Theoretical Construct for Global Competency Formation in Industrial Engineering: Dynamic Learning, Teacher Mediation, and Global Citizenship

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Abstract

Purpose: This study aimed to generate a theoretical construct for the formation of global competencies in Industrial Engineering students at the Universidad Francisco de Paula Santander (UFPS), Cúcuta, Colombia. In an era characterized by accelerated globalization, the development of global competencies in engineering programs has become imperative to prepare professionals capable of addressing complex, interconnected challenges across borders.

Design/methodology/approach: Grounded in the interpretive paradigm, the study employed a phenomenological qualitative methodology following the frameworks of Fuster (2019) and Martínez (2004, 2006). Data were collected through semi-structured interviews with eight key informants—four professors and four students from the Industrial Engineering program—and analyzed through categorization, contrast, and theorization processes. Trustworthiness was ensured through Lincoln and Guba's (1985) criteria of credibility, transferability, consistency, and neutrality.

Findings: Three emergent categories were identified: Global Competencies, Curriculum Pertinence, and Pedagogical Process. From these, five interrelated theoretical subconstructs were derived: (1) student-centered teaching for global competency acquisition, (2) the teacher as a learning mediator, (3) formative competencies grounded in globality, (4) dynamic and interdependent global learning, and (5) global competencies in industrial engineer formation. The construct integrates experiential learning theory (Kolb, 1984), constructivism (Vygotsky; Piaget), complexity theory (Morin), and the OECD's (2018) global competence framework.

Originality/value: This study contributes an original theoretical framework that articulates how global competencies can be systematically integrated into Industrial Engineering curricula in Latin American contexts, addressing a gap in literature that has predominantly focused on Anglo-Saxon educational settings. The construct positions the teacher as a mediator, the student as an active agent, and global citizenship as a formative horizon.

Keywords: global competencies, industrial engineering education, theoretical construct, curriculum pertinence, teacher mediation, phenomenological research, global citizenship, higher education, Colombia.

1. Introduction

The transformations wrought by globalization since the latter decades of the twentieth century have profoundly altered every sphere of human endeavor—economic, cultural, technological, and educational. Higher education institutions, particularly engineering programs, face the imperative of preparing graduates who can navigate complexity, collaborate across cultural and disciplinary boundaries, and contribute to sustainable development in an interconnected world (Hadgraft & Kolmos, 2020; Lucena et al., 2008). The Organisation for Economic Co-operation and Development (OECD, 2018) formalized this imperative through its Global Competence Framework, integrated into the Programme for International Student Assessment (PISA) 2018 cycle, defining global competence as the capacity to examine local, global, and intercultural issues, understand and appreciate the perspectives of others, engage in open and effective interactions across cultures, and take action for collective well-being and sustainable development.

Despite this growing consensus on the importance of global competencies, their integration into engineering curricula remains uneven. Research has predominantly focused on Anglo-Saxon and European contexts (Parkinson, 2009; Jesiek et al., 2014), while Latin American engineering education has received comparatively less scholarly attention. In Colombia, regulatory frameworks such as Decreto 1330 de 2019 have emphasized outcome-based and competency-driven approaches to higher education quality, yet the curricular

operationalization of global competencies in specific disciplines, particularly Industrial Engineering, lacks both empirical investigation and theoretical grounding. Industrial Engineering occupies a distinctive position at the intersection of technical systems optimization and human organizational processes, making it particularly amenable to—and in need of—global competency integration. Industrial engineers are increasingly called upon to manage global supply chains, lead multicultural teams, and address sustainability challenges that transcend national borders (Rawboon et al., 2019; Trevelyan, 2019). Yet the pedagogical processes through which such competencies are formed, the role of teachers as mediators of globally oriented learning, and the curricular structures that enable or constrain this formation remain insufficiently theorized.

The present study addresses this gap by generating a theoretical construct for the formation of global competencies in Industrial Engineering students at the Universidad Francisco de Paula Santander (UFPS), located in Cúcuta, Norte de Santander, Colombia. Situated on the Colombian-Venezuelan border, UFPS operates in a context where cross-border dynamics, migration, and regional socioeconomic challenges render the question of global competency formation especially salient. The research draws on the lived experiences and conceptions of professors and students within the Industrial Engineering program, employing a phenomenological qualitative approach to uncover the meanings, practices, and conditions that shape competency formation.

Three research objectives guided the inquiry: (1) to reveal the conceptions and experiences underlying global competencies among Industrial Engineering educational actors; (2) to interpret curriculum pertinence from the pedagogical processes implemented by teachers for global competency formation; and (3) to derive theoretical constructs grounded in the emergent findings. The resulting theoretical framework comprises five interrelated subconstructs that articulate the relationships among student-centered pedagogy, teacher mediation, formative competencies in globality, dynamic learning, and the specific demands of industrial engineer formation in a globalized era.

2. Theoretical Framework

2.1 Global Competencies: Conceptual Foundations

The concept of global competence has evolved from disparate notions of intercultural awareness, international literacy, and cross-cultural communication into a more integrated framework. The OECD's (2018) definition, developed for PISA 2018, represents the most widely adopted formulation, encompassing four interrelated dimensions: (a) examining issues of local, global, and cultural significance; (b) understanding and appreciating the perspectives and worldviews of others; (c) engaging in open, appropriate, and effective interactions across cultures; and (d) taking action for collective well-being and sustainable development. This framework has been both influential and contested. Cobb and Couch (2018) critically examined its socializing function, revealing an underlying tension between market-oriented competitiveness and genuine intercultural understanding. Ledger et al. (2019) demonstrated that powerful voices disproportionately shape the OECD's construction of global competency, raising questions about whose knowledge and values are privileged.

In the engineering education context, global competence has been operationalized through various frameworks. Parkinson (2009) identified thirteen dimensions of global competence for engineers, ranging from technical knowledge applicable across borders to appreciation of cultural differences and ethical reasoning. Rawboon et al. (2019) assessed global competencies required by multinational companies in Thailand, finding that companies consistently valued intercultural collaboration, communication skills, and adaptability alongside technical proficiency. Bushey (2024) documented the integration of global competency in STEAM fields in U.S. higher education, identifying statistically significant differences in integration scores across disciplines.

For Latin American contexts, the conceptualization of global competencies must reckon with what Phillipson (2013) termed 'educational imperialism'—the risk that globalization frameworks reproduce epistemic hierarchies favoring Northern knowledge systems. Byram and Kramsch (2014) similarly cautioned that globalization's impact on education can homogenize rather than enrich local pedagogical traditions. This tension between global frameworks and local relevance is central to the present study's approach.

2.2 Curriculum Pertinence in Engineering Education

Curriculum pertinence—the degree to which educational programs align with both disciplinary knowledge and the social, cultural, and economic contexts of learners—constitutes a critical dimension of educational quality. Posner (2005) distinguished five types of curriculum: official (institutionally mandated), operational (actually enacted in classrooms), hidden (implicit values and norms transmitted), null (what is deliberately or inadvertently excluded), and extra (activities beyond formal instruction). This typology is particularly revealing for analyzing global competency formation, as global perspectives may be present in official curricula but absent from operational practice, or conveyed through hidden curriculum elements such as the language of instruction and the cultural assumptions embedded in textbook examples.

In the Colombian context, Decreto 1330 de 2019 established outcome-based quality criteria for higher education programs, emphasizing curricular relevance, graduate profiles aligned with societal needs, and institutional capacity for continuous improvement. Álvarez et al. (2018) argued that curriculum pertinence in Latin American universities requires not merely adapting

international standards but genuinely engaging with the region's distinctive challenges—inequality, border dynamics, technological gaps, and the imperative of inclusive development. The Tuning Latin America project (Serrano et al., 2019) contributed to defining generic competencies for higher education across the region, though its application to specific engineering disciplines remains underdeveloped.

2.3 Pedagogical Theories Supporting Global Competency Formation

Several pedagogical theories inform the formation of global competencies. Kolb's (1984) experiential learning theory posits that learning occurs through a cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation. This theory is particularly relevant to global competency formation, as intercultural understanding and collaborative problem-solving are best developed through direct experience and structured reflection (Botelho et al., 2015; Clinciu, 2023). Vygotsky's zone of proximal development and the concept of mediated learning position the teacher as a facilitator who scaffolds students' engagement with increasingly complex global challenges. Piaget's constructivism emphasizes that learners actively construct knowledge through interaction with their environment, suggesting that global competencies cannot be merely transmitted but must be constructed through meaningful engagement.

Morin's (2001) complexity theory provides an epistemological foundation for understanding global competencies as inherently multidimensional and interconnected. From this perspective, the formation of globally competent engineers requires pedagogical approaches that embrace uncertainty, integrate multiple disciplinary perspectives, and cultivate systemic thinking. Ausubel's (1983) meaningful learning theory complements these perspectives by emphasizing that new knowledge must be anchored in learners' existing cognitive structures, implying that global competency formation should build upon students' prior cultural experiences and knowledge frameworks.

Tünnermann (2011) contributed to understanding the university's role in societal transformation, arguing that higher education must transcend mere professional training to cultivate citizens capable of critical engagement with global challenges. This perspective aligns with Freire's (2003) emancipatory pedagogy, which positions education as a practice of freedom that develops critical consciousness and the capacity for transformative action—essential elements of global citizenship.

3. Methodology

3.1 Research Design

This study was situated within the interpretive paradigm, which seeks to understand social phenomena through the meanings that participants ascribe to their experiences (Gurdián-Fernández, 2010). The qualitative approach was adopted because the research aimed to explore the subjective conceptions and lived experiences of educational actors regarding global competencies—phenomena not amenable to quantitative measurement alone. The phenomenological method was selected as the specific qualitative approach, following the methodological orientations of Fuster (2019) and Martínez (2004, 2006, 2008). Van Manen's (1990) hermeneutic phenomenology informed the interpretive stance, emphasizing the researcher's engagement with participants' lifeworlds to uncover the essential structures of experience.

The phenomenological method was operationalized through four phases: (1) a preliminary stage of theoretical and contextual immersion; (2) data collection through semi-structured interviews; (3) structural analysis involving categorization, contrast, and theorization; and (4) the generation of theoretical constructs grounded in the emergent findings.

3.2 Setting and Participants

The study was conducted at the Universidad Francisco de Paula Santander (UFPS) in Cúcuta, Norte de Santander, Colombia. UFPS is a public university whose Industrial Engineering program serves a student population shaped by the socioeconomic and cultural dynamics of the Colombian-Venezuelan border region. Eight key informants were purposively selected: four professors (coded D1INGIND through D4INGIND) from the Industrial Engineering program, chosen for their experience in teaching courses with global content, and four students (coded EST1_MOV, EST2_MOV, ESTI1, ESTI2), including students who had participated in international mobility programs and students without such experience, to capture diverse perspectives on global competency formation.

The selection criteria for professors included: (a) permanent or contract faculty in the Industrial Engineering program, (b) a minimum of five years' teaching experience, and (c) involvement in courses related to internationalization, globalization, or intercultural content. Student criteria included: (a) enrollment in the final semesters of the Industrial Engineering program, and (b) willingness to participate and provide informed consent. This purposive sampling strategy aligned with phenomenological research principles, which prioritize depth of understanding over statistical representativeness.

3.3 Data Collection

Data were collected through semi-structured interviews, a technique particularly suited to phenomenological inquiry as it allows participants to describe their experiences in their own terms while ensuring thematic coverage. Interview protocols were developed around three thematic axes: (a) conceptions and experiences of global competencies in Industrial Engineering education; (b) perceptions of curriculum pertinence regarding global

competency formation; and (c) pedagogical processes, strategies, and conditions that support or hinder the development of global competencies.

All interviews were conducted in Spanish, audio-recorded with participants' informed consent, and transcribed verbatim. The ethical protocol included informing participants of the study's purposes, guaranteeing confidentiality through coded identifiers, and obtaining signed informed consent forms in accordance with institutional research ethics requirements.

3.4 Data Analysis

Data analysis followed a three-stage process: categorization, contrast, and theorization (Martínez, 2004). In the categorization stage, transcribed interviews were read and re-read to identify recurrent themes, patterns, and meaning units. Open codes were assigned to segments of text, which were then grouped into subcategories and categories through constant comparison. In the contrast stage, the emergent categories were compared across informants (professor-professor, student-student, and professor-student contrasts) and triangulated with the theoretical literature to assess convergence, divergence, and novel contributions. In the theorization stage, the relationships among categories were articulated into a coherent theoretical construct comprising five interrelated subconstructs.

3.5 Trustworthiness

Trustworthiness was established through Lincoln and Guba's (1985) four criteria. Credibility was ensured through prolonged engagement with participants, member checking of interview transcripts, and triangulation across informant types (professors and students) and data sources. Transferability was addressed through thick description of the research context, participants, and processes, enabling readers to assess the applicability of findings to analogous settings. Consistency (dependability) was maintained through systematic documentation of methodological decisions and an audit trail. Neutrality (confirmability) was pursued through reflexive journaling and the grounding of interpretations in direct participant quotations.

4. Results

The analysis of interviews with eight key informants yielded three emergent macro-categories, each comprising subcategories and codes that captured the lived experiences and conceptions of professors and students regarding global competency formation in Industrial Engineering. Table 1 summarizes the categorical structure.

Table 1. Emergent Categories and Subcategories

Category 1 — Global Competencies: Professional Training Competencies; Skills Required for Globality; UFPS and Industrial Engineering Internationalization.

Category 2 — Curriculum Pertinence: Pedagogical Strategies for Global Competency Formation; Curricular Relevance and Updating; Institutional Support for Internationalization.

Category 3 — Pedagogical Process: Teaching-Learning Approaches; Teacher Role and Mediation; Student Engagement and Autonomy.

4.1 Category 1: Global Competencies

Informants consistently identified global competencies as multidimensional attributes encompassing cognitive, attitudinal, communicative, and self-formative dimensions. Professors emphasized that professional training in Industrial Engineering must extend beyond technical knowledge to include critical thinking, intercultural sensitivity, and the capacity to operate in diverse professional environments. As one professor articulated:

"Developing in any field of engineering represents a fascinating challenge, because the formation of intellectual capacities, resource management, interdisciplinary work, and communication, among others, are put into motion to confront and solve complex problems" (D2INGIND).

Students who had participated in international mobility programs reported transformative experiences that reshaped their understanding of professional competence. They described developing adaptability, communication skills in foreign languages (particularly English), and an appreciation for diverse problem-solving approaches. One mobility student noted:

"The experience of studying abroad made me realize that engineering problems are universal, but the way people approach them is deeply cultural. You learn to listen differently" (EST1_MOV).

Students without international experience expressed awareness of globalization's demands but reported feeling inadequately prepared. They identified English language proficiency as the most significant barrier to global engagement and called for more structured opportunities for intercultural interaction within the curriculum.

4.2 Category 2: Curriculum Pertinence

The analysis revealed a tension between the official curriculum's stated commitment to internationalization and the operational curriculum as experienced by students and enacted by professors. While institutional documents referenced global competencies and internationalization, informants described a curriculum that remained predominantly focused on local and national contexts. Professors identified several barriers to curriculum pertinence for global competency formation: First, the predominance of Spanish-language instruction and materials limited students' exposure to global academic discourse. Second, curricular rigidity—particularly the density of technical course requirements—left little space for interdisciplinary or internationally oriented electives. Third, the assessment

system privileged technical knowledge reproduction over the development of critical intercultural competencies. As one professor observed:

"The curriculum says we should form global citizens, but in practice, our evaluations measure whether students can solve optimization problems, not whether they can collaborate with someone from a different culture" (D3INGIND).

Nevertheless, informants identified pedagogical strategies that effectively fostered global competency formation: project-based learning involving real-world problems with international dimensions, case studies drawn from global industry contexts, collaborative activities with students from other countries through virtual exchange programs, and the integration of English-language technical resources into course activities.

4.3 Category 3: Pedagogical Process

The pedagogical process category illuminated the dynamics of teaching and learning as they relate to global competency formation. A central finding was the pivotal role of the teacher as a mediator—not merely a transmitter of disciplinary knowledge but a facilitator of students' engagement with global perspectives. Professors who had international academic or professional experience were perceived as more effective mediators, as they could draw upon firsthand cross-cultural encounters to enrich their teaching.

The analysis revealed that student-centered pedagogical approaches were most conducive to global competency formation. These approaches positioned students as active constructors of knowledge who engage with global challenges through inquiry, collaboration, and reflection. The contrast between teacher-centered transmission models and student-centered constructivist approaches was a recurrent theme. As one professor articulated:

"Teaching must be conceived from the perspective that positions constructivism as an active process, in which the student constructs their own knowledge from prior experiences and interactions with peers, the professor, and their environment" (D1INGIND).

Students confirmed that their most meaningful learning experiences related to global competencies occurred in courses that employed active methodologies—problem-based learning, team projects with international components, and reflective exercises that connected technical content to broader social and cultural implications.

5. The Theoretical Construct: Five Interrelated Subconstructs

The theorization process yielded a comprehensive theoretical construct comprising five interrelated subconstructs. These subconstructs emerged from the integration of empirical findings with the theoretical frameworks discussed in Section 2 and represent the study's principal contribution to knowledge.

5.1 Subconstruct 1: Student-Centered Teaching for Global Competency Acquisition

The first subconstruct posits that the acquisition of global competencies in Industrial Engineering requires a fundamental shift from teacher-centered transmission to student-centered pedagogical approaches. This shift involves three interrelated dimensions: (a) recognizing the student as an active, autonomous agent in the learning process; (b) designing learning experiences that promote inquiry, collaboration, and reflection on global issues; and (c) developing assessment practices that value not only technical knowledge but also intercultural competencies, critical thinking, and collaborative problem-solving.

This subconstruct is grounded in constructivist learning theory (Piaget; Vygotsky) and aligned with experiential learning principles (Kolb, 1984). It extends these theories by specifying how student-centered pedagogy can be operationalized for global competency formation in engineering: through the integration of globally contextualized problems into project-based assignments, the use of reflective journals that prompt students to examine their assumptions about engineering practice in different cultural contexts, and the creation of learning communities that include diverse perspectives—whether through international mobility, virtual exchange, or the incorporation of students' own cross-cultural experiences.

5.2 Subconstruct 2: The Teacher as Learning Mediator

The second subconstruct reconceptualizes the role of the Industrial Engineering professor from knowledge transmitter to learning mediator. Within this framework, the teacher's mediating function operates across three domains: (a) facilitation—creating environments conducive to global competency development by selecting appropriate pedagogical strategies and resources; (b) orchestration—organizing learning experiences that connect technical content to global contexts through carefully sequenced activities; and (c) promotion of autonomous learning—developing students' capacity for self-directed engagement with global challenges beyond the formal curriculum.

The mediating teacher possesses specific characteristics identified through the data analysis: awareness of globalization's impact on Industrial Engineering practice, intercultural sensitivity and experience, pedagogical versatility in employing active methodologies, and commitment to continuous professional development in both disciplinary and pedagogical domains. This subconstruct draws upon Vygotsky's mediation theory and Tünnermann's (2011) vision of the transformative university teacher, extending them to articulate the specific competencies required of engineering educators in a globally oriented program.

5.3 Subconstruct 3: Formative Competencies Grounded in Globality

The third subconstruct identifies and articulates the specific formative competencies that constitute global competence in Industrial Engineering. Through the analysis, four clusters of competencies emerged:

(a) High-level cognitive skills: critical and systemic thinking, complex problem analysis, capacity for interdisciplinary integration, and the ability to evaluate engineering solutions in diverse global contexts.

(b) Attitudinal and axiological competencies: intercultural sensitivity, ethical reasoning in global contexts, openness to diversity, social responsibility, and commitment to sustainable development.

(c) Communication and collaboration skills: proficiency in English and other languages, effective cross-cultural communication, teamwork in multicultural settings, and digital literacy for global collaboration.

(d) Self-formation and pedagogical-technological skills: autonomous learning capacity, digital competence for global professional practice, adaptability to changing technological environments, and lifelong learning orientation.

This competency framework builds upon the OECD's (2018) global competence dimensions while contextualizing them for Industrial Engineering practice and Latin American educational realities. It recognizes that global competence in engineering is not a single attribute but a dynamic constellation of knowledge, skills, attitudes, and values that must be cultivated through intentional pedagogical design.

5.4 Subconstruct 4: Dynamic and Interdependent Global Learning

The fourth subconstruct characterizes the learning process for global competency formation as inherently dynamic and interdependent. Drawing on Kolb's (1984) experiential learning cycle and Morin's (2001) complexity theory, this subconstruct proposes that global competency development is not a linear progression but a recursive process involving continuous movement between experience and reflection, local knowledge and global awareness, individual learning and collaborative construction.

Three principles define this dynamic learning process: (a) the active and engaged role of the student, who brings prior cultural and experiential knowledge to the learning encounter; (b) the development of learning capacity—the meta-cognitive awareness of how one learns about and from diverse global contexts; and (c) interdependence in learning—the recognition that global competency formation depends on reciprocal interactions among students, teachers, institutional structures, and the broader sociocultural environment.

This subconstruct challenges the transmission model of education that persists in many engineering programs and proposes instead an ecological view of learning in which global competencies emerge from the dynamic interaction of multiple factors—individual disposition, pedagogical approach, curricular design, institutional support, and external global dynamics.

5.5 Subconstruct 5: Global Competencies in Industrial Engineer Formation

The fifth subconstruct addresses the specific implications of global competency formation for Industrial Engineering education and practice. It identifies five interconnected dimensions:

(a) The influence of globalization on Industrial Engineering formation: Globalization has transformed the practice of Industrial Engineering by expanding the geographic and cultural scope of production systems, supply chains, and organizational processes. Engineering education must prepare students for this expanded scope through pedagogical approaches that embed global awareness into technical training.

(b) Current approaches in university teaching and formation: The analysis revealed that existing pedagogical approaches in Industrial Engineering education range from traditional transmission models to emerging constructivist and experiential approaches. The construct advocates for the systematic adoption of active pedagogies that explicitly address global competency dimensions.

(c) Local culture and language as formation tools: Rather than positioning local culture as an obstacle to global competence, this dimension recognizes cultural identity and local knowledge as assets that enrich global engagement. English language proficiency is identified as essential but must be developed alongside—not at the expense of—students' cultural heritage and Spanish-language academic traditions.

(d) Strengthening global competency in university formation: Institutional strategies for strengthening global competencies include international mobility programs, curriculum internationalization, virtual exchange initiatives, industry partnerships with global companies, and faculty development in intercultural pedagogies.

(e) University education in the global era: This dimension situates Industrial Engineering education within the broader project of university transformation, arguing that global competency formation is not merely a curricular add-on but a fundamental reorientation of the university's educational mission toward the formation of global citizens capable of contributing to just and sustainable development.

6. Discussion

The theoretical construct generated in this study advances the understanding of global competency formation in engineering education in several important ways. First, it provides an empirically grounded, contextually situated framework that bridges international competency frameworks—particularly the OECD's (2018) global competence model—with the specific realities of Latin American engineering education. While previous studies have predominantly examined global competency in Anglo-Saxon contexts (Parkinson, 2009; Ball, 2011; Jesiek et al., 2014), the present study demonstrates that

the formation of global competencies in a Colombian border-region university involves distinctive dynamics related to language, border culture, economic constraints, and institutional structures.

The finding that teacher mediation constitutes a central mechanism for global competency formation aligns with and extends research on the role of faculty in internationalization (Muñoz-Escalona et al., 2020; Rhee et al., 2020). The construct's conceptualization of the teacher as a mediator—rather than merely a facilitator or content deliverer—draws upon Vygotskian theory to argue that global competency development requires intentional pedagogical intervention that scaffolds students' movement from local perspectives to global awareness. This is particularly significant in contexts where students may have limited direct international experience, as the teacher's mediation can create vicarious global learning opportunities through carefully designed pedagogical activities.

The study's emphasis on curriculum pertinence as a mediating factor between global competency aspirations and actual formation outcomes resonates with Posner's (2005) curriculum typology and reveals the gap between the official curriculum's internationalization rhetoric and the operational curriculum's persistent localism. This finding is consistent with research documenting the challenges of curriculum internationalization in higher education (Trevelyan, 2019; Hadgraft & Kolmos, 2020) and suggests that structural reforms—including assessment redesign, English-language integration, and interdisciplinary space within curricula—are necessary conditions for meaningful global competency formation.

The dynamic and interdependent learning subconstruct contributes to educational theory by integrating experiential learning (Kolb, 1984) with complexity theory (Morin, 2001) in the specific domain of global competency formation. This integration suggests that global competencies cannot be developed through isolated curricular interventions but require a systemic approach that involves recursive cycles of experience, reflection, and action across multiple learning contexts—classroom, laboratory, community engagement, and international exchange.

The study has several limitations that warrant acknowledgment. The phenomenological approach, while appropriate for generating deep understanding of participants' experiences, limits the statistical generalizability of findings. The study was conducted in a single institutional context, and while the thick description provided supports transferability judgments, replication in diverse engineering education settings would strengthen the construct's broader applicability. The sample of eight informants, though consistent with phenomenological research standards, represents a limited range of perspectives. Future research might employ larger samples or mixed-methods designs to complement and extend these findings.

7. Conclusions

This study generated a theoretical construct for the formation of global competencies in Industrial Engineering students, comprising five interrelated subconstructs that articulate the pedagogical, curricular, and institutional dimensions of global competency formation. The principal conclusions are as follows:

First, global competency formation in Industrial Engineering requires a fundamental pedagogical reorientation from teacher-centered transmission to student-centered, experiential approaches that position learners as active constructors of globally relevant knowledge and skills. This reorientation demands not merely the adoption of active methodologies but a reconceptualization of what counts as engineering knowledge and competence in a globalized world.

Second, the teacher's role as learning mediator is decisive for global competency formation, particularly in contexts where students' direct international experience is limited. Engineering educators must develop specific mediating competencies—intercultural awareness, pedagogical versatility, and the capacity to connect technical content with global contexts—to effectively facilitate global learning.

Third, formative competencies grounded in globality encompass cognitive, attitudinal, communicative, and self-formative dimensions that must be systematically integrated into curricula. English language proficiency, while essential, must be developed alongside deeper intercultural competencies and critical global awareness.

Fourth, the learning process for global competency formation is dynamic and interdependent, requiring institutional ecosystems that support recursive cycles of experience and reflection through diverse learning modalities—including international mobility, virtual exchange, project-based learning with global dimensions, and community engagement.

Fifth, the integration of global competencies into Industrial Engineering formation is not merely a curricular enhancement but an imperative that responds to the transformation of engineering practice in a globalized world. Programs must evolve to prepare engineers who are not only technically proficient but also culturally sensitive, ethically engaged, and capable of contributing to sustainable development as global citizens.

These conclusions carry implications for educational policy, curriculum design, faculty development, and institutional strategy in engineering education, particularly in Latin American contexts. The theoretical construct offers a framework that can guide the systematic integration of global competencies into Industrial Engineering programs while respecting and leveraging the distinctive cultural, linguistic, and socioeconomic resources of local educational communities.

Author Contributions

R.I. Laguado Ramírez: Conceptualization, methodology, investigation, data collection and analysis, writing—

original draft. E.G. Flórez Serrano: Supervision, validation, writing—review and editing. R.P. Ramírez Delgado: Supervision, validation, writing—review and editing.

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The authors declare no conflicts of interest.

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