	Honesty	96	4
3	True information	96	4
4	Caution	94	6
5	Responsibility	94	6
6	Personal interest vs the general	93	7
7	Loyalty	84	16
8	Quality	83	17
9	Professional secrecy	83	17
10	Resource use	70	30

The ethical principles of "use of resources", "professional secrecy", "quality" and "loyalty" require greater attention for their effective training; In the same way, it is identified that the most successful skills were: "fairness", "honesty" and "true information" (Fig. 3).

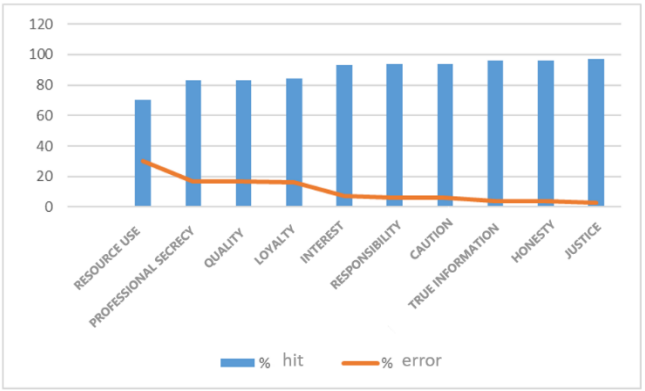

Fig. 3. Hit and miss scores

Below are the training proposals aligned with the subjects of the systems engineering curriculum (Table III):

TABLE III. PROPOSALS FOR TRAINING IN ETHICAL PRINCIPLES

Actions to strengthen	Subjects (Cycle)	Justification
PROFESSIONAL SECRECY[16]		
1. Persisting in professional secrecy should be considered an ethical principle. 2. Persisting in the confidentiality of data secrecy: personal and sensitive. 3. Relate the importance of linking real casuistry with respect to professional secrecy, the importance of supporting professional secrecy of all the facts and news that you know by reason of your professional performance.	- Database (5th) - Software Modelling & Analysis (6th) - E-Business & Web Analytics (10th) - Capstone Project (10th)	The achievement of the courses requires the development of applications or software products that solve real problems and within the realistic considerations to be evaluated, it has been determined to emphasize the importance of professional secrecy in this type of projects.
LOYALTY[17]		
4. Work on role-playing that allows you to analyze trust actions between teams. 5. Propose teamwork scenarios where solidarity collaboration with colleagues, clients and other actors in the environment is shown. 6. Analyze cases where loyal and disloyal actions are shown, avoiding positions	- Introduction to Systems Engineering (1st) - Fundamentals of Algorithms (2nd) - Software Design & Architecture (7th) - Pre-	The selected courses strengthen the competence of the graduate profile of teamwork, thus reinforcing the importance of loyalty in multidisciplinary teams.

Actions to strengthen	Subjects (Cycle)	Justification
of conflict, but always respecting other professions and freedom of interpretation.	professional internships (8th)	
PERSONAL INTEREST VS GENERAL [18]		
7. Analyze cases where the importance of social good is understood. 8. Work on cases where legal, economic, social consequences, etc. are analyzed for not prevailing the general good and work honestly. 9. Staging of cases where the consequences of acting based on personal interest are shown.	- Introduction to Systems Engineering (1st) - Computer Architecture (6th) - Software Project Management (9th) - Intelligent Systems (9th)	The achievement of these courses involves the creation of software products that have a positive impact on the environment, including those that help people with disabilities or vulnerable people (in line with what is required by Peruvian university law).
RESOURCE USE [18]		
10. Optimal use of resources in project allocation. 11. Honest Resource Usage Analysis. 12. Raise awareness about making good use of your work time.	- Introduction to Systems Engineering (1st) - Software Project Management (9th) - Robotics workshop (8th) - Video Games & Mobile Apps (8th)	At the end of these courses, students are expected to consider different intercultural aspects or behaviors of society in project management, which could affect their success.
TRUE INFORMATION[19]		
13. Inform the need-to-know reality (space and time), its importance and meaning for society. 14. Also, considering that the reality is complex, the use of official and professionally recognized sources can be taken as a reference. 15. With an intelligent gaze, without prejudice or partiality, and with a reflective attitude, reality will be found with truth,	- Database (5th) - Software Modeling & Analysis (6th) - E-Business & Web Analytics (10th) - Capstone Project (10°)	The achievement of these courses looks to develop solutions considering realistic constraints that could affect the success or failure of projects. Among them, the risk analysis that would be

Actions to strengthen	Subjects (Cycle)	Justification
at the service of society, providing only the necessary data and opinions with appropriate language. 16. Role-playing consequences for the use of untrue information.		generated by not handling true information is mentioned.
RESPONSIBILITY[20]		
17. Use of formal knowledge with activities that allow the acquisition of essential values for the development and well-being of society. 18. Cultivate responsibility with experiences, practical applications and behaviors that promote coherence between principle and action. 19. Generate confidence by motivating the conception of an ideal professional with professional goals, strengthening self-learning and recognition of effort.	- Introduction to Systems Engineering (1st) - Computer Architecture (6th) - Software Project Management (9th) - Intelligent Systems (9th) - Capstone Project (10°)	The selected courses strengthen the competence of the graduate profile of teamwork, thus reinforcing the importance of responsibility for the success of the projects.
CAUTION[21]		
20. Ensure that subjectivity is protected to avoid consequences for lack of criteria and non-compliance. 21. Cultivate reflection and prior analysis before the performance, from daily personal and group challenges that allow cause and effect to be assessed in the form of simulation. 22. Consider real-life situations related to professional activity and regulatory compliance.	- Database Workshop (6th) - Intelligent Systems (9th) - Computer Security (10th)	These courses were selected because they contribute to the achievement of the general competence of creative and critical thinking, where the student supports each of the decisions, they make based on technical knowledge and considering the constraints of the environment.
JUSTICE[22]		
23. Adjust curricula to include knowledge and practices that guide social justice analysis and practices, in tandem with a society with an uplifting culture. 24. Include activities for the	- Introduction to Systems Engineering (1st) - Software Project Management	The achievement of these courses involves the creation of software products that

Actions to strengthen	Subjects (Cycle)	Justification
protection of nature and life, human rights, and duties towards society, with equal conditions, with a reduction in abandonment, misery, and oppression. 25. Promote training in actions in favor of justice and democracy, with inclusive dialogue, overcoming deficiencies in social integration that dignify the human being.	(9th) - Intelligent Systems (9th) - Capstone Project (10°)	have a positive impact on the environment, including those that help people with disabilities or vulnerable people (in line with what is required by Peruvian university law), promoting the importance of being fair not only in the profession.
HONESTY[23]		
26. Develop training strategies that seek to play a leading role in students through constant dialogue and the search for group consensus. 27. Include self-assessment and co-assessment as part of the link to professional practice.	- Database (5th) - Software Quality (7th) - Robotics workshop (8th) - Software Project Management (9th)	At the end of these courses, students are expected to consider different intercultural aspects or behaviors of society in project management, with dishonesty being a current problem and therefore its importance is issued.
QUALITY[24]		
28. To train based on efforts aimed at the development of proposals in alternatives to raise professional quality according to the establishment of new requirements. 29. Respond to changing needs and trends in the profession, aligned with continuous training, and the progressive growth of society's demand.	- Database (5th) - Software Quality (7th) - Software Project Management (9th) - Capstone Project (10°)	The courses also contribute to the competence in the use of tools, where the importance of Quality in the exercise of the profession and the importance of staying up to date in technological careers are evaluated in rubrics.

Challenges encountered in implementation

As part of the implementation process, the curriculum encountered the following challenges, linked to:

(a) Importance of contextualization of ethical cases

Many students may fail to see the practical relevance of ethical cases, especially if they are not contextualized in real situations or close to their field (such as software development, artificial intelligence, cybersecurity, etc.).

(b) Technical thinking versus ethical thinking

Computer systems engineering students are typically more oriented to solving technical problems and may see ethics as a soft skill rather than a critical part of their professional training.

(c) Cultural or attitudinal resistance

Some students may show resistance or lack of interest in ethical issues, considering them irrelevant to subjects such as programming, networks or artificial intelligence.

(d) Selection of out-of-date or irrelevant cases

There was a great challenge to have cases that were not aligned with the current problems of the field because they lost pedagogical impact.

(e) Ethical Learning Assessment

It is still somewhat complex to measure the impact of ethical learning. That is, assessing whether a student has developed moral judgment or ethical sensitivity is not as straightforward as grading a technical exam. Therefore, the importance of studying.

Like Sabbi and Herrán [2], it seeks to continue with the analysis and study of ethics in search of the general good of society through the formation of conscience, identifying everyday situations in the professional context that seeks spaces for reflection, ensuring that students know the actions of coherence and prudence in the face of reality [3].

The training of ethics in the career of Systems Engineering will be the axis of ethics in the exercise of the profession, which is why the need to propose actions that train and strengthen ethics and correct decisions is justified [4].

Compared to the background included, proposals for action have been formulated for each ethical principle in various general and specialized training subjects using real cases and seeking to contribute to the teaching of ethics in systems engineering in a practical way, and being part of the curriculum [5], [6], throughout the entire curriculum [8].

Finally, it is possible to define ethical criteria that guide the training and action of the systems engineer, taking into account virtues such as honesty and justice, and valuing the implication of their practice [9].

IV. Conclusions And Recommendations

The use of case studies of ethics was able to identify that the ethical principles: "resource use", "professional secrecy", "quality" and "loyalty" require greater attention for their effective formation.

The ethical principles with the best training were: "justice", "honesty" and "true information" that strengthen the training developed in the curriculum.

A proposal of actions was prepared for the formation and strengthening of each ethical principle, seeking to ensure its development through various subjects of the curriculum.

The proposed subjects must plan the implementation of actions in their learning sessions based on the conception of ethical principles, their development and application.

Based on the present study, a subsequent evaluation is important for planning and continuous improvement in the ethical training of students.

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