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ETHICS IN COMPUTER SYSTEMS AND MECHATRONICS ENGINEERING: A COMPARATIVE CONTENT ANALYSIS USING THE BEREDAY METHOD IN MEXICO

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Abstract— This article provides a comparative analysis of the thematic content of ethics courses in Computer Systems Engineering and Mechatronics Engineering programs at UNAM, IPN, UANL, and ITESM, using the TecNM Ethics Workshop as a central reference. The Bereday method (description, interpretation, juxtaposition, and comparison) is applied based on a review of official syllabi. The results identify three curricular orientations: philosophical-humanistic, socio-technical-contextual, and civic-legal. Areas for improvement are highlighted in philosophical depth, curricular verticality, and ethics in artificial intelligence, with implications for the curricular design of ethics education in engineering.

Keywords—comparative education, higher education, engineering education, professional ethics, educational research.

Abstract-- This article presents a comparative analysis of ethics course content in Computer Systems Engineering and Mechatronics Engineering programs at UNAM, IPN, UANL, and ITESM, using TecNM's Taller de Ética as the central reference. The Bereday method (description, interpretation, juxtaposition, and comparison) is applied through a review of official syllabi. The results identify three curricular orientations: philosophical-humanistic, socio-technical-contextual, and civic-legal. The study highlights areas for improvement in the TecNM ethics course regarding philosophical depth, curricular verticality, and emerging ethical dilemmas in artificial intelligence, with implications for the design of ethics curricula in engineering education.

Keywords—comparative education, educational research, engineering education, higher education, professional ethics.

INTRODUCTION

Professional ethics has established itself as an indispensable element in the training of engineers, practically inseparable from the concepts of social responsibility and professional integrity. Numerous voices in the literature emphasize that the ethical dimension is not an afterthought but rather the core of an engineer's knowledge and practice (Miñano Rubio and Génova Fuster, 2021). The critical role of ethics in engineering is recognized globally and is integrated into accreditation criteria: for example, ABET stipulates that graduates must be able to recognize their ethical and

professional responsibilities, and to make informed decisions while considering the impact of their solutions in global, economic, environmental, and social contexts (ABET, n.d.).

In Mexico, the National Technological Institute of Mexico (TecNM) implemented the Ethics Workshop (TecNM, 2023) as a required course common to all its engineering programs (code ACH-2307, SATCA 1-3-4). A preliminary assessment revealed that only 68% of the faculty members teaching the course have the appropriate background or specific training (Olayo Valles et al., 2019). Recently, TecNM adopted the "Humanism for Social Justice" educational model, which positions ethics education as a structural pillar of all degree programs (National Technological Institute of Mexico, 2024). In this context, it is relevant to compare the content of TecNM's Ethics Workshop with that of equivalent courses at other leading national institutions, both public and private.

The selection of the Computer Systems Engineering (ISC) and Mechatronics Engineering programs reflects the specific ethical challenges that arise in these fields: data privacy, artificial intelligence, responsible automation, and bioethics in robotics (Martin et al., 2021; Yin and Zhang, 2022). The inclusion of ITESM as a leading private institution also allows us to explore whether the distinction between public and private higher education leads to substantive differences in how engineers' ethical training is conceived and structured. The questions guiding the analysis are: (1) What similarities and differences exist between the content of TecNM's Ethics Workshop and that of equivalent courses at UNAM, IPN, UANL, and ITESM?; (2) What pedagogical perspectives prevail in the teaching of ethics in higher-level engineering programs?; and (3) Are there systematic differences between public and private institutions regarding the curricular design of ethics education?

General Objective

To conduct a comparative analysis of the thematic content of ethics courses in ISC and Mechatronics Engineering programs at UNAM, IPN, UANL, and ITESM, using TecNM's Ethics Workshop as the central reference and applying the Bereday method, in order to evaluate their relevance and identify areas for improvement, with special attention to differences between public and private institutions.

Specific Objectives

1. To identify the thematic content, theoretical approaches, and pedagogical approaches of the eight ethics courses in ISC and Mechatronics Engineering programs at the four selected institutions.
2. Describe the structure and learning outcomes of these courses in relation to each institution's graduate profiles.

3. Analyze the similarities and differences between TecNM's Ethics Workshop and equivalent courses using Bereday's comparative method.
4. To evaluate the differences in the curriculum design for ethics education between public institutions and the private institution used as a benchmark.
5. Determine areas for improvement in the TecNM Ethics Workshop based on the results of the analysis.

Rationale

This research addresses the need to improve the relevance of TecNM's Ethics Workshop, as a previous assessment revealed gaps in faculty preparation (Olayo Valles et al., 2019). A comparative analysis with benchmark institutions—including a highly regarded private institution such as ITESM—allows for a triangulation of perspectives on how the ethical education of engineers is conceived across different educational models, institutional missions, and socioeconomic contexts. This relevance is further strengthened by technological advances in AI and robotics, which generate new ethical complexities that demand updated content (Yin and Zhang, 2022), and by the imperative of TecNM's new humanistic model to ensure coherence between the explicit curriculum and institutional values (National Technological Institute of Mexico, 2024).

DEVELOPMENT

Theoretical Framework

This research falls within the field of comparative education (Leal and Cazales, 2013), which studies educational systems, programs, and processes in different contexts with the aim of identifying similarities, differences, and relevant relationships. The comparison between institutions of different types—public and private—is particularly relevant in the Mexican context, where the missions, pedagogical models, and graduate profiles of public and private universities differ substantially (Pérez Perdomo and López Pérez, 2024).

In engineering, the transition from a purely technical approach to a socio-technical one has integrated ethics as a response to project failures and controversial technological advances (Yin and Zhang, 2022). There is a recognized need to move beyond individual microethics to address macrosocial impacts (Martin et al., 2021). In Mexico, TecNM, with its humanistic model, and ITESM, with its mission centered on citizenship and Mexico's development, represent two distinct approaches to this same need. Balakrishnan et al. (2019) show that programs with innovative methodologies improve

, while Esquerda et al. (2019) point out that a single course is not enough, and that ongoing approaches integrated into the curriculum are required.

The Bereday Comparative Method

The Bereday method, structured in four phases (description, interpretation, juxtaposition, and comparison), is a standard tool in comparative education (Adick, 2018; Osorio and Rodríguez, 2018), applicable both to national education systems and to the comparison of curricula and courses (Mohammadifar and Afshar, 2019). Its phases operate as follows:

Description: a descriptive account of each program, including its objectives, content, methodology, and assessment, gathering relevant pedagogical data in isolation.

Interpretation: a contextual analysis of the data in light of the educational model, the institutional mission, and the cultural or regulatory particularities of each university (Adick, 2018).

Juxtaposition: Organization of the cases into comparative matrices to systematically identify thematic and pedagogical similarities and differences.

Comparison: a comparative synthesis to draw conclusions about strengths, areas for improvement, and recommendations, including the public/private dimension.

Methodology

This is a qualitative-comparative study based on a documentary analysis of official syllabi, graduate profiles, and publicly available curriculum guidelines. Eight study programs from four institutions were analyzed: UNAM (Faculty of Engineering: Mechatronics Engineering and Computer Engineering), IPN (ESCOM/UPIIZ: ISC, and UPIITA: Mechatronics), UANL (FIME: Ethics, Society, and Profession, and General Initial Education: Ethics, Transparency, and Culture of Legality), and ITESM (Computational Technologies: Ethics, the Individual, and Society), plus the TecNM Ethics Workshop as a point of reference. The selection was based on each institution's national academic standing, the large enrollment in the engineering programs under study, and the public availability of their curricula. A standardized document review protocol was employed, focusing on: course title, semester/level, credits, delivery format, purpose/objective, content structure, pedagogical approach, assessment system, and required faculty profile.

DISCUSSION AND ANALYSIS OF RESULTS

Description Phase: Characterization of the Eight Programs

TecNM – All engineering degree programs: Ethics Workshop (ACH-2307).

The Ethics Workshop (course code ACH-2307, SATCA 1-3-4) is the central reference course for the analysis (TecNM, 2023). Unlike the other institutions, it is taught as a common course for all TecNM degree programs, with no distinction between ISC and Mechatronics. Its specific learning outcome is: "Develops an awareness of the meaning and purpose of ethics to analyze and guide one's behavior when applying acquired knowledge in harmonious coexistence with oneself, within one's community and professional contexts." The syllabus is organized into four topics: (1) The purpose of studying Ethics: philosophical overview (Socrates, Plato, Aristotle, Epicurus), branches of ethics (metaethics, normative ethics, applied ethics), and an extensive list of ethical values: respect, dignity, freedom, love, gratitude, equity, truth, justice, service, work, commitment, and honesty; (2) The sociocultural significance of ethics: ethical behavior in personal, academic, civic, and community contexts; moral and ethical judgment; axiology; virtues; and human rights; (3) Ethics in professional practice: ethics in science and technology, ethical implications of scientific research, technoethics and bioethics, deontology, codes of professional ethics, and professional ethical dilemmas; and (4) Ethics in institutions and organizations: human rights in the workplace, social responsibility, business ethics, ethical leadership, ethical decision-making, and ethical organizational culture. The course is structured as a workshop (with an emphasis on reflective practice), featuring a competency profile that includes instrumental skills (analysis, synthesis, decision-making), interpersonal skills (ethical commitment, teamwork), and systemic skills (application of knowledge, research, creativity).

UNAM – Mechatronics Engineering: Professional Ethics.

The course "Professional Ethics" (code 2188) is offered in the 7th semester, with 6 credits and 48 hours of lecture (UNAM, 2008). Its stated objective is for students to "strengthen their human and professional calling through an awareness of dignity, duty, and the exercise of freedom." The syllabus comprises six units:

(1) Introduction (3 h), (2) Ethics: What Is It For? (conceptualization, historical perspective, current ethical issues) (6 h), (3) Values (definition, theories, hierarchy, basic ethical values) (9 h), (4) Ethics, Freedom, and Engineering (ethics of happiness, professional responsibility) (9 hours), (5) Professional Codes of Ethics for Engineers (professional societies, purposes and limits, moral, legal, and institutional aspects) (9 hours), and (6) Case Studies (12 hours). Bibliography of classical philosophical works (Aristotle, Kant, Harris and Robins, Martin and Schinzinger).

UNAM – Bachelor's Degree in Computer Science: Professional Ethics.

Also known as "Professional Ethics," this course is offered in the 8th semester with 6 credits and a total of 64 hours (2 hours of theory + 2 hours of practice per week), in a theoretical-practical format (UNAM, 2015). Its objective expands upon the

that of Mechatronics by adding the conceptual philosophical framework, the ethical problems of contemporary society, and the analysis of paradigmatic cases. The six units include: (1) Philosophy, ethics, and morality: conceptual framework (8 hours), (2) Ethical issues in contemporary society (4 hours), (3) Axiology in engineering (4 hours), (4) Deontology in engineering (5 hours), (5) Critical awareness and social responsibility (5 hours), and (6) Professional Ethics for Engineers in the Knowledge Society (6 hours), plus 32 hours of independent study and case presentations. Contemporary bibliography (Cortina, Jonas, Bauman, Beuchot).

IPN – ISC (ESCOM/UPIIZ): Engineering, Ethics, and Society.

The course is titled "Engineering, Ethics, and Society," taught in the second semester with 9 TEPIC credits and 81 theoretical hours, at a rate of 4.5 hours per week (IPN, 2020). In effect since 2020, its purpose is for students to explain the role of engineering in society based on the history of human knowledge, its ethical implications, and its environmental impact. Five units: (I) Historical Development of Scientific and Technological Knowledge (15 hours), (II) Industrial Revolutions (18 hours), (III) Engineering and Society (16.5 hours), (IV) Ethics and engineering (ethical dilemmas in sustainability, health, and equity) (18 hours), and (V) Engineering, productivity, and sustainability (13.5 hours). Assessment is based on case studies, essays, presentations, and a portfolio.

IPN – Mechatronics Engineering (UPIITA): Ethics for Professional Practice.

Called "Ethics for Professional Practice," this course is offered at Level III with 4.5 TEPIC credits and a total of 54 hours, consisting of 1.5 hours of theory and 1.5 hours of practice per week (IPN, 2011). Purpose: "to evaluate the code of values and the social significance of engineering based on axiological and ethical foundations." Three modules: (I) The field of ethics and axiology, (II) Ethics, Mechatronics Engineering, and society, and (III) Professional ethics for mechatronics engineers. Methods include maieutic, heuristic, and analogical approaches; group dynamics (debate, panel discussion, roundtable); and ethical dilemmas. Assessment is based on a portfolio with self-assessment and peer assessment.

UANL – FIME: Ethics, Society, and the Profession.

2 UANL credits and 60 hours (45 synchronous + 15 asynchronous) in a non-campus-based format (UANL, 2020). Three phases: (Phase 1) Ethics: the philosophy of morality and its development in Western culture; (Phase 2) Sociocultural changes and ethical issues; and (Phase 3) Applied ethics in contemporary society: civic and professional ethics. Includes a Research Project on the Application of Ethics (PIA). Its graduate competencies include the practice of UANL's institutional values: truth, equity, honesty, freedom, solidarity, respect for life, integrity, ethical behavior, and justice. ***UANL – Mechatronics (General Initial Education): Ethics, Transparency, and a Culture of Legality.***

This course is the most distinctive in the program: "Ethics, Transparency, and a Culture of Legality," worth 2 credits in a blended learning format (UANL, 2022). Three phases: (Phase 1) Ethics and transparency in a culture committed to the rule of law (moral norms, human rights, access to information, protection of personal data, culture of legality); (Phase 2) Human behavior in the face of ethical dilemmas; and (Phase 3) Citizen participation within the framework of ethical reflection, transparency, and a culture of legality. Final Project: An interpretive report on a social issue from the perspectives of control and influence to promote ethical behavior and a culture of legality.

ITESM – Computer Technologies: Ethics, the Individual, and Society (H1018).

The course "Ethics, the Individual, and Society" (H1018, CIP: 380101 Philosophy) belongs to the Department of Humanities within the School of Humanities and Education (ITESM, n.d.). With a course load of CL-L-U-CA-UDC 3-0-8-3-3.5 (3 hours of in-person instruction, 8 hours of independent study per week) and a prerequisite (H1017 or H1040), this indicates the existence of a vertical ethics curriculum with at least two levels. The course is available to students in most of ITESM's engineering programs. Its curricular intent is for students to "discover the importance of ethics in guiding their personal life plans and social coexistence from the perspective of the good, duty, and justice," to develop the ability to make responsible decisions committed to respecting the dignity and rights of others, and to value their role as citizens capable of transforming their environment in an equitable, just, responsible, and sustainable manner. The general objective states that students "will be able to envision a life plan grounded in high moral standards, thanks to the acquisition of skills in critical analysis, reasoning, and the resolution of ethical problems, while committing to the construction of a just, supportive society that respects human dignity." The teaching method is collaborative learning. The bibliography stands out for its contemporary philosophical rigor: Adela Cortina (multiple titles), Norbert Bilbeny, Monique Canto-Sperber, Simon Blackburn, and André Comte-Sponville. The instructor profile requires a master's or doctoral degree in philosophy, the humanities, or ethics.

Juxtaposition Phase: Comparative Matrix

Table 1 presents a side-by-side comparison of the structural characteristics of the eight programs. The table with the complete comparison is attached at the end of this paper as Appendix I. The shaded columns indicate the type of institution: green = TecNM (reference), blue = public, and yellow = private.

Table 1. *Summary of structural characteristics by program*.

Aspect	TecNM (ref.)	UNAM Mechanical Engineering	UNAM Comp.	IPN ISC	IPN Mechanical Engineering	UANL FIME	UANL Mechanical Engineering	ITESM Computer Tech.
Type of Higher Education Institution	Federal public	Federal public	Federal public	Federal public	Federal public	State public	State public	Private
Semester /level	General (no fixed semester)	7th	8th	2	Level III	1st–2nd	1st–2nd	Basic Level (prerequisite)
Total hours	~64 (workshop)	48	64	81	54	60	~60	~110 (3 hours + 8 hours of independent study per week)
Format	Workshop	Theoretical	Theoretical-practical	Theoretical	Theoretical-practical	Not enrolled in school a	Blended	In-person + self-directed
Primary focus	Humanities + Values + Professional Ethics	Classical philosophical-humanistic	Philosophy + axiology + knowledge society	History of science + sociotechnical + sustainability	Axiological + Mechatronics	Philosophical + sociocultural	Citizenship + legal + data	Philosophical + life plan + citizenship
Ethical Curriculum	A unique subject	A subject	A subject	A subject	A subject	A subject	A subject	Minimum of 2 levels (H1017→H1018)
Required faculty profile	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Master's/Doctorate in Philosophy/Ethics

Source: Author's *own work* (2026).

Table 2 complements this analysis with a map showing the presence and absence of 17 specific thematic topics across the eight programs, including the common gap in ethics related to artificial intelligence and emerging technologies.

Table 2. *Specific thematic content by program*.

Thematic Content	TecNM (Ref.)	UNAM Mec.	UNAM Comp.	IPN ISC	IPN Mechanical Engineering	UANL FIME	UANL Mechanical Engineering	ITESM Computer Engineering
Philosophical Foundations of Ethics	Yes	Yes	Yes	Yes	Yes	Yes	Partial	Yes
Axiology / Theory of Values	Yes	Yes	Yes	No	Yes	Yes	Partial	Yes
Professional Ethics / Codes of Professional Conduct	Yes	Yes	Yes	No	Yes	Partial	No	No
Social Responsibility	Yes	Yes	Yes	Yes	Yes	Partial	Yes	Yes
Human rights	Yes	Implicit	Implicit	Yes	Implicit	Yes	Yes	Yes
Bioethics / Technoethics	Yes*	No	No	No	No	No	No	No
History of Science / Industrial Revolutions	No	Partial	No	Yes	No	Yes	No	No
Sustainability / Environment	No	No	No	Yes	No	No	No	Partial
Organizational/Business Ethics	Yes	No	No	No	No	Partial	No	No
Citizenship and Social Participation	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Legal Information / Transparency / Personal Data	No	No	No	No	No	No	Yes	No

Contemporary Ethical Dilemmas	Partial	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethics in AI / Emerging Technologies	No	No	No	No	No	No	No	No
Data Privacy / Cybersecurity	No	No	No	No	No	No	Yes	No
Life Plan / Personal Development	Partial	No	No	No	No	No	No	Yes
Ethics in Science and Research	Yes	No	No	Yes	No	No	No	No
Ethical leadership	Yes	No	No	No	No	No	No	No

Source: *Prepared by the author* (2026).

ANALYSIS OF RESULTS

Comparison Phase: Integrated Analysis

Commonalities among the eight institutions

The analysis identifies the following common denominators among the programs studied:

- Universal mandatory status: all eight programs are mandatory, reaffirming the consensus on the importance of ethics education in engineering, in line with ABET standards (n.d.) and TecNM policies.
- Inclusion of case studies or ethical dilemmas: all programs include, to varying degrees, some strategy for analyzing cases or dilemmatic situations, recognized as fundamental to the development of applied ethical reasoning (Martin et al., 2021).
- Addressing professional responsibility and values: All programs incorporate the notion that engineering graduates must practice their profession ethically and with an awareness of their social impact.
- Inclusion of human rights: With varying degrees of emphasis, all programs make explicit or implicit reference to human rights as a normative framework for ethical behavior.

Differences: Variations among the programs

- Timing of instruction: The variation from the 1st to the 8th semester reflects opposing philosophical decisions regarding whether ethics should underpin the curriculum from the outset or serve as a synthesis at the end. ITESM and UANL advocate for early ethical training as the foundation for the rest of the degree program; UNAM positions it as an integrative culmination; TecNM does not specify a fixed semester.
- Name and conceptual scope: The variety of names reveals differences in the conception of what ethics entails for engineers. TecNM, ITESM, and part of UNAM adopt

names that emphasize the educational nature of the course (workshop, person, professional ethics); the IPN-ISC integrates it into a broader sociotechnical framework; the UANL links it to citizenship and the rule of law.

- Course load and credits: The variation from ~48 hours (UNAM Mec.) to ~110 hours (ITESM, including independent study) indicates substantial differences in the depth given to the subject. The UANL and ITESM have the lowest in-person course load; the difference lies in the fact that ITESM compensates for this with hours of structured independent study.
- Treatment of the sociotechnical dimension: Only the IPN-ISC explicitly integrates environmental impact, sustainability, and the industrial revolutions as a context for ethical reflection. The TecNM addresses technoethics and bioethics, but in a more limited manner.
- A shared absence of AI ethics: None of the eight programs explicitly includes ethical dilemmas related to artificial intelligence, data privacy, or automation, despite these being competencies required by the graduate profiles in ISC and Mechatronics.
- Philosophical depth: ITESM is the only institution that requires a prerequisite course in ethics (H1017/H1040) and explicitly requires faculty to hold a master's or doctoral degree in philosophy, indicating a greater institutional investment in the philosophical depth of the program.

Comparative Analysis from the Perspective of Public and Private Higher Education

The inclusion of ITESM as a leading private institution allows us to explore whether the public or private nature of an institution is associated with systematic differences in the curriculum design of ethics education. The analysis reveals three major dimensions of distinction:

Institutional mission and approach to ethics education: Public institutions (UNAM, IPN, UANL, and TecNM) respond to constitutional mandates of mass access, equity, and national development. This is reflected in a diversity of ethical approaches ranging from classical philosophy (UNAM) to citizenship and the rule of law (UANL), including the socio-technical dimension (IPN) and humanism for social justice (TecNM). ITESM, with an explicit mission to train leaders committed to Mexico's development, adopts an approach more centered on the individual (the "life project with moral integrity") and on responsible citizenship. Both approaches are legitimate but reflect distinct conceptions: while public institutions tend to link ethics to the broader social context (inequality, rights, legality, sustainability), ITESM links it more directly to personal development and the individual's moral autonomy.

Philosophical Rigor and Faculty Profile: ITESM is the only institution that: (a) explicitly requires a faculty member with a graduate degree in Philosophy or Ethics to teach the course; (b) establishes an ethics prerequisite (at least two levels of training in ethics); and (c) uses a consistently high-level philosophical reading list (Cortina, Comte-Sponville, Blackburn). This contrasts with the finding by Olayo Valles et al. (2019) that only 68% of TecNM faculty members have a profile suitable for the course, and with the absence of specific faculty requirements in the programs at UNAM, IPN, and UANL. The difference can be explained by the private institution's greater pedagogical autonomy in defining specialized faculty profiles.

Training model: continuous cross-curricular approach vs. single course. In contrast to the predominant model of a single ethics course (at the four public institutions), ITESM offers at least two sequential levels of ethics training, which approximates the ideal of "ethics across the curriculum" described by Olayo Valles et al. (2019) and recommended in the specialized literature (Martin et al., 2021; Miñano Rubio & Génova Fuster, 2021). This finding is particularly relevant for TecNM, whose new humanistic model specifically advocates for continuous and cross-curricular ethics education, but whose current curriculum concentrates it into a single course.

In summary, the private institution analyzed shows relative advantages in terms of philosophical rigor, curricular verticality, and faculty specialization, while public institutions offer greater diversity of approaches and a more explicit connection to the national social, political, and technological context. An enriched curriculum model for TecNM could incorporate the strengths of both models: the philosophical depth and verticality of ITESM, along with the sociotechnical contextualization of IPN and the humanistic-civic dimension that TecNM itself already cultivates in its educational model.

Relationship with TecNM's Ethics Workshop: Strengths and Areas for Improvement

The comparative analysis allows us to identify, based on documentary evidence, the main strengths and areas for improvement of TecNM's Ethics Workshop:

Strengths: (a) broad thematic coverage structured around four major themes that range from philosophical foundations to organizational ethics; (b) a workshop format that prioritizes reflective practice; (c) universal nature (applicable to all degree programs); and (d) alignment with TecNM's new humanistic model, which provides the course with institutional coherence and its own philosophical framework (Mexican humanism for social justice).

Areas for improvement: (a) the extensive list of values in Topic 1 (love, forgiveness, redemption, gratitude) is more closely aligned with personal virtue ethics than with the professional ethics of engineering, which may make it difficult to connect these values to the specific dilemmas faced in ISC and Mechatronics; (b) the content on Technoethics and Bioethics appears as a subtopic within Topic 3, without being developed to the depth required by the contemporary challenges of AI and automation; (c) there is no prerequisite or ongoing ethics training throughout the degree program, unlike the ITESM model; (d) there is no specification for a faculty profile with training in philosophy or ethics, which may explain the finding by Olayo Valles et al. (2019); and (e) the syllabus is identical for all degree programs, which limits the relevance of ethical dilemmas for specific fields such as ISC or Mechatronics.

CONCLUSIONS

This study applied Bereday's comparative method to analyze eight ethics courses in Computer Systems Engineering and Mechatronics Engineering programs at four Mexican institutions: UNAM, IPN, and UANL (public) and ITESM (private), using the TecNM Ethics Workshop as a reference point.

The results of the description and juxtaposition phases reveal that there is no single dominant model for the ethical education of engineers in the national higher education system. Three major orientations are identified: (1) philosophical-humanistic, represented primarily by UNAM, ITESM, and TecNM; (2) socio-technical-contextual, represented by IPN; and (3) civic-legal, represented by UANL. This diversity is in itself a significant finding, pointing to different conceptions of the social function of ethics in engineering education.

The findings of this study engage with previous research in the field of engineering ethics. The identification of a predominantly philosophical-individual orientation in most of the programs studied coincides with the assessment by Herkert (2005), who documented that the teaching of engineering ethics has historically focused on microethics—the responsibility of the individual and internal professional relationships—while neglecting the macroethical dimension, which examines the collective and social impact of technology; the present analysis confirms that this trend persists in the Mexican context. Meanwhile, the absence of a teaching standard in seven of the eight programs analyzed—previously noted by Olayo Valles et al. (2019) for TecNM—is supported by the findings of Hess and Fore (2018), who, in their systematic review of engineering ethics interventions in the United States, identified variability in faculty training as one of

the factors explaining the low consistency in ethical learning outcomes. Finally, the predominance of the single-course model at the four Mexican institutions analyzed is consistent with the critique by Conlon and Zandvoort (2011), who argue that the teaching of engineering ethics must transcend the individualistic approach focused on a single course to adopt a collective and socio-technical perspective integrated throughout the curriculum, which reinforces the relevance of the proposal for continuous ethics education that TecNM's own humanistic model encompasses.

The analysis of the public/private dimension shows that the private institution (ITESM) has relative advantages in terms of philosophical depth, curricular verticality, and a specialized faculty profile, while public institutions offer greater diversity of approaches and a more direct connection to the national social and technological context. For TecNM, the findings suggest that its Ethics Workshop (which has strengths in thematic coverage and humanistic coherence) could be enriched by incorporating: greater curricular verticality, a deeper exploration of ethical dilemmas specific to ISC and Mechatronics (particularly in AI), and more explicit standards for faculty profiles.

The most critical common gap is the absence of content on ethics in artificial intelligence and emerging technologies across the eight programs analyzed, representing a curricular lag compared to the competencies required by updated graduate profiles. This gap presents an opportunity for TecNM, with its new humanistic model, to lead a curricular update that integrates this dimension and positions itself as a national leader in the teaching of ethics in engineering.

FUTURE WORK

Three priorities have been identified as research projects stemming from this study. First, expanding the sample of institutions to include universities in Latin America and the United States—including programs with an explicit focus on engineering ethics, such as Harvard's Embedded EthiCS and MIT's program—would provide a continental perspective that contextualizes the national findings and enriches the comparative analysis with more established curricular models. Second, it is pertinent to conduct an analysis of the alignment between the content of TecNM's Ethics Workshop and the specific graduate profiles for the Computer Systems Engineering and Mechatronics Engineering programs, with the aim of identifying specific gaps between what the ethics curriculum offers and the competencies that the programs state they expect their graduates to possess. Finally, as an applied synthesis of the above, we propose designing a plan to update the Ethics Workshop curriculum that integrates, in a coherent manner, the philosophical depth characteristic of the programs at UNAM and

ITESM, the sociotechnical contextualization of the IPN-ISC model, the explicit treatment of ethics in artificial intelligence and specific dilemmas in computing and mechatronics, as well as the establishment of a specialized faculty profile standard that ensures the disciplinary suitability of those who teach the course.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY

All datasets relevant to the results of this study are available in their entirety in the article.

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This study did not receive funding from any organization.

STATEMENT ON GENERATIVE AI

The authors declare that no generative artificial intelligence tools were used at any stage of this study.

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APPENDICES

Appendix 1. *Structural Characteristics by Program.*

Aspect	TecNM (ref.)	UNAM Mechanical Engineering	UNAM Comp.	IPN ISC	IPN Mechanical Engineering	UANL FIME	UANL Mechanical Engineering	ITESM Computer Engineering
Name	Ethics Workshop	Professional Ethics	Professional Ethics	Engineering, Ethics, and Society	Ethics for Professional Practice	Ethics, Society, and the Profession	Ethics, Transparency, and Culture Law.	Ethics, the Individual, and Society
Type: Higher Education Institution	Federal public	Federal public	Federal public	Federal public	Federal public	State public	State public	Private
Semester/Grade Level	General (no fixed semester)	7th	8th	2nd	Level III	1st–2nd	1st–2nd	Basic Level (prerequisite)
SATCA/credits	1-3-4 (4 cr.)	6 credits	6 credits	9 TEPIC	4.5 TEPIC	2 UANL	2 UANL	3.5 ITESM
Total hours	~64 (workshop)	48	64	81	54	60	~60	~110 (3 hours + 8 hours of independent study per

								week)
Format	Workshop	Theoretical	Theoreti cal-practical	Theoretical	Theoreti cal-practical	Not enrolled in school a	Blended	In-person + self-paced
Units/phases	4 topics	6 units	6 units	5 units	3 blocks	3 phases + PIA	3 phases + PIA	No breakdown (summary)

Case studies	Yes (dilemmas)	Yes (12 hours)	Yes (32 hours of practical work)	Yes	Yes	Yes (PIA)	Yes (report)	Yes (ethical controversies)
Dominant approach	Humanistic + values + professional ethics	Classical philosophical-humanistic	Philosophy + axiology + knowledge society	History of science + sociotechnical + sustainability	Axiological + Mechatronics	Philosophical + sociocultural	Citizenship + legal + data	Philosophical + life plan + citizenship
Ethical Curriculum	A unique subject	A subject	A subject	A subject	A subject	A subject	A subject	Minimum of 2 levels (H1017→H1018)
Required faculty profile	Not specified or	Not specified or	Not specified or	Not specified or	Not specified or	Not specified or	Not specified or	Master's/Doctorate in Philosophy/Ethics

Source: *Compiled by the author* (2026).



