Integration of the PMI Approach in Educational Human-Computer Interaction Projects: Real-World Project-Based Learning with Technological Entrepreneurship Potential

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***Abstract*– Engineering education demands innovative strategies that combine professional standards with active learning. This paper systematizes an educational experience in the Human-Computer Interaction (INHUCO) course, where the Project Management Institute (PMI) framework was integrated as the backbone of field-based practices. The course structure followed the PMBOK® Guide life cycle—initiation, planning, execution, monitoring, and closure—linking each phase with tools such as Business Model Canvas, requirements analysis, user-centered prototyping, and accessibility evaluation.**

Using a qualitative-descriptive methodology, the study analyzed documents, mapped competencies, and reviewed student deliverables. Results indicate significant development in technical skills (planning, scope, scheduling), transversal competencies (leadership, communication, collaboration), and contextual abilities (accessibility, stakeholder engagement). Moreover, several projects addressed real societal needs and showed potential for technological entrepreneurship.

This paper proposes a replicable educational model for project-based learning in engineering, combining PMI principles with user-centered design and inclusive practices. The experience confirms the feasibility of integrating traditional project management frameworks into active methodologies, fostering meaningful learning, functional value delivery, and professional preparedness.

***Keywords*-- Project Management, PMI, Project-Based Learning, User-Centered Design, Technological Entrepreneurship, Engineering Education.**

I. Introduction

The teaching of project management in engineering programs has undergone significant transformation in recent decades, driven by the need to prepare professionals capable of leading complex initiatives, adapting to changing environments, and generating value in real-world contexts. Within this framework, the approach promoted by the Project Management Institute (PMI), through its PMBOK® Guides, has established itself as a global standard that integrates best practices, principles, and domains applicable across various productive sectors [1].

Simultaneously, the adoption of Project-Based Learning (PBL) has become a widely recognized pedagogical strategy in engineering education, as it bridges theoretical knowledge with practical application in authentic contexts. PBL fosters the development of key skills such as problem-solving, collaboration, effective communication, and decision-making in multidisciplinary environments [2][3]. When implemented as a structural component of the curriculum—rather than an isolated activity—it enables the integration of technical and transversal competencies, addresses social and technological issues, and embeds values and critical reflection within the learning experience [4].

Various studies support the positive impact of integrating project management methodologies with active strategies like PBL, particularly in engineering education. The implementation of the PMI framework, especially the PMBOK® Guide, in educational settings has shown concrete benefits in strengthening competencies such as planning, time management, leadership, decision-making, and teamwork. A systematic review of the literature on project management education concludes that courses incorporating formal frameworks like PMI tend to foster greater student engagement and stronger development of transversal competencies, as well as enhance future employability [5].

This effect is amplified when such frameworks are combined with active approaches like PBL. For instance, [6] proposes a hybrid model called Project-Based Problem Learning (PBPL), which blends the best of problem-based and project-based learning. The model demonstrated significant improvements in students' problem-solving skills, critical thinking, structured planning, and oral presentation abilities. Additionally, students showed greater self-confidence and autonomy when tackling complex projects with real and multidimensional deliverables.

Moreover, the use of innovative tools such as simulations, gamified environments, or digital platforms complements and reinforces experiential learning. In [7], a scientometric review explores the use of digital games and simulations in teaching project management in higher education. The findings reveal that such strategies enhance knowledge retention, promote active participation, and allow students to experience real project dynamics (e.g., conflicts, resource allocation, risk management) in a controlled environment. These tools are particularly effective in internalizing PMI principles, such as value-based decision-making, adaptability to uncertainty, and stakeholder engagement.

In addition, [8] identifies key success factors for implementing agile management in university courses, highlighting that combining traditional frameworks (such as PMI) with agile practices (such as SCRUM or Design Thinking) in real academic projects foster adaptability, encourages collaboration, and facilitates iterative cycles that solidify learning. This methodological integration has also been shown to enhance the acquisition of tacit knowledge through social interaction, shared reflection, and group decision-making [9].

Overall, the available evidence suggests that convergence between professional project management frameworks like PMI and active methodologies such as PBL is not only feasible but highly beneficial in educational contexts—particularly when addressing authentic problems that require functional, user-centered solutions.

Within this context, the university where the present study was conducted launched a curricular innovation in the first semester of 2025, integrating the PMI approach into the field-based practices of the Human-Computer Interaction (INHUCO) course. This practice requires students to develop a functional prototype that is both accessible and user-centered, progressively applying the phases of project management: initiation, planning, execution, monitoring, and closure. Throughout the process, students employ tools such as the Business Model Canvas, scheduling, requirements analysis, usability testing, and accessibility assessments, all with continuous instructor guidance and feedback.

The methodological redesign of the Human-Computer Interaction course also addresses an educational need aligned with international project management competency frameworks, which emphasize technical, behavioral, and contextual dimensions [10]. It additionally seeks to strengthen engagement with real stakeholders (SMEs, social institutions, local ventures), fostering the delivery of tangible value through functional products relevant to their contexts.

This paper presents an analysis and systematization of this experience, with the aim of proposing a replicable model for integrating the PMI approach into engineering courses focused on user-centered design. Using a case study methodology, it describes the implementation process, the observed outcomes in terms of student competencies, and offers a structured proposal that can be adopted in other higher education contexts.

Furthermore, the projects developed in the course opened opportunities to explore ideas with entrepreneurial potential, enhancing the identification of value propositions and sustainable business models in real-world scenarios—thus expanding the educational impact of the PMI approach toward a culture of technological entrepreneurship.

II. Methodology

A. Methodological Approach

This research adopts a qualitative-descriptive approach through an educational case study, focused on the systematization of an innovative pedagogical experience: the integration of the Project Management Institute (PMI) framework into the field-based practices of the Human-Computer Interaction (INHUCO) course, part of the curriculum of the Computer Systems Engineering program at the university where this study was conducted.

The methodological objective was to analyze how the PMI approach was implemented in the course, what competencies were developed, and what tools, instruments, and strategies were employed to ensure a learning experience aligned with the principles of the PMBOK® Guide. A triangulation strategy was prioritized, integrating institutional documents, curricular evidence, assessment rubrics, and academic literature.

B. Study Context

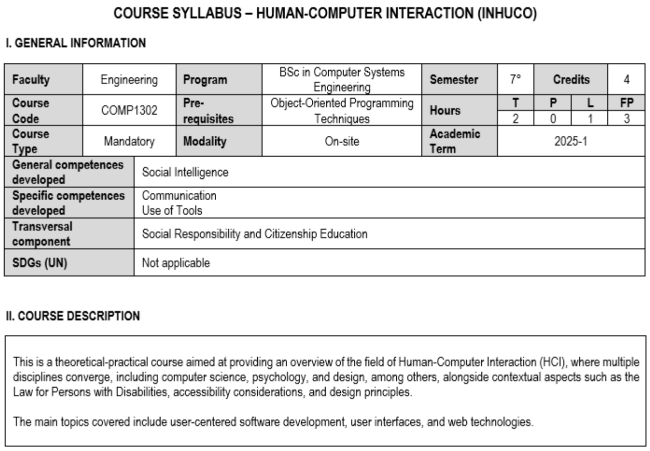
The Human-Computer Interaction course is designed as a theoretical-practical subject, placed in the seventh semester of the academic program. Its purpose is for students to design, implement, and evaluate user interfaces centered on people, considering principles of accessibility, inclusive design, and usability. Since the first semester of 2025, this course has incorporated field practices managed through the project life cycle defined by PMI: initiation, planning, execution, monitoring, and closure.

The selection of real-world problems and the use of the Business Model Canvas significantly enhanced the students' entrepreneurial mindset. Beyond applying project management principles, students were challenged to identify unmet needs within authentic social and economic contexts, analyze stakeholder dynamics, and define clear value propositions. This process not only fostered user-centered design but also enabled teams to outline minimum viable products (MVPs) with potential for real implementation. Through iterative validation with users from sectors such as healthcare, education, and local commerce, students explored feasibility, desirability, and viability criteria—key pillars in entrepreneurial innovation. As a result, the projects evolved from purely academic exercises to solutions with tangible potential for social entrepreneurship, contributing to a culture of innovation and purposeful impact.

C. Sources of Information

The following sources were used for analysis:

- Curricular documentation: including the course syllabus, which specifies thematic units, competencies, methodologies, and assessments.



COURSE SYLLABUS – HUMAN-COMPUTER INTERACTION (INHUCO)

I. GENERAL INFORMATION

Faculty	Engineering	Program	BSc in Computer Systems Engineering	Semester	7°	Credits			4
Course Code	COMP1302	Pre-requisites	Object-Oriented Programming Techniques	Hours	T	P	L	FP	
					2	0	1	3	
Course Type	Mandatory	Modality	On-site	Academic Term	2025-1				
General competences developed	Social Intelligence								
Specific competences developed	Communication Use of Tools								
Transversal component	Social Responsibility and Citizenship Education								
SDGs (UN)	Not applicable								

II. COURSE DESCRIPTION

This is a theoretical-practical course aimed at providing an overview of the field of Human-Computer Interaction (HCI), where multiple disciplines converge, including computer science, psychology, and design, among others, alongside contextual aspects such as the Law for Persons with Disabilities, accessibility considerations, and design principles.

The main topics covered include user-centered software development, user interfaces, and web technologies.

Fig. 1. Header of the Human-Computer Interaction (INHUCO) course syllabus.

- Practical project guide: a document detailing, week by week, the activities, deliverables, and tools used in each phase of the project according to the PMI approach.

TABLE I
PMI PHASES AND WEEKLY DELIVERABLES

PMI Phase	Week	Deliverable
Initiaton	1	Glossary of HCI terms in APA format. Project presentation with HCI focus.
Planning	2	Project planning report (including BMC, Ishikawa diagram, business rules).
Execution	3	User-centered design report (personas, user stories, journey maps, initial testing).
	4	Inclusive redesign report (accessibility requirements, solution redesign).
Monitoring & control	5	Validation and feedback report (user testing with real users).
Closing	6	Functional dashboard. Final project report (includes reflection and learning consolidation).
Post-closing	7-8	Instructor feedback. Evidence uploads in Blackboard.

- Institutional implementation report: prepared by the faculty responsible for the course at the end of the 2025-1 semester, this document systematizes the student-developed cases, lessons learned, and evidence of final products.
- Assessment instrument: rubric used to grade the final presentation of the field project, explicitly outlining the achievement criteria related to project management, functional design, and user experience.

TABLE II
FINAL EVALUATION RUBRIC FOR FIELD PROJECT PRESENTATION

Criterion	Good	Fair	Poor
Problem and glossary (Week 1)	Problem clearly defined and contextualized; complete glossary in APA, aligned with HCI framework.	The problem is well defined; the glossary has minor omissions.	Problem lacks context; glossary is incomplete or superficial.
Planning and scope (Week 2)	Well-structured BMC; clear objectives; correct use of Ishikawa; well-defined business rules.	Adequate BMC; clear objectives but poorly detailed rules.	Incomplete or confusing BMC; shallow analysis.
User-centered design (Week 3)	Coherent personas, scenarios, stories, and journey maps; well-documented initial testing; clear metrics.	Components are present but lack depth or coherence.	Missing or poorly articulated components.
Inclusive redesign (Week 4)	Solid evidence of accessibility adaptation; clear technical and ethical redesign; references to Law 29973 and WCAG 2.1.	Inclusive elements are considered but with some omissions.	Superficial or unjustified adaptations.
Validation and testing (Week 5)	Rigorous testing with real users; detailed report of findings and feedback.	Testing conducted but only partially documented.	Limited testing evidence or low user involvement.
Dashboard and final results (Week 6)	Clear and functional dashboard; reflective analysis of the process; evidence of meaningful learning.	Basic or non-interactive dashboard; reflection is brief.	Non-functional dashboard; vague or absent reflection.
Final Demo presentation	Smooth, functional, and accessible demo; clear integration of PMI and HCD phases.	Functional demo with minor issues; accessibility mentioned but not demonstrated.	Unclear or technically flawed demo.
Visual design and communication	Professional design, correct template usage; excellent readability and visual coherence.	Clear design with minor inconsistencies.	Overloaded or unclear design.

D. Analysis Procedure

The analysis was conducted in five phases:

1. Document review: the course syllabus, project guide, and evaluation rubric were examined to explicitly identify the PMI elements applied in the course (processes, phases, tools, principles).

2. Competency mapping: the declared competencies of the course were compared with international project management competency frameworks, identifying correspondences in areas such as planning, scope management, collaborative work, and value orientation.

TABLE III
COURSE COMPETENCIES AND CORRESPONDENCE WITH PMBOK® / PMI FRAMEWORK

Course competency	Correspondence in PMBOK / PMI Framework	Description of convergence
Project planning	Planning Performance Domain (PMBOK 7)	Students develop schedules, WBS, and project charters aligned with planning processes.
Scope and requirements management	Scope Management (PMBOK 6) / Value Delivery (PMBOK 7)	Functional requirements and deliverables are defined and validated with real users.
Collaborative work and role distribution	Team Performance Domain (PMBOK 7) / Power Skills (PMI Talent Triangle)	Roles such as PM, QA, and UI/UX are assigned to promote collaboration and mutual feedback.
User-centered value delivery	Value Delivery System (PMBOK 7) / Strategic & Business Management (TT)	Each product must meet real user needs, prioritizing accessibility and usability.
Stakeholder communication and feedback	Stakeholder Performance Domain / Communication Management	Deliverables are validated through active interaction with users, instructors, and peers.
Time management and iterative delivery	Schedule Management / Agile Approach (PMI-ACP)	Agile practices like prototyping and rapid testing are applied within adaptive timelines.

3. Classification of tools and deliverables: the use of instruments such as the Business Model Canvas, Lean UX Canvas, Ishikawa diagram, stakeholder matrix, activity schedule, high-fidelity prototypes, usability tests, and final dashboards was categorized, identifying in which phase of the PMI cycle each was applied.
4. Systematization of observed results: the outputs generated by students (prototypes, dashboards, reports, user feedback) were analyzed based on the case studies documented in the institutional report.
5. Theoretical triangulation: findings were contrasted with relevant academic literature on project management education using the PMI framework in higher education, as well as the implementation of PBL in engineering [11].

E. Criteria for Rigor

To ensure the quality of the analysis, the following criteria were applied:

- Credibility: triangulation of sources was used (curriculum, reports, rubrics, scientific literature).
- Transferability: the context, instructional strategies, and tools employed were precisely documented, enabling replication or adaptation in other courses or institutions.
- Consistency: a coherent theoretical and methodological framework was maintained throughout the process, aligned with prior studies on PMI integration in educational settings.
- Confirmability: the analyzed evidence is available in institutional archives and course-related faculty repositories.

III. ANALYSIS AND RESULTS

The analysis of the implementation of the PMI approach in the INHUCO course was organized into four dimensions: (1) instructional design based on PMI, (2) competency development, (3) engagement with real stakeholders and accessibility, and (4) evaluation through progressive deliverables. Each dimension was examined in light of curricular, pedagogical, and institutional evidence.

A. Instructional Design Structured Around the PMI Approach

Beginning in the first semester of 2025, the Human-Computer Interaction course was redesigned to align its field-based practice with the project life cycle outlined in the PMBOK® Guide, following the phases of initiation, planning, execution, monitoring, and closure. This redesign is documented in the practical project guide, where each week corresponds to a specific phase with clearly defined objectives, activities, tools, and deliverables.

For example:

- Initiation: problem identification, team and stakeholder definition, development of an HCI terminology glossary.
- Planning: use of the Business Model Canvas, application of Design Thinking, definition of business rules, and causal analysis using the Ishikawa diagram.
- Execution: creation of user personas, scenarios, user stories, prototypes, and initial validation.
- Monitoring: user testing with real participants, design adjustments, and documentation of feedback.
- Closure: consolidation of a functional dashboard, team reflection, and final project delivery.

This framework enables students to understand the sequential logic of real-world projects and take on active roles in project management, anticipating risks, organizing resources, and delivering value in an iterative manner

B. Development of Project Management Competencies

The pedagogical experience facilitated the acquisition of both technical and transversal competencies. According to the project management competency model in higher education [12], students developed:

- Technical competencies: scope management, requirements analysis, scheduling, and dashboard development.
- Transversal competencies: leadership, collaborative work, effective communication, and social responsibility.
- Contextual competencies: adaptation to real stakeholder needs, user-centered focus, and awareness of accessibility.

These competencies were made visible and evaluated through the final assessment rubric, which includes criteria such as problem clarity, relevance of the Canvas, functionality of the demo, and visual coherence of the presentation. This approach aligns with findings in [13], where the inclusion of PMI professional practices in education strengthens the development of employability skills, and with [14], which highlights the synergy between agile and traditional frameworks in dynamic educational environments.

C. Engagement with Real Stakeholders and Accessibility Criteria

One of the most innovative components of the course was its connection with real-world scenarios and authentic users, which fostered a deep understanding of value delivery. Student teams collaborated with entities such as:

- Healthcare centers (the *Salud Total* case) for the management of medical appointments.

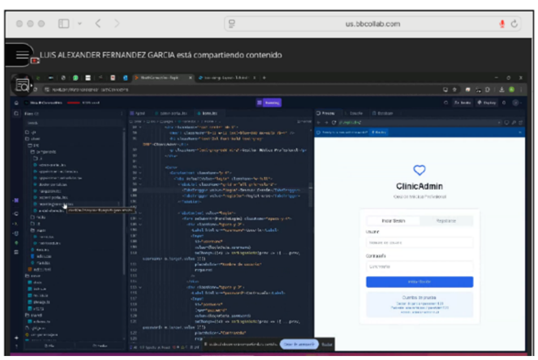


Fig. 2. "Salud Total" Case: Accessible and Efficient Medical Appointment Management Platform

- Community pharmacies (e.g., the *VillaFarma* case) to optimize internal processes.

Fig. 3. "VillaFarma" Case: Inclusive E-Commerce Prototype for Community Pharmacies.

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- Internal platforms of educational institutions (e.g., the *WebClass* case) to enhance the user experience.

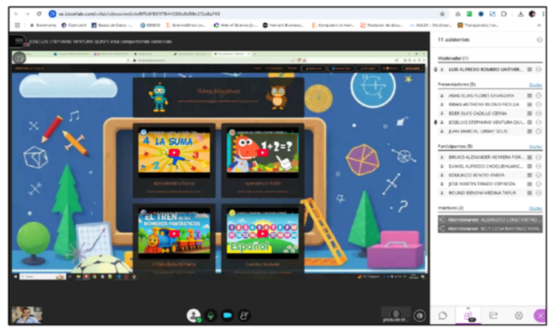

Fig. 4. "WebClass" Case: Inclusive Educational Platform for Primary School Students.

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In addition, students incorporated digital accessibility principles based on WCAG 2.1 and Peruvian Law No. 29973, implementing both functional and design adjustments to include users with visual or motor disabilities. This reinforces the socially engaged nature of the project, in line with the observations in [15], which emphasize the value of co-creating knowledge through collaboration, trust, and hands-on experience within IT teams.

In several cases, the solutions designed demonstrated viability beyond the academic setting, generating interest from the stakeholders involved (clinics, pharmacies, educational institutions), suggesting potential for evolution into technological ventures with social impact.

D. Evaluation Through Progressive Deliverables

Throughout the six weeks of the project, students submitted structured deliverables that served both to evaluate progress and to document decision-making processes. These deliverables included:

- APA-style glossary of HCI terminology
- Business Model Canvas and business rules
- User scenarios, prototypes, usability testing reports, and accessibility assessments
- Functional dashboards

- Final report with user feedback and team reflection

This continuous, formative, and summative evaluation scheme allowed for the identification of progress at each stage of the project, timely feedback, and the consolidation of a culture of continuous improvement. The rubric ensured transparency and alignment with PMI criteria in terms of clarity, coherence, functional impact, and professional presentation.

E. Statistical Validation of Results

To strengthen the validity of the findings, a quantitative comparison was conducted between two cohorts of the Human-Computer Interaction course: the 2024-2 group (n=40), which followed the traditional methodology, and the 2025-1 group (n=40), which implemented the PMI-based approach.

The mean final project grade for the 2024-2 cohort was 80% (SD=4.5%), whereas the 2025-1 cohort achieved a higher mean of 90% (SD=5.0%). An independent samples t-test confirmed that this difference was statistically significant ($t = 8.94$, $p < 0.001$).

TABLE IV
COURSE COMPETENCIES AND CORRESPONDENCE WITH PMBOK® / PMI FRAMEWORK

Cohort	N	Mean (%)	SD (%)
2024-2 (without PMI)	40	80%	4.5
2025-1 (with PMI)	40	90%	5.0

These results demonstrate that the integration of the PMI framework led to a 10% increase in student performance, reinforcing the qualitative evidence obtained from project deliverables and stakeholder feedback.

IV. PROPOSED MODEL

Based on the systematization of the experience implemented in the Human-Computer Interaction course during the 2025-1 semester, we propose a pedagogical model titled: Integrated Educational Project Management Model with a PMI Approach. This model is oriented toward the development of professional competencies through real, user-centered projects. It can be adapted to engineering and technology courses with practical components, especially those related to design, digital solution development, and user experience.

A. General Structure of the Model

The model is organized into four interrelated components:

Project Life Cycle (PMI)

- The initiation, planning, execution, monitoring, and closure phases become the temporal backbone of the course.
- Each phase is translated into a weekly module with specific deliverables and associated tools.

Competency Dimensions

Competencies are aligned with international standards (IPMA/ICB) and classified as:

- *Technical*: planning, scope, requirements, risk management
- *Contextual*: environmental awareness, value orientation
- *Transversal*: leadership, communication, teamwork.

Pedagogical Tools per Phase

Each project phase integrates professional tools adapted for educational use:

- Initiation: glossary, stakeholder mapping, role matrix
- Planning: Business Model Canvas, Ishikawa diagram, requirements definition, scheduling
- Execution: prototyping, user testing, accessible design
- Monitoring: testing, validation matrices, peer feedback
- Closure: dashboards, reflective reports, final pitch.

Progressive and Formative Assessment

Assessment is based on phase-based deliverables, iterative feedback, and rubrics aligned with competency development.

B. Foundations of the Model

The model is grounded in:

- The PMI framework and its most recent PMBOK® Guide editions, integrating both the process-based (6th ed.) and performance domain-based (7th ed.) approaches
- Established Project-Based Learning (PBL) practices, widely documented in engineering education
- Hybrid models such as Project-Based Problem Learning (PBPL), which combine problem-solving, iterative deliverables, and real-user engagement
- The need for education tailored to VUCA (Volatile, Uncertain, Complex, Ambiguous) environments, where adaptability and collective knowledge creation are key.

C. Applicability and Scalability

The proposed model is scalable and adaptable:

- Scalable: applicable to both short courses (6–8 weeks) and full-semester subjects, adjusting depth and number of deliverables.
- Adaptable: transferable to other disciplines (e.g., business, architecture, health, education) where social, technologically, or community-impactful projects are developed.
- Flexible: allows for the integration of agile tools (Scrum, Kanban), digital simulations, or collaborative platforms, enhancing its potential for hybrid and virtual environments.

This model is not only transferable to other technical courses but also adaptable to subjects related to innovation, project incubation, or technological entrepreneurship, aligning project management with business opportunity identification and early-stage solution validation.

E. Model Representation

The proposed pedagogical model is structured around the alignment of PMI project life cycle phases with the course's learning objectives, tools, developed competencies, and generated deliverables. This representation synthesizes students' progression through a real-world project management experience with a professional approach, within a guided and formative academic environment.

TABLE IV
PEDAGOGICAL ALIGNMENT MATRIX BASED ON PMI FRAMEWORK

Phase	Educational Objective	Competencies	Deliverables
Initiation	Understand the problem in a real-world context, identify stakeholders, and define the preliminary project scope.	Needs identification Contextual analysis Interpersonal communication	Problem statement Stakeholder list Technical glossary
Planning	Design the solution model and organize the work plan using project management tools.	Scope management Project planning Requirements definition Teamwork	Business model Validated schedule Functional requirements document
Execution	Implement functional solutions through user-centered prototyping and accessibility principles.	UX design Iterative development Accessibility standards application	Clickable prototypes Preliminary accessibility report
Monitoring	Validate the solution through testing with real users and structured feedback.	Critical evaluation Continuous improvement Feedback analysis	User testing report Documented functional adjustments
Closing	Systematize and present the project results with critical reflection on achievements and areas for improvement.	Effective presentation Reflective thinking Professional communication	Final project report Interactive dashboard Live pitch presentation

This framework was built upon the course's didactic planning, evaluation criteria, and the products generated by student teams during the 2025-1 semester.

D. Entrepreneurial Dimension

One of the key enhancements of the proposed model is its intentional integration of an entrepreneurial perspective into the educational project workflow. Beyond developing technical and managerial competencies, students are guided to identify market opportunities, define value propositions, and validate scalable solutions with real users.

This entrepreneurial dimension is embedded throughout the project life cycle:

- Initiation phase: students analyze real-world needs and select problems with business potential, often related to underserved communities or operational inefficiencies in local organizations.
- Planning phase: the use of the Business Model Canvas helps students articulate customer segments, channels, revenue streams, and cost structures, fostering an entrepreneurial mindset early in the design process.
- Execution phase: prototypes are developed and iterated with a focus on functional viability and user desirability, simulating the development of Minimum Viable Products (MVPs).
- Monitoring and closure: feedback from stakeholders is used not only for academic assessment but also to refine ideas with market potential. Final presentations incorporate elevator pitches, encouraging students to communicate their solutions with business clarity and purpose.

By embedding entrepreneurship into the course structure, the model fosters not only professional and social impact but also innovation and venture creation capabilities among engineering students. This alignment makes the model particularly suited for institutions aiming to cultivate student-led startups or link academic projects to institutional incubators.

Each deliverable was designed to serve a dual purpose: to provide evidence of project progress and to promote formative reflection on the decisions made in each phase. This progressive logic also allows instructors to monitor team performance and offer timely feedback at every stage, as recommended in the literature on project-based learning in engineering education.

Furthermore, the explicit alignment with the PMI phases enables students to internalize a professionally recognized methodological structure, fostering the transfer of learning to future workplace contexts.

V. CONCLUSIONS AND FUTURE WORK

A. Conclusions

The implementation of the Project Management Institute (PMI) framework in the field-based practices of the Human-Computer Interaction (INHUCO) course has proven to be an effective pedagogical strategy to strengthen the holistic training of engineering students, integrating technical, transversal, and contextual competencies within a real-world project-based learning environment.

First, the redesign of the course—centered on the project life cycle defined in the PMBOK® Guide—allowed the learning experience to be structured into five clearly defined phases (initiation, planning, execution, monitoring, and closure), facilitating the progressive appropriation of tools and processes inherent to professional project management.

Second, the statistical validation confirmed that the 2025-1 cohort (n=40), which implemented the PMI-based approach, achieved an average final performance of 90%, compared to 80% in the 2024-2 cohort (n=40) that followed the traditional methodology. The 10% increase was statistically significant ($p < 0.001$), reinforcing the effectiveness of the proposed methodology.

Third, the integration of real stakeholders into the projects brought authenticity and a sense of social responsibility, reinforcing student motivation and their awareness of technology's impact in local contexts. Cases such as VillaFarma, WebClass, and Salud Total showed that value delivery is achievable within the academic setting when supported by solid methodology, appropriate tools, and relevant pedagogical guidance.

Finally, this experience validated the feasibility of combining traditional frameworks such as PMI with active approaches like Project-Based Learning (PBL). This convergence enabled the integration of theory, practice, critical thinking, and interdisciplinary collaboration into a single educational process, offering an effective response to the challenges of university training in VUCA (Volatile, Uncertain, Complex, Ambiguous) environments.

B. Recommendations and Future Work

Based on this systematized experience, the following recommendations are proposed for future implementations:

- Expand the application of the PMI-INHUCO model to other project-oriented courses such as requirements engineering, software development, or technological innovation, enabling the construction of integrated project-based learning pathways across the curriculum.
- Strengthen formative and self-assessment mechanisms by incorporating reflective journals, collaborative rubrics, and cross-team feedback sessions to enhance critical thinking and metacognitive processes in each project phase.
- Incorporate digital tools and simulations to deepen the understanding of complex scenarios, including project management simulators, version control systems, agile dashboards, and remote collaboration platforms.
- Conduct longitudinal impact studies to evaluate the transfer of acquired competencies to professional contexts, as well as the performance of graduates in managing real-world projects within companies or entrepreneurial ventures.
- Develop faculty training programs for implementing project management frameworks in the classroom, promoting the formation of interdisciplinary teaching teams capable of co-designing and delivering PMI-based learning experiences in a contextualized and reflective manner.
- Establish links between course-developed projects and institutional incubation or entrepreneurship programs, enabling functional prototypes to evolve into economically sustainable and market-scalable solutions.

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