Global Competencies in Industrial Engineering Education: Curricular Relevance and Pedagogical Practices From the Perspective of Educational Actors

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Abstract

Global competence has become a central criterion of quality in engineering education, yet little is known about how it is understood and enacted in programs located in peripheral, non-elite institutions where structural internationalization is limited. This study examines how academic staff and students of an industrial engineering program at a Colombian public university located on the Venezuelan border interpret global competencies, assess the relevance of their curriculum, and describe the pedagogical practices through which such competencies are, or fail to be, developed. A qualitative, hermeneutic-phenomenological design was adopted. Eight key informants (four faculty members, including two with program-direction experience, and four students, two of whom had completed international academic mobility) participated in semi-structured interviews. Data were analyzed following the categorization, contrastation, structuring, and theorization sequence, yielding three categories and six subcategories. Findings show a shared but unequally elaborated conception of global competence in which adaptability, intercultural interaction, critical thinking, and second-language proficiency are recurrent; a curriculum that is internationally compatible in structure yet declarative in intent, since global competence is neither named nor assessed in micro-curricular documents and English operates as a graduation requirement rather than a formative pathway; and a repertoire of pedagogical practices — state-of-the-art review, case analysis, mirror classes, classroom projects with local firms, and industrial visits — that produces global competence as a by-product of research training rather than as a planned learning outcome. Access to mobility is concentrated in a minority of students, making the enacted curriculum the principal equity lever. The study contributes an empirically grounded account of internationalization at home under resource constraints and proposes implications for curricular design, faculty development, and assessment in engineering programs of the Global South.

Keywords: Global Competence; Engineering Education; Curricular Relevance; Pedagogical Practices; Internationalization At Home; Qualitative Research; Colombia

INTRODUCTION

The professional field of industrial engineering has been reshaped by the same forces that have reorganized production itself: global value chains, distributed teams, digital process technologies, and a regulatory environment increasingly framed by sustainability

commitments. Graduates now design, improve, and manage processes that cross organizational, sectoral, and national boundaries, and they do so alongside colleagues whose professional training, language, and cultural repertoires differ from their own. The competencies that this situation requires — the capacity to interpret problems in multiple contexts, to communicate across differences, to examine local realities against international referents, and to act with an awareness of global consequences — have been grouped under the label of global competence (OECD, 2018).

The construct has strong normative backing. The Organisation for Economic Co-operation and Development defines global competence as the capacity to examine local, global, and intercultural issues, to understand and appreciate the perspectives and worldviews of others, to engage in open and effective interactions across cultures, and to act for collective well-being and sustainable development (OECD, 2018). The United Nations Educational, Scientific and Cultural Organization frames a related agenda through global citizenship education, which combines cognitive, socio-emotional, and behavioral learning objectives (UNESCO, 2015). In engineering specifically, global competence has been theorized as the ability to work effectively with people who define problems differently (Downey et al., 2006), and has been operationalized through situational judgment instruments (Jesiek et al., 2020) and through curricular frameworks such as CDIO (Crawley et al., 2014). Accreditation regimes have followed: outcome-based criteria now require evidence of communication, teamwork, ethical reasoning, and the recognition of the global, economic, environmental, and societal impacts of engineering solutions.

There is, however, a persistent gap between this normative architecture and the ordinary life of undergraduate programs. Internationalization research has repeatedly shown that the benefits of mobility accrue to a small and socioeconomically advantaged minority of students, which has motivated the shift toward internationalization at home and toward internationalization of the curriculum as the only mechanisms capable of reaching the whole student body (Beelen & Jones, 2015; Leask, 2015; Soria & Troisi, 2014). Yet the literature describing how that shift actually occurs is dominated by institutions with comparatively abundant resources. Far less is known about programs that operate under conditions of restricted mobility budgets, limited software licensing, uneven faculty language proficiency, and curricula governed by national accreditation rules that do not name global competence as such. These programs constitute the majority of engineering education worldwide, and they are precisely where the distance between the declared curriculum and the enacted curriculum is most consequential.

The Colombian case adds further specificity. National regulation organizes program quality around the notions of curricular relevance and learning outcomes, and high-quality accreditation explicitly values internationalization; at the same time, most public universities fund mobility through competitive, small-scale schemes. When the institution is located in a border region, the international dimension is not an aspiration but a daily fact of classroom composition, since students from the neighboring country study alongside local students. This produces an instructive paradox: intercultural contact is ordinary, while institutional internationalization is scarce. How educational actors interpret and use that paradox is an open empirical question.

RESEARCH PROBLEM AND PURPOSE

This article addresses that question in the industrial engineering program of the Universidad Francisco de Paula Santander (UFPS), a public university in Cúcuta, Norte de Santander, Colombia, on the border with Venezuela. The program has a broad professional profile and a curriculum organized into basic sciences, basic engineering, applied engineering, and socio-humanistic areas. Global competence is not a named component of that curriculum, although several of its constituent abilities circulate in institutional discourse under other labels, such as transversal competencies or soft skills.

The purpose of the study was to interpret how educational actors — faculty members and students — understand global competencies, how they assess the relevance of the curriculum for developing them, and which pedagogical practices they identify as effective, insufficient, or absent. Three research questions guided the inquiry:

RQ1. How do faculty members and students of the industrial engineering program conceptualize global competencies, and which abilities and knowledge do they associate with them?

RQ2. What relevance do educational actors attribute to the current curriculum for the formation of global competencies, and where do they locate its limits?

RQ3. Which pedagogical practices, resources, and assessment approaches do educational actors identify as mediating the development of global competencies?

Contribution

The study makes three contributions. Empirically, it provides a detailed, actor-centered account of global competence formation in a setting that is typical of Latin American public engineering education yet underrepresented in the international literature. Analytically, it distinguishes between three layers of curricular existence — the declared, the interpreted, and the enacted curriculum — and shows that in this program global competence exists strongly in the third layer and weakly in the first, which reverses the sequence assumed by most curricular internationalization models. Practically, it derives implications for programs that cannot expand mobility and must therefore convert everyday teaching practice into the principal vehicle of global formation.

THEORETICAL BACKGROUND

Global Competence: Convergent Definitions, Divergent Operationalizations

Definitional work on global competence has converged on a multidimensional structure combining knowledge, skills, attitudes, and values. Hunter et al. (2006) established an early consensus that global competence requires an openness to learning from difference together with a working knowledge of world events and systems. Deardorff (2006) demonstrated, through expert consensus, that intercultural competence is better understood as a developmental process than as a stable trait, comprising attitudes of respect and curiosity, knowledge of cultural self-awareness, skills of observation and interpretation, and internal and external outcomes. Byram (1997) and Bennett (1993) provide complementary accounts, the former emphasizing critical cultural awareness in language learning and the latter a developmental progression from ethnocentric to ethnorelative orientations.

The OECD (2018) framework is the most widely used policy referent, in part because it was designed for assessment. Its four dimensions — examining issues of local, global, and cultural significance; understanding and appreciating others' perspectives; engaging in open, appropriate, and effective interactions; and taking action for collective well-being — translate relatively well into learning outcomes. Its assessment component, however, has been contested, and the PISA 2018 results underscored substantial cross-national variation in students' opportunities to develop the construct at school (OECD, 2020). UNESCO's global citizenship education agenda (UNESCO, 2015) and the more recent call for a new social contract for education (International Commission on the Futures of Education, 2021) situate the same abilities within a normative project of solidarity and sustainability rather than of employability.

In parallel, the employability literature has produced a functionally similar vocabulary. Bourn (2018) argues that global skills — cooperation across difference, comfort with complexity, systemic thinking, and ethical judgment — are what employers actually reward, and Jones (2013) shows that intercultural experience produces transferable skills that graduates can articulate. The World Economic Forum's periodic skill projections have placed analytical thinking, resilience, flexibility, and technology literacy at the top of employer demand (World Economic Forum, 2023). This convergence is important for engineering programs because it means that the case for global competence can be made simultaneously on civic and on labor-market grounds, and the two arguments imply somewhat different curricular designs.

Global Competence in Engineering Education

Engineering education research has developed its own line of work on this construct. Downey et al. (2006) proposed that the globally competent engineer is defined less by international experience than by the capacity to collaborate with people who define problems differently, a formulation that displaces the emphasis from geographic mobility to epistemic flexibility. Lucena et al. (2008) documented how competence frameworks have been reorganized across the United States, Europe, and Latin America, showing that apparently universal lists of outcomes carry distinct institutional histories. Male (2010) and Passow and Passow (2017) synthesized the evidence on generic or professional competencies, consistently identifying communication, teamwork, problem-solving, and self-directed learning as the abilities most valued in practice and least systematically taught. Jesiek et al. (2020) advanced measurement by developing a situational judgment test for global engineering competency, and Klein-Gardner and Walker (2011) proposed definitions specific to undergraduate engineering.

Curricular models have followed. The CDIO initiative embeds professional and interpersonal competencies in an integrated conception of engineering practice, arguing that they must be taught through the same project-based experiences that teach technical content rather than appended as separate courses (Crawley et al., 2014). Graham (2018) mapped the global state of the art in engineering education and found that the most influential programs share design-centered, socially contextualized curricula and strong institutional support for pedagogical change. In Latin America, the Tuning project articulated generic and subject-specific competencies through regional consultation (Beneitone et al., 2007), extending the European framework (González & Wagenaar,

2003) to the regional context, while competency-based approaches were disseminated through works such as Tobón (2013) and Villa and Poblete (2008). Despite this abundance, the empirical literature documenting whether and how such frameworks reach the classroom in resource-constrained public universities remains thin.

Curricular Relevance and the Distance Between Declaration and Enactment

Curricular relevance, in the Latin American tradition, denotes the correspondence between the formative project and the needs of the social, productive, and cultural context in which graduates act. It is an evaluative criterion in Colombian quality assurance and therefore has regulatory force. Analytically, however, relevance can only be assessed if one distinguishes between the curriculum as declared in institutional documents, as interpreted by teachers, and as enacted in classrooms. Leask (2015) makes this distinction central to curricular internationalization, arguing that the informal and hidden curricula frequently carry more international learning than the formal one, and that disciplinary teams — not international offices — are the decisive actors. Knight (2004) had already warned that internationalization tends to be measured through inputs such as agreements and mobility counts rather than through learning, a bias that de Wit and Altbach (2021) find persistent.

Constructive alignment (Biggs, 1996) offers the mechanism that connects these layers: unless an intended outcome is stated, taught through aligned activities, and assessed, it remains rhetorical. Applied to global competence, this implies that a program can be internationally compatible in structure — comparable course sequences, transferable credits, recognized degrees — and still not form global competence, because compatibility governs mobility logistics rather than learning. The distinction matters for the present case, in which the curriculum facilitates exchange for those who can access it while leaving the competence itself unnamed for everyone else.

Pedagogical Mediation and Learning Theories

The pedagogical dimension of the study draws on constructivist and experiential traditions. Kolb (1984) models learning as a cycle in which concrete experience is transformed through reflective observation and abstract conceptualization into active experimentation, a sequence that describes the learning reported by students returning from mobility or from industrial visits. Ausubel (1968) grounds meaningfulness in the relation between new material and existing cognitive structure, which explains why case analysis anchored in familiar local processes can support the interpretation of unfamiliar international ones. Bruner (1961) and Gardner (1983) support, respectively, discovery-oriented teaching and the plurality of ability profiles, both of which appear in participants' accounts of what works. Zimmerman (2002) provides the self-regulation vocabulary that participants use when they attribute global competence to autonomous study. Schön (1983) frames the reflective practitioner, and Mezirow (1991) the transformative potential of disorienting experience — a construct directly relevant to students who confront, abroad, the limits of their preparation. Morin (1999) supplies the complexity perspective through which several faculty members articulate the interdependence of local and global problems.

Finally, the critical literature on language warns against treating English proficiency as a neutral technical skill. Phillipson (2009) argues that the global spread of English carries

asymmetries of power that education reproduces when it naturalizes the language as the sole gateway to professional opportunity. In a border program whose students already operate across a linguistic and national boundary of a different kind, this critique is not abstract: it raises the question of which forms of intercultural capability the curriculum recognizes and which it renders invisible.

Synthesis and Gap

Taken together, the literature establishes what global competence is, why engineering needs it, and through which curricular mechanisms it can be developed. What remains underdocumented is how these elements combine in programs where structural internationalization is scarce, where the international dimension enters the classroom through migration rather than through mobility agreements, and where faculty members themselves report limited proficiency in the language that the framework assumes. The present study addresses that gap by reconstructing, from the accounts of those who teach and study in such a program, the conceptions, curricular judgments, and pedagogical practices through which global competence is currently produced.

METHOD

Design and Paradigmatic Position

The study adopted a qualitative design framed within the interpretive paradigm, whose purpose is to understand human conduct through the meanings that actors attribute to their experience rather than to explain it through external variables. The method was hermeneutic phenomenology, which seeks to describe the essential structure of a lived experience as it is given to consciousness and to interpret its significance within the participants' world (Moustakas, 1994; Van Manen, 1990). This choice followed from the object of inquiry: global competence in this program has no documentary existence, so it can only be reconstructed from the concepts, judgments, and practices of those who teach and learn there.

The procedural structure followed the four phases described in the Spanish-language phenomenological tradition (Fuster Guillén, 2019; Martínez Miguélez, 2006): a previous phase, in which the researcher makes explicit the presuppositions and theoretical frames that orient the inquiry; a descriptive phase of gathering lived experience; a structural phase of analysis in which meanings are delimited and organized; and a final phase of writing, in which individual structures are integrated into a group structure. The first author is a faculty member of the program under study, a position that afforded access and contextual understanding while requiring deliberate reflexive control, described below.

Setting

The setting was the industrial engineering program of the Universidad Francisco de Paula Santander, a public institution located in Cúcuta, Norte de Santander, Colombia, on the border with Venezuela. The program's curriculum is organized into four formative areas — basic sciences, basic engineering, applied engineering, and socio-humanistic studies — and leads to a professional degree. Two features of the setting are analytically relevant. First, the institution hosts students from other departments of Colombia and from the neighboring country, so cultural and national heterogeneity is

a routine property of classrooms. Second, international mobility is available through inter-institutional agreements but is financially and numerically restricted, so participation is exceptional rather than typical.

Participants

Eight key informants were selected through purposive criterion sampling. Key informants were understood as individuals whose position and accumulated experience allow them to represent a defined group and to provide information of high interpretive value. Four selection criteria were established a priori: two students who had completed an internationalization experience (academic mobility, exchange semester, or professional placement); two students enrolled in applied engineering courses between the fifth and tenth semesters; two faculty members with more than three years of teaching in the applied engineering area; and two faculty members who had assumed responsibility for the direction of the academic program. This design deliberately combined positions with contrasting vantage points — managerial and classroom, mobile and non-mobile — in order to surface disagreement rather than consensus.

Table 1 presents the participants and their codes. Codes preserve anonymity and are used throughout the Results.

Table 1: *Key Informants, Selection Criteria, and Analytic Vantage Points*

Code	Role	Selection criterion	Analytic vantage point
T1	Faculty member	Applied engineering area; program direction experience	Institutional and curricular governance
T2	Faculty member	Applied engineering area; program direction experience	Curricular design and internationalization processes
T3	Faculty member	More than three years in applied engineering	Classroom practice; micro-curriculum
T4	Faculty member	More than three years in applied engineering	Classroom practice; faculty development
S1	Student	Completed international mobility (Argentina)	Comparative experience of two academic systems
S2	Student	Completed international mobility (Mexico)	Comparative experience;

			technology exposure
S3	Student	Enrolled in applied engineering courses	Non-mobile student trajectory
S4	Student	Enrolled in applied engineering courses	Non-mobile student trajectory

Data Collection

Data were generated through individual semi-structured interviews conducted face to face. Two interview guides were developed, one for faculty members (13 questions) and one for students (8 questions), both organized around three thematic blocks: the conception of global competencies and their constitutive abilities and knowledge; the role of the curriculum in internationalization and its perceived relevance; and the pedagogical strategies, resources, and assessment practices associated with the formation of these competencies. The guides were reviewed by external experts for clarity and thematic coverage prior to fieldwork.

The semi-structured format was selected because it guarantees comparability across informants while permitting the interviewer to follow the informant's own line of reasoning, which is a methodological requirement of phenomenological work. Interviews were audio-recorded with consent and transcribed verbatim. Participants received an explanation of the purpose and nature of the study, and informed consent was obtained individually; codes replaced names at the point of transcription.

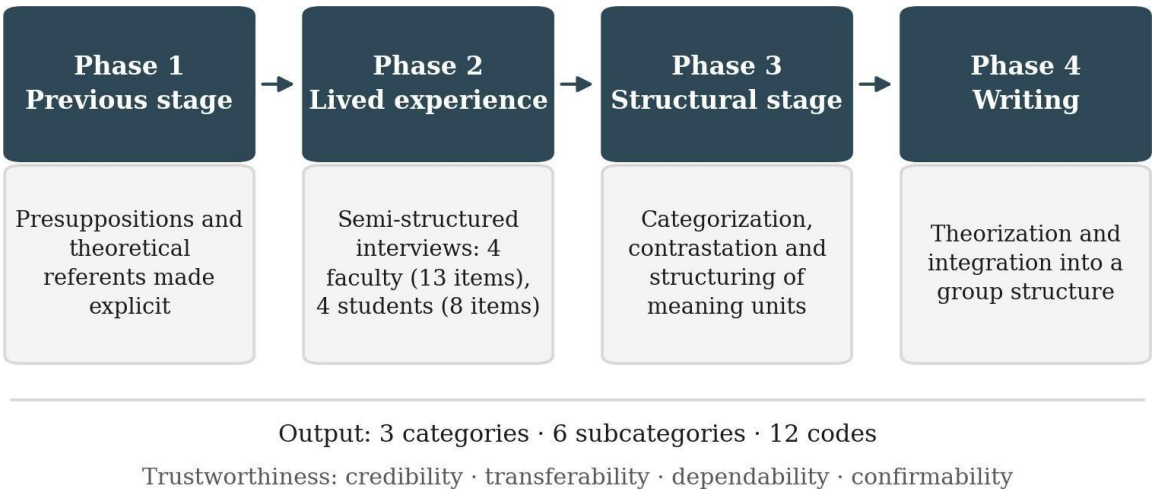
Data Analysis

Analysis proceeded through four recursive operations (Martínez Miguélez, 2006). In categorization, transcripts were read repeatedly to obtain a global sense of content; meaning units were then delimited and labeled with brief expressions that preserved the informant's own language, after which pedagogical and curricular terminology was assigned. In contrastation, categories were compared across informants and across the two participant groups, and were confronted with the theoretical referents described above. In structuring, the relations among categories, subcategories, and codes were organized into descriptive structures, first individual and then collective. In theorization, the group structure was integrated into an interpretive account of how global competence is formed in this program.

Two decisions bound the scope of the present article. First, the analysis reported here covers the first three operations — categorization, contrastation, and structuring — which produce the descriptive and interpretive account of the phenomenon. The fourth operation, in which the group structure is converted into a theoretical construct with its corresponding epistemological propositions, exceeds the limits of a single article and is developed in a separate study by the same research team; this article therefore reports findings and their discussion, not the resulting model. Second, the analytic emphasis falls on the contrast between the two participant groups, which the data showed to be

more informative than aggregate description. Figure 1 summarizes the methodological sequence and its outputs.

Figure 1*Methodological Sequence of the Hermeneutic-Phenomenological Analysis*



Note. The fourth phase is reported partially in this article: the group structure is presented in the Results, while the derivation of a theoretical construct from it is developed in a separate study.

The procedure yielded three categories and six subcategories, presented in Table 2. Coding was performed manually, with an audit trail linking each code to its supporting meaning units.

Table 2*Emergent Categories, Subcategories, and Illustrative Codes*

Category	Subcategory	Illustrative codes
Global competencies	Competencies for professional formation	Global competencies in the development of the professional profile; openness to change regarding the idea of global competencies; technologies and global competencies; research and global competencies
Curricular relevance	Educational foundations	Educational management from the professional profile; curricular foundations of the industrial engineering program; professional formation of the industrial engineer;

		contextualization of educational realities; innovation in the formation of the industrial engineer
Pedagogical process	Teaching and learning in the industrial engineering program	Teaching strategies for global competencies; teaching resources for global competencies; assessment of the pedagogical process

Trustworthiness

Scientific rigor was addressed through the four criteria proposed by Lincoln and Guba (1985) and widely adopted in Spanish-language qualitative methodology (Gurdián-Fernández, 2007). Credibility was pursued through prolonged familiarity with the setting, verbatim transcription, and the triangulation of the two participant groups, which allowed convergent and divergent accounts of the same practices to be identified. Transferability was supported by thick description of the setting, the curriculum structure, and the participants' positions, so that readers may judge the applicability of the findings to comparable programs. Dependability was addressed through an explicit audit trail of the categorization process and through the use of two structured interview guides. Confirmability was pursued through reflexive control of the first author's insider position: presuppositions were written out in the previous phase of the method, interpretations were contrasted with the literal content of transcripts, and analytic decisions were discussed with the co-authors, who are not members of the program's teaching staff in the same capacity.

Ethical Considerations

The study followed the ethical requirements applicable to research with human participants in higher education institutions. Participation was voluntary and based on informed consent; participants were informed of the purpose, the use of recordings, and their right to withdraw. Anonymity was protected through coding, and no information allowing individual identification is reported. Because the first author teaches in the program, particular attention was paid to avoiding any relation of academic dependency with student participants, who were selected among those not enrolled in her courses at the time of the interview.

Presentation of Quotations

Interviews were conducted in Spanish. Quotations reproduced in the Results were translated into English by the authors, with priority given to semantic fidelity over stylistic smoothing; hesitations and repetitions were removed only where they impeded comprehension. The original Spanish formulations are retained in the research archive.

RESULTS

The three categories are presented in turn. Within each, convergences and divergences between faculty and student accounts are made explicit, since the contrast between the

two groups proved to be the most analytically productive feature of the data.

Category 1: Conceptions of Global Competencies

A Shared Core Organized Around Adaptability.

All four faculty members converged on adaptability as the defining attribute of the globally competent industrial engineer, though each derived it from a different premise. T1 grounded it in the disciplinary purpose of the profession, arguing that because the industrial engineer exists to improve organizational processes, and organizations are embedded in territories with distinct cultures, competence consists in the capacity to absorb changes in local, regional, and international dynamics:

Global competencies in this profession would be the capacity that those professionals or graduates have for adaptability, the ability to draw on their prior knowledge to quickly absorb changes in the dynamics of their local, regional or international environment. (T1)

T2 derived the same core from the composition of the classroom rather than from the nature of the profession, describing global competence as the capacity to analyze situations across economic, social, political, environmental, and cultural domains, and locating its formative opportunity in the diversity of the student body: the program hosts students from the metropolitan area, from other departments, from the neighboring country, and occasionally from Mexico. T3 formulated competence as a set of universal capabilities valid in any context of application, professional or personal, while T4 emphasized integration and synergy, arguing that the breadth of industrial engineering obliges graduates to coordinate the work of professionals from other fields.

Students articulated a narrower and more instrumental conception. S1 described competencies as tools that one is capable of deploying across different fields, and S3 defined them as the characteristics that make a professional competent, exemplified by leadership and conflict resolution within a firm, with the ambition of projecting those abilities beyond Colombia. S2 framed the construct almost entirely in terms of employer recognition, defining global competence as the abilities that international firms value in industrial engineers. Only S4 produced a formulation close to the faculty's, describing the capacity to learn, to adapt to change, and to hold multiple perspectives.

The divergence is analytically significant. Faculty members conceptualize global competence as a disposition toward complexity; students conceptualize it as a portfolio of marketable capabilities. Both conceptions are legitimate within the literature — the first closer to the OECD (2018) and complexity traditions, the second closer to the employability line of Bourn (2018) — but their coexistence without mediation means that teachers and learners are pursuing partially different objects under the same name.

The Abilities and Knowledge Associated With Competence.

When asked to specify constitutive abilities, faculty converged on a cluster of continuous learning, willingness to change, communication, and leadership (T1); attitudes and values, problem analysis, decision making, intercultural awareness, commitment to corporate social responsibility, and critical thinking (T2); openness to second-language

learning, literacy, self-directed learning, perseverance, discipline, and time management (T3); and autonomous work, change generation, problem solving, leadership, responsibility, creativity, process innovation, and teamwork, to which T4 added inclusive language, including sign language, as a condition for serving users with disabilities.

Required knowledge was formulated at two levels. T1 emphasized regulatory and agenda-setting knowledge — the Sustainable Development Goals, United Nations frameworks, climate change — as the conceptual basis from which an engineer builds awareness of global problems. T4 emphasized instrumental knowledge, specifically foreign languages beyond English and programming and software literacy sufficient for business needs, while T2 and T3 stressed ethical and intercultural knowledge and the disposition to understand that a process can be approached differently depending on its environment.

Table 3 synthesizes the attributes named by each group, showing overlap and asymmetry.

Table 3:*Attributes of Global Competence Named by Faculty and Students*

Dimension	**Attributes named by faculty**	**Attributes named by students**	**Observation**
Cognitive	Critical and creative thinking; problem analysis; decision making; systemic reading of contexts	Process evaluation and optimization; mathematical logic	Students name discipline-specific cognition; faculty name generic cognition
Intercultural	Cultural and intercultural awareness; respect; empathy; openness to other worldviews	Adaptation to different working environments; learning from other cultures	Convergent but students anchor it in workplaces, not societies
Linguistic	English; additional languages; technical reading in a second language; inclusive language	English as the single most important competence; technical English in class	Students give English greater priority than faculty do

Technological	Use of technology to access global problems; software and simulation; automation	Programming languages; Excel and office tools; Industry 4.0; simulation licenses	Students frame technology as an access barrier, faculty as a resource
Attitudinal and ethical	Adaptability; continuous learning; humility; social and environmental responsibility; ethics	Resilience; self-criticism; self-motivation; initiative	Faculty emphasize values; students emphasize self-regulation
Research-related	Scientific literature review; state-of-the-art analysis; research seedbeds	Research as a graduation route and as an access condition for mobility	Research is the strongest shared bridge to global formation

Technology and Research as Vehicles of Global Formation.

Two codes emerged as the principal mechanisms through which participants believe global competence is currently acquired. The first is technology, understood less as content than as access: T2 described motivating students to use technology in order to know problems beyond nearby borders, and T1 identified connectivity and access to academic databases as the material condition of a global outlook. The second is research. T1 described a systematic requirement that students locate three local, three national, and three international antecedents for any project and analyze the similarities and differences among them, explicitly using contextual variation as a pedagogical object. S1 confirmed the mechanism from the student side, reporting that membership in a research seedbed and a published product were preconditions for accessing mobility. Research training thus operates as the de facto curriculum of global competence in this program — a finding with significant equity implications, since research participation is itself selective.

Category 2: Curricular Relevance

International Compatibility Without Curricular Declaration.

Faculty members assess the curriculum as structurally compatible with international programs. T1 described this compatibility as a strength, noting that the way the curriculum is conceived allows students to adapt in exchanges or placements abroad because of its similarity to foreign programs, and connected it to national accreditation trends favoring curricular flexibility and multidisciplinarity. T2 listed the destinations that this compatibility has enabled — Mexico, Brazil, Argentina, Spain — and the

reciprocal arrival of students from those countries, and described mirror classes with national and international colleagues as a flexibilization device that brings global content into ordinary courses.

This positive assessment coexists with a decisive limitation, stated most clearly by T3:

On the basis of the micro-curriculum, what a global competence is is not clearly defined; however, there are competencies and soft skills that are there, for example teamwork. (T3)

The competence therefore exists in practice without existing in the formal document. T3 drew the operational consequence, identifying as a principal challenge the absence of an institutional or program-level guideline that would allow all teachers to orient their contribution, and proposing that global competencies be defined, prioritized, and worked on from the first semester to the end of the program, with learning outcomes explicitly related to them. In the language of constructive alignment (Biggs, 1996), the program has activities without intended outcomes and without aligned assessment, which is precisely the configuration that produces uneven and unaccountable learning.

The Language Question.

The most frequently named curricular deficiency across both groups was English, but faculty and students diagnosed it differently. T2 located the problem in the curriculum's architecture, observing that English is not contemplated as part of the formative process but as a graduation requirement, with the consequence that the resulting proficiency does not reach the level required for international employment. T4 located it in the teaching body, acknowledging with unusual frankness that faculty themselves often cannot teach in a second language and are therefore in the contradictory position of demanding from students what they have not mastered; the strategy reported for addressing this was autodidactic learning.

Students experienced the deficiency as an event rather than as a structural feature. S2 identified English as the single most important global competence and judged institutional promotion efforts to be unsuccessful. S1 provided the most detailed account, having discovered during mobility to Argentina that the common language among international residents was English rather than Spanish:

In my mind, before travelling, I thought: I speak Spanish, in Argentina they speak Spanish. When I arrived at the building where I was to live, it was only international students, and the only language in common among us was English. (S1)

S3 proposed a concrete and low-cost remedy — closing classes in English, presentations in that language, slides prepared in English — noting that only some teachers do this and that it is how technical vocabulary is actually acquired. The convergence between a student's proposal and a teacher's confessed limitation identifies faculty language development as the binding constraint.

Mobility as a Scarce and Stratified Good.

Faculty and students agreed that mobility produces the strongest formative effects and that access to it is restricted. T4 stated the problem in distributive terms, arguing that mobility should be opened so that it is not so restricted in the number of students who can access it. T2 described the compensating devices — mirror classes, international

conference presentations, research networks, and the example of faculty who have studied abroad — which constitute, in effect, an internationalization-at-home repertoire assembled without that label.

The formative depth of mobility is best documented by S1, whose account describes a classic disorienting dilemma (Mezirow, 1991). Placed in a course taught inside partner firms rather than in classrooms, and confronted with peers from Europe who had stronger practical preparation, S1 reported never having seen a turbine, a heat exchanger, or a thickness gauge, and identified self-criticism, self-motivation, self-directed learning, and resilience as the capabilities that made completion possible. The experience reorganized the student's trajectory, since the encountered barrier — programming — became the subject of the degree project. S2's account is parallel but technological: participation in a large technology convention in Guadalajara revealed that Industry 4.0 and augmented reality belonged to the knowledge that industrial engineers should possess.

Non-mobile students describe a different and narrower horizon. S3 and S4 locate their most global experiences in classroom projects investigating firms in Norte de Santander and in industrial visits outside the city, which S4 described as situations that make one think that, depending on the type of work, one has to adapt to the environment. The comparison between the two subgroups makes visible a stratification of formative opportunity that the curriculum does not currently compensate.

Relevance Judged Against Future Trends.
Asked about future curricular trends, faculty produced a consistent agenda: sustainable development and the environmental impact of industrial processes, technological innovation and reengineering, and circular economy (T1); sustainable and socioeconomic project development and the adaptability lessons of the COVID-19 experience (T2); second-language proficiency, citizenship competencies, ethics, and corporate social and environmental responsibility (T3); and process automation, simulation, and management software, with English as a mandatory subject rather than a requirement (T4). Students named Industry 4.0, technology-mediated problem solving, closer contact with firms, and research (S1, S2, S4), and conflict resolution and resilience (S3).

The two agendas are compatible but differently weighted: faculty foreground sustainability and ethics, students foreground technology and practice. Notably, one faculty member (T4) introduced innovation and entrepreneurship as a curricular gap, arguing that the program's strength in production should be complemented by the formation of an innovative and entrepreneurial engineer — a proposal that resonates with students S2 and S4, who asked for strategies oriented toward venture creation from the early semesters.

Category 3: The Pedagogical Process
Strategies: A Repertoire Built Around Comparison.
The teaching strategies reported by faculty share an underlying logic: they place a local referent and an international referent in the same analytic frame and require students

to account for the difference. Four devices recur. The first is state-of-the-art and literature review, required across courses and often in a second language (T1, T2, T3). The second is case study analysis, with T1 describing the discussion of cases from industrialized countries facing complex problems in globally leading organizations and the deliberate exercise of criticizing them from a local perspective. The third is classroom projects in which students analyze the trends and challenges of a product or service at local, national, and international levels while integrating technical, social, cultural, and environmental considerations (T3). The fourth is deliberate group reconfiguration: T4 reported breaking up teams that had operated together since earlier semesters so that students must work outside their comfort zone, on the argument that accepting the viewpoints of others is the affective basis of global competence.

Students recognize these strategies unevenly. S1 offered a striking observation on this point, noting that students often do not recognize the strategies teachers use, and describing practical courses in which little step-by-step instruction is given, which forces the development of self-directed learning and self-criticism. S3 and S4 recognized the strategies with the clearest external referent — firm-based projects, socialization of current topics, teamwork, and product and process design tasks — but not the comparative logic underlying them. The pedagogical implication is that the strategies work better than they are understood to work, and that making their purpose explicit would cost little and add much.

Resources: Availability Without Sufficiency.

Faculty enumerated institutional resources — libraries, classrooms, virtual classrooms, academic databases, the simulation laboratory, audiovisual aids — and student-owned devices (T1, T2, T3), with T4 reporting deliberate use of institutional email and students' own mobile devices during class. T1 emphasized connectivity and intellectual property access as the primary material conditions of global formation.

Students accept this inventory and contest its sufficiency. S2 reported that simulation software is used to represent business reality but that practice is shallow and infrequent, and identified the number of licenses as the constraint. S1 asked for more agreements with firms that could serve as spaces for observing how industry actually works and for real access to the Industry 4.0 laboratory. S3 requested more training in new technologies and more industrial visits. The gap is therefore not one of inventory but of access intensity: the resources exist and are underused relative to the pedagogical model that both groups describe as desirable.

Assessment: Process Visibility Without Competence Assessment.

Asked how they evaluate the effectiveness of pedagogical processes for developing global competencies, faculty described strategies rather than criteria. T1 reported promoting permanent state-of-the-art review and using case-study presentations, group discussions, and debates. T2 listed problem solving, working sessions, prior readings, and the analysis of failed projects to identify causes. T3 described second-language article reading, classroom projects, and collaborative environments, judging collaborative work to be effective and to permit evaluation of learning processes. T4 described consciousness-raising through images and videos, followed by project fairs and public presentation of

results, and framed the intended outcome as students recognizing novelty, trend, and fashion in a topic as the basis for new professional initiatives.

No participant described an instrument, rubric, or indicator specific to global competence. Effectiveness is inferred from participation, from the quality of project outputs, and from graduate feedback; T4 cited returning mobility students and interns who report that the knowledge acquired proved useful abroad and in firms. This is the clearest evidence of the alignment deficit identified in Category 2: a competence that is not declared cannot be assessed, and what is not assessed cannot be improved systematically.

Expected Learning Outcomes.

Faculty accounts of expected outcomes are predominantly dispositional. T1 located them at the end of the program, when integrality becomes perceptible, and defined them as the capacity to work with people who are not industrial engineers and with whom synergies must be generated. T2 listed applied knowledge, analysis of diverse contexts, self-motivated inquiry, multicultural openness, autonomy, and environmental and social responsibility. T3 named second-language proficiency, interpersonal relations, research spirit, adaptability, and use of new technologies. T4 emphasized autonomy, problem identification and solution, and, notably, humility and empathy, arguing that a globalized world requires more humble professionals willing to help and to generate change.

Students formulated outcomes in terms of expanded possibility. S3 described global competencies as opening opportunities beyond national employment or entrepreneurship, and S1 described them as reinforcing both hard and soft skills and producing confidence to face any field or context. The convergence on disposition rather than on demonstrable performance reinforces the finding that global competence in this program is currently a formative climate rather than a specified outcome.

DISCUSSION

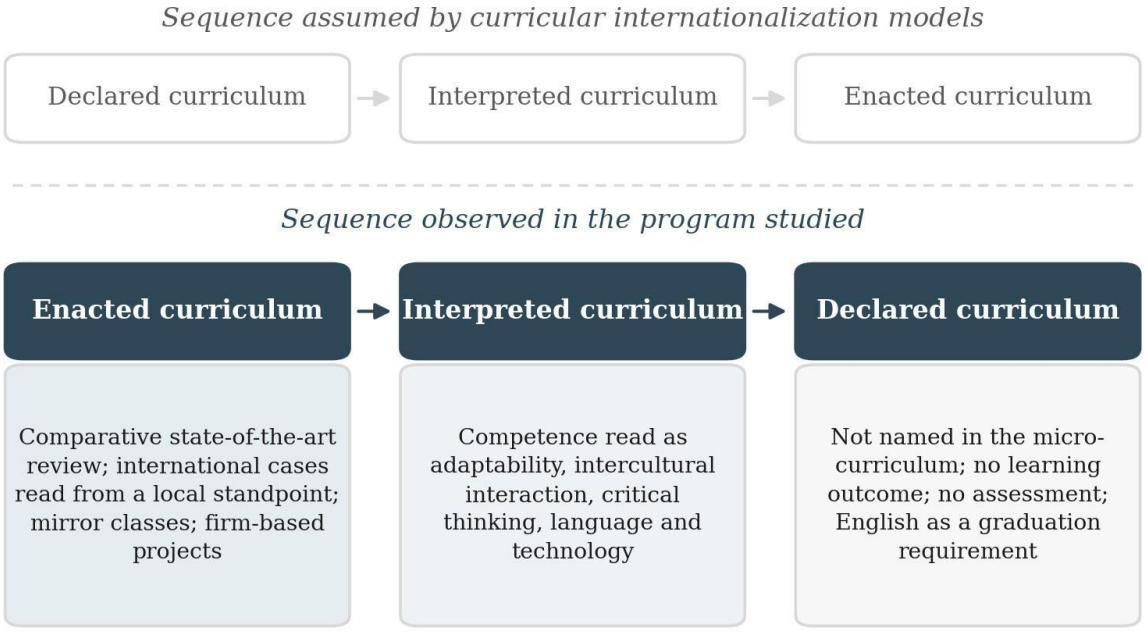
The findings allow three interpretive claims, each of which speaks to a different body of literature and carries distinct practical consequences.

Global Competence Exists in the Enacted Curriculum and Is Absent From the Declared One

The central result of the study is an inversion of the sequence that curricular internationalization models normally assume. Frameworks such as Leask's (2015) posit a movement from institutional intent to program-level outcomes and thence to classroom practice; accreditation logics assume the same direction. In the program studied, the movement runs the other way. Teachers deploy a coherent and theoretically defensible repertoire — comparative state-of-the-art review, international case analysis criticized from a local standpoint, mirror classes, heterogeneous team composition, projects that integrate technical, social, cultural, and environmental dimensions — and students accumulate genuinely global learning through it. Yet the micro-curriculum does not name the competence, no learning outcome refers to it, and no instrument assesses it.

Figure 2 represents this inversion. This configuration has two consequences that the literature predicts. The first is unevenness: because the competence depends on individual teachers' interpretations, its presence varies by course and by instructor, which is precisely what T3 identified when requesting program-level guidelines. The second is invisibility: learning that is not declared cannot be evidenced in accreditation processes, cannot be communicated to employers, and cannot be recognized by students themselves. S1's remark that students often do not recognize the strategies teachers use is the clearest expression of this second cost. Constructive alignment (Biggs, 1996) offers the remedy at low cost, since it does not require new activities but the explicit statement, alignment, and assessment of outcomes that existing activities already pursue.

Figure 2:*Inversion of the Curricular Sequence in the Program Studied*



Note. The upper sequence represents the direction assumed by curricular internationalization models. The lower sequence represents the direction observed in the data, in which practice precedes and exceeds declaration.

The finding also qualifies a common assumption in the internationalization literature, namely that the absence of a declared international dimension indicates the absence of international learning. Knight's (2004) critique of input-based measurement applies here in reverse: a program that would score poorly on declared internationalization indicators may nonetheless be producing substantive global learning through disciplinary teaching. Measuring internationalization through documents alone would misclassify this program, and the misclassification would be consequential for the resources it receives.

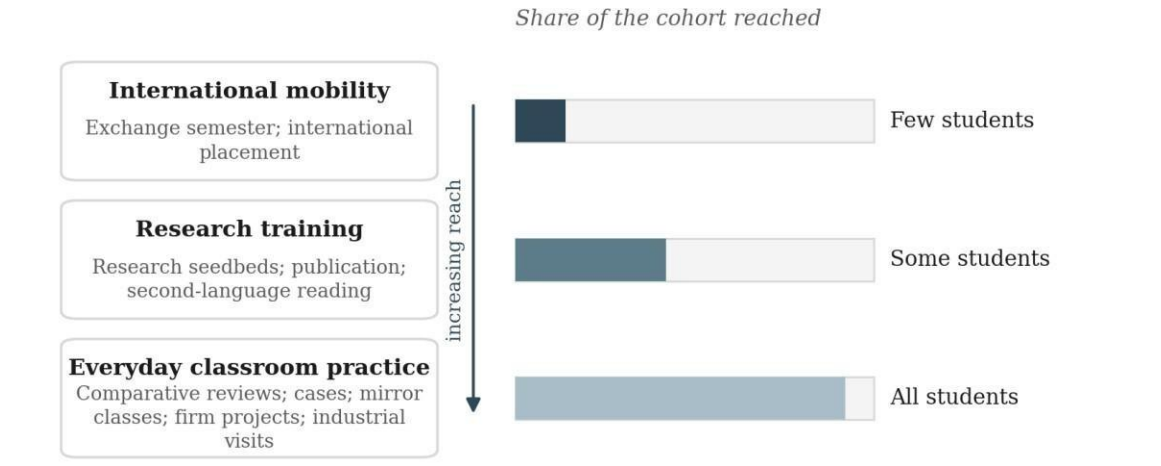
Research Training Functions as the De Facto Curriculum of Global Competence, With Equity Costs

The second claim concerns the mechanism. Across both participant groups, the practice most consistently associated with global formation was research: mandatory review of

local, national, and international antecedents; reading of scientific articles in a second language; participation in research seedbeds; presentation of results at external events. S1's report that a published product and seedbed membership were preconditions for mobility makes the mechanism explicit — research participation is the gateway to the most intensive global experience available in the program.

Figure 3 represents the three formative routes and the fraction of the cohort each one reaches. This is pedagogically sound, since inquiry-based comparison is an efficient vehicle for the dimension of the OECD (2018) framework concerned with examining issues of local and global significance, and it corresponds to the experiential cycle described by Kolb (1984). It is, however, distributively problematic. Research seedbeds are voluntary and selective; mobility is financially restricted; laboratory and software access is licence-limited. A formative architecture that routes global competence through these channels will reproduce, rather than compensate, the advantages students bring with them. The contrast between the accounts of S1 and S2, whose mobility produced transformative reorganizations of their professional projects, and those of S3 and S4, whose most global experiences were industrial visits and firm-based classroom projects, illustrates the stratification directly.

Figure 3:*Formative Routes to Global Competence and Their Reach Across the Cohort*



Note. Reach is an interpretive estimate derived from participants' accounts of access to mobility, research seedbeds, and ordinary coursework; it is not a statistical measure.

The internationalization-at-home literature (Beelen & Jones, 2015; Soria & Troisi, 2014) was developed to address exactly this problem, and the program already possesses several of its instruments — mirror classes, international guest teaching, culturally heterogeneous classrooms, research networks — without conceptualizing them as a coherent strategy. Naming them as such would convert a set of dispersed initiatives into an equity mechanism reaching the whole cohort rather than its most mobile fraction.

The Language Constraint Is a Faculty Development Problem Before It Is a Student Problem

The third claim reframes the most frequently cited deficiency. Both groups identified

English as the principal barrier, and the temptation in such cases is to treat the problem as one of student proficiency, addressable through requirements and testing. The data do not support that framing. English already functions as a graduation requirement, and T2's assessment is that the resulting competence does not reach the level needed for international employment. The structural feature that explains this outcome is the position of language in the curriculum: a requirement is a filter applied at exit, whereas a competence is built through distributed, repeated use.

T4's acknowledgment that faculty themselves often lack second-language fluency locates the binding constraint in the teaching body, and S3's proposal — slides, presentations, and class closings in English, which only some teachers currently do — identifies the corresponding intervention. This is consistent with Leask's (2015) argument that disciplinary academics, not language departments, determine whether internationalization reaches the curriculum, and with Graham's (2018) finding that institutional support for faculty pedagogical development distinguishes leading engineering programs.

The critical literature on language adds a caution that is particularly relevant in this setting. Phillipson (2009) warns against naturalizing English as the unique gateway to opportunity. The program's classrooms already contain a form of intercultural capability produced by the border condition — students from the neighboring country, comparison of productive realities across a frontier, adaptation to heterogeneous working environments — which the curriculum does not recognize as global competence. S1's mobility experience is instructive in both directions: the student's decisive difficulty was English, but the capability that resolved it was resilience and self-directed learning built at home. A program that treated its border condition as a curricular asset rather than a demographic accident would be able to formulate intercultural learning outcomes for which it already possesses the raw material.

Convergences and Divergences Between Actors

The two participant groups converge on the content of global competence — adaptability, intercultural interaction, critical thinking, technological and linguistic capability — and diverge on its purpose and location. Faculty locate it in a disposition toward complexity, formulated in terms of values, sustainability, ethics, and humility; students locate it in employability and in practice, formulated in terms of tools, firms, and access to international labor markets. Both positions are represented in the literature, and neither is mistaken. The risk lies in their remaining implicit: when teachers pursue dispositional aims through activities that students interpret instrumentally, the activities are completed without the intended meaning being constructed. Making the competence explicit in the micro-curriculum would, at minimum, allow the two purposes to be negotiated.

A further divergence concerns technology. Faculty describe technology as a resource for accessing global problems; students describe it as a competence in its own right and as a barrier when licences, laboratory access, and programming instruction are insufficient. Given that industrial engineering is being reorganized by digital process technologies, and that both T4 and the students named automation, simulation, and Industry 4.0 among future curricular trends, this divergence identifies a concrete curricular decision

rather than a difference of opinion.

Implications for Practice

Five implications follow, ordered by feasibility. First, declare the competence: define global competence for the program, disaggregate it into observable learning outcomes, and map those outcomes across the four formative areas from the first semester, as T3 proposed. Second, assess it: develop rubrics for the artifacts that already exist — comparative antecedent reviews, international case analyses, project presentations — so that existing work yields evidence. Third, redistribute the international experience: consolidate mirror classes, virtual collaborative projects, and international guest sessions into a structured internationalization-at-home track that reaches non-mobile students, and extend research seedbed participation. Fourth, invest in faculty language and pedagogical development, treating second-language teaching capability as institutional infrastructure rather than individual merit. Fifth, resolve the access constraints that students identify with precision — software licences, laboratory availability, firm agreements — since these are bounded, costed problems rather than diffuse aspirations.

Limitations

Four limitations bound the claims made here. The study involved eight key informants in a single program, so its findings are transferable rather than generalizable; the purposive design maximized variation in position but cannot represent the distribution of views across the faculty or student body. Second, data derive from self-report in interviews; no classroom observation or document analysis of syllabi was conducted, so the correspondence between reported and actual practice could not be verified independently. Third, the first author is a member of the program's teaching staff, which afforded access and interpretive depth but introduces the possibility of desirability effects in participants' accounts, mitigated but not eliminated by coding, reflexive control, and co-author review. Fourth, quotations were translated from Spanish, and translation involves interpretive decisions that readers cannot audit against the originals.

Future Research

Four lines of inquiry follow directly. The first is already in progress: the derivation of a theoretical construct for the formation of global competencies from the structures reported here, which constitutes the theorization phase of the method and is developed by the same team in a separate study. A document-based study comparing syllabi, program project documents, and accreditation self-assessments against the practices reported here would establish the magnitude of the declaration gap. A longitudinal study following mobile and non-mobile students through the final semesters and into early employment would test whether the stratification observed in formative opportunity persists in professional outcomes. Finally, a multi-institutional study across Colombian and Latin American public engineering programs would establish whether the inversion documented here — enacted without declared competence — is a local peculiarity or a regional pattern, which is the question with the greatest policy relevance.

CONCLUSIONS

This study set out to interpret how educational actors in a Colombian public industrial

engineering program understand global competencies, judge the relevance of their curriculum, and describe the pedagogical practices that form them. Three conclusions answer the research questions.

Regarding conceptions, faculty and students share a core definition organized around adaptability, intercultural interaction, critical thinking, and linguistic and technological capability, but assign it different purposes: dispositional and ethical for teachers, instrumental and employment-oriented for students. The shared vocabulary conceals a divergence of aims that remains unnegotiated because the competence is never made explicit.

Regarding curricular relevance, the program is internationally compatible in structure and declaratively silent in content. It enables mobility for those who can access it while leaving global competence unnamed in the micro-curriculum, unlinked to learning outcomes, and unassessed. English, positioned as a graduation requirement rather than a formative pathway, exemplifies the pattern, and the constraint is located in faculty capability as much as in student proficiency.

Regarding pedagogical practices, teachers deploy a coherent comparative repertoire — state-of-the-art review, international case analysis criticized from a local standpoint, mirror classes, heterogeneous teams, firm-based projects, industrial visits — through which global competence is in fact produced, principally as a by-product of research training. Because this route is selective, the current architecture distributes global formation unequally, and the enacted curriculum, not mobility, is the only lever capable of correcting that.

The wider contribution is to document a configuration that internationalization models rarely describe: a program in which global learning precedes its own declaration. For programs in comparable settings, this is encouraging and demanding in equal measure. It is encouraging because the pedagogical substance already exists and does not have to be imported. It is demanding because converting that substance into declared, aligned, and assessed learning is an act of curricular governance, and governance, unlike good teaching, cannot be improvised course by course.

Declarations

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Conflicts of interest. The authors declare no conflicts of interest.

Ethical approval and consent. The study followed the ethical guidelines applicable to research with human participants in higher education institutions. All participants gave informed consent prior to the interviews, and anonymity was protected through coding.

Data availability. The interview transcripts supporting the findings are not publicly available in order to protect participant anonymity, and may be requested from the corresponding author under conditions that preserve confidentiality.

Derivation from a doctoral dissertation. This article derives from the doctoral

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Author contributions. R. I. Laguado Ramírez: conceptualization, methodology, investigation, formal analysis, writing — original draft. E. G. Flórez Serrano: methodology, validation, writing — review and editing. F. Y. Hernández Villamizar: formal analysis, validation, writing — review and editing. All authors read and approved the final manuscript.

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