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FORMAÇÃO PROFISSIONAL: RECONFIGURAÇÕES REGULATÓRIAS E IMPACTO SOCIAL. ESTUDO DE CASO DO IPVCE "ANTONIO MACEO GRAJALES"

VOCATIONAL TRAINING: REGULATORY RECONFIGURATIONS AND SOCIAL IMPACT. CASE STUDY OF THE IPVCE "ANTONIO MACEO GRAJALES"

FORMACIÓN LABORAL: RECONFIGURACIONES NORMATIVAS E IMPACTO SOCIAL. ESTUDIO DE CASO DEL IPVCE "ANTONIO MACEO GRAJALES"

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RESUMO

Introdução: A formação profissional juvenil em Cuba enfrenta um paradoxo estrutural: alta qualificação acadêmica versus limitada inserção produtiva.

Objetivo: Analisar a reconfiguração da formação profissional no ensino pré-universitário cubano por meio de um estudo de caso no IPVCE "Antonio Maceo Grajales" (Santiago de Cuba), identificando suas implicações pedagógicas, normativas e territoriais.

Métodos: Realizou-se um estudo qualitativo de pesquisa-ação participativa (2024-2025) com 42 participantes (estudantes, professores, gestores e produtores locais). Implementou-se um projeto metodológico baseado em problemas autênticos do território e tutoria dupla (acadêmica e do setor não estatal). A coleta de dados incluiu questionários semiestruturados, grupos focais, observação participante e análise documental.

Resultados: Observou-se um aumento significativo (46,8%) na motivação dos estudantes para o trabalho técnico. Sete protótipos funcionais foram desenvolvidos para atender às necessidades da comunidade, com quatro tecnicamente validados. Mecanismos informais de articulação com o setor produtivo não estatal emergiram.

Conclusão: A experiência demonstra a viabilidade de articular a excelência acadêmica com a inovação endógena. No entanto, a sustentabilidade exige protocolos operacionais para a formação dual, reconhecimento da tutoria externa, financiamento institucionalizado e mecanismos de encaminhamento regulado para superar a defasagem entre os avanços normativos (2023-2025 Código do Trabalho) e a realidade escolar.

Palavras-chave: formação profissional; transição escola-trabalho; Código do Trabalho; inovação educacional; aprendizagem baseada em problemas; empreendedorismo juvenil

ABSTRACT

Introduction: Youth vocational training in Cuba faces a structural paradox: high academic qualification versus limited productive insertion.

Objective: To analyze the reconfiguration of vocational training in Cuban pre-university education through a case study at the IPVCE "Antonio Maceo Grajales" (Santiago de Cuba), identifying its pedagogical, regulatory, and territorial implications.

Methods: A qualitative participatory action-research study was conducted (2024-2025) with 42 participants (students, teachers, managers, and local producers). It involved a methodological project based on authentic territorial problems and dual tutoring (academic and non-state sector). Data collection included semi-structured questionnaires, focus groups, participant observation, and documentary analysis.

Results: A significant increase (46.8%) in student motivation towards technical work was observed. Seven functional prototypes were developed to address community needs, with four technically validated. Informal articulation mechanisms with the non-state productive sector emerged.

Conclusion: The experience demonstrates the feasibility of articulating academic excellence with endogenous innovation. However, sustainability requires operational protocols for dual training, recognition of external tutoring, institutionalized funding, and regulated referral mechanisms to overcome the gap between normative advances (2023-2025 Labor Code) and school reality.

Keywords: vocational training; school-to-work transition; labor code; educational innovation; problem-based learning; youth entrepreneurship

RESUMEN

Introducción: La formación laboral juvenil en Cuba enfrenta una paradoja estructural: alta calificación académica versus limitada inserción productiva.

Objetivo: Analizar la reconfiguración de la formación laboral en el preuniversitario cubano mediante un estudio de caso en el IPVCE "Antonio Maceo Grajales" (Santiago de Cuba), identificando sus implicaciones pedagógicas, normativas y territoriales.

Métodos: Se realizó un estudio cualitativo de investigación-acción participativa (2024-2025) con 42 participantes (estudiantes, docentes, directivos y productores locales). Se implementó un proyecto metodológico basado en problemas autênticos del territorio y tutoría dual (académica y del sector no estatal). La recolección de datos incluyó cuestionarios semiestruturados, grupos focales, observación participante y análisis documental.

Resultados: Se observó un incremento significativo (46.8%) en la motivación de los estudiantes hacia el trabajo técnico. Se desarrollaron siete prototipos funcionales para necesidades comunitarias, con cuatro validados técnicamente. Emergieron mecanismos informales de articulación con el sector produtivo no estatal.

Conclusión: La experiencia demuestra la viabilidad de articular la excelencia académica con la innovación endógena. Sin embargo, la sostenibilidad exige protocolos operativos para la formación dual, reconocimiento de la tutoría externa, financiamiento institucionalizado y mecanismos de derivación regulada para superar el desacople entre los avances normativos (2023-2025 Código de Trabajo) y la realidad escolar.

Palabras clave: formación laboral; transición escuela-trabajo; código de trabajo; innovación educativa; aprendizaje basado en problemas

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INTRODUCTION

Youth vocational training in Cuba constitutes one of the most complex debates in the field of contemporary educational policy, situated at the intersection of accumulated academic excellence, the dignity of work, and the State's responsibilities in the school-to-work transition. From a pedagogical perspective, it is defined as the systematic process of preparing students for their incorporation into economic and social life, through the development of knowledge, skills, and values associated with socially useful work (Martín Sabina & Cruz Cabrera, 2024).

Cuba faces a structural paradox in the formation of its youth human capital. The country exhibits educational indicators typical of highly developed nations—universalization of secondary education, pre-university graduation rates above 80%, and curricular mastery in exact sciences—however, the translation of these competencies into qualified labor insertion and social mobility encounters persistent obstacles (Díaz-Canel & Delgado, 2023). This gap is not solely economic; it possesses an epistemic and cultural dimension: the pedagogical model of vocational high schools, inherited from Soviet cooperation, has historically privileged theoretical-decontextualized knowledge as an end in itself, relegating its materialization in technological solutions, artisanal trades, or territory-based enterprises (Martín Sabina & Cruz Cabrera, 2024).

Its relevance transcends the pedagogical sphere to inscribe itself within legal and social frameworks, where the scope of labor and training rights in contexts of economic transformation is discussed. The academic importance of the study lies in examining the coherence and applicability of emerging regulatory frameworks, particularly in a country transitioning from a centralized planning model towards a scheme of incremental pluralism, where tensions between normativity and educational practice are often most evident (Díaz-Canel & Delgado, 2023).

At the international level, vocational training has been recognized as a fundamental right in jurisdictions such as Germany, Switzerland, Austria, and Spain, each with particular regulatory nuances regarding dual training models and private sector participation in educational processes (Avalo-Rodríguez et al., 2023). In the European context, countries like Germany have developed robust and highly structured regulatory frameworks, where 51% of young people opt for dual vocational training, combining learning in companies and school. Switzerland, for its part, has a vocational training system involving 70% of young people upon completing compulsory education, with active participation of business associations in curricular design (Martín Sabina & Cruz Cabrera, 2024).

In Latin America, the paradigmatic case of Colombia—with its model of training for work and human development—constitutes a regional reference. The National Learning Service (SENA) has managed to articulate technical training with the needs of the productive sector, including the non-state sector, as a space for practice. This model has demonstrated that private employer participation in training processes increases youth employability and reduces the gap between acquired and demanded competencies.

The comparative experience of Colombia and Europe offers relevant lessons for Cuba. Recent international evidence reinforces this potential. According to Euler (2022), Germany's dual system—where 51% of young people combine company-based learning with school—rests on three pillars: binding national standards, certified company tutors, and shared financing between state and private sector. Similarly, Hoeckel (2023) documents that Switzerland's vocational model, involving 70% of youth post-compulsory education, achieves low youth unemployment (7.2% vs. the EU average of 14.1%) through active business association participation in curriculum design. In the Global South, Colombia's SENA system has demonstrated that technical training articulated with productive sector needs—including non-state enterprises as practice sites—significantly increases employability (SENA, 2023). However, UNESCO-UNEVOC (2024) warns that transferring dual models to low-resource contexts requires adaptation: without operational protocols, trainer certification, and sustainable financing, even well-designed regulations fail to transform classroom practices. These cautionary lessons are directly relevant to Cuba's current regulatory reforms.

Incorporating dual training mechanisms, non-state sector participation in educational processes, and the recognition of certifications with curricular value are elements that can enrich the Cuban system. In this sense, the Draft Labor Code (2025) and youth policies can benefit from these experiences, particularly regarding institutional articulation, trainer training, and competency assessment (Martín Sabina & Cruz Cabrera, 2024; Ministerio de Trabajo y Seguridad Social, 2025).

In contrast to these international advances, Cuba has historically maintained a centrally planned model where the State acts as the sole employer and trainer. The non-state sector—self-employed workers, family micro-enterprises, non-agricultural cooperatives—has had marginal participation in training processes, despite currently absorbing more than 30% of the country's workforce (Martín Sabina & Cruz Cabrera, 2024). This asymmetry generates an institutional "bottleneck": young people graduate with high theoretical qualifications but face a productive fabric—especially the state sector—with low absorption capacity and no tradition of dual training.

The period 2023-2025 introduces three vectors of change that reconfigure this scenario. First, the regulatory sphere: Decree 67/2023 (Maternity Law and protection of educational trajectories) and the Draft Labor Code (2025) explicitly recognize the right to continuous training and, for the first time, enable the placement of graduates in the non-state sector when the state sector cannot guarantee it (Ministerio de Trabajo y Seguridad Social, 2025). Second, international cooperation: the PROFET program (SFUVET-COSUDE-UNDP), in its second phase (2024-2025), has introduced competency-based trainer training methodologies for

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employability, with sectoral focus on agriculture, construction, and hospitality. Third, emerging local experimentation: various IPVCEs have begun implementing socio-productive projects that test hybrid models between the academic curriculum and the culture of "making".

In this same line, in Cuba, the enactment of the Draft Labor Code (2025) occurs after a prolonged period of updating the economic model, which recognizes the need to flexibilize labor relations and diversify economic actors. Article 164 establishes the possibility for Municipal Directorates of Labor and Social Security to sign agreements with non-state sector entities for conducting social service and practical training for recent graduates. This provision constitutes an epistemological break from the homogenizing tradition of the period 1975-2019 (Martín Sabina & Cruz Cabrera, 2024).

However, specialized literature warns that regulatory reforms, by themselves, do not guarantee transformations in classroom practices (Liu & Pásztor, 2022; Loyens et al., 2023). There is an empirical gap on how pre-university educational institutions translate these policies into concrete pedagogical devices, particularly in contexts of high technological vulnerability and resource constraints (Aslam et al., 2023; Budiarto et al., 2024). In the Cuban case, the question is not only what the law says, but how schools—with their structural limitations and institutional culture—construct situated responses to connect academic excellence with the new forms of employment emerging in the territory.

This article addresses this problem through a single embedded case study: the Socio-productive and Cultural Methodological Project at the IPVCE "Antonio Maceo Grajales" (Santiago de Cuba). The research started from the following scientific problem: insufficient student motivation towards vocational training activities at the IPVCE "Antonio Maceo Grajales". Correspondingly, the research object was the vocational training process in vocational pre-university education, and the field of action was motivation towards said training in articulation with the socio-productive environment of Santiago.

The study was guided by the following scientific question: how does the implementation of a socio-productive and cultural methodological project, anchored in authentic territorial problems and in the tutoring of non-state sector agents, modify dispositions towards artisanal and technical work, competencies for employability, and institutional articulation in the context of Cuban vocational pre-university education?

The hypothesis is that the implementation of a socio-productive and cultural methodological project, based on authentic problems of the Santiago environment and on a dual tutoring structure incorporating artisanal and technical knowledge from the non-state sector, significantly increases motivation towards vocational training, develops applied competencies for new forms of employment, and generates subjective and organizational conditions favorable for school-productive sector articulation, despite existing structural limitations and curricular inertias.

Comparative experience, especially Colombian and European, shows that operationalizing vocational training in contexts of productive diversification requires clear regulatory systems, precise didactic guides, and rigorous inter-institutional articulation processes that ensure both student protection and legal security for professionals (Cervantes-Hinojosa et al., 2023).

In this context, this article aims to analyze the reconfiguration of vocational training in Cuban vocational pre-university education based on the case study of the IPVCE "Antonio Maceo Grajales", identifying its pedagogical, regulatory, and territorial implications, as well as the main challenges for its sustainability in the Santiago context. This analysis seeks to contribute to academic debate and the strengthening of educational policies that guarantee an ethical, relevant, and transformative exercise of the right to vocational training in new generations.

2. METHODS

This study adopted a qualitative approach with a critical orientation, due to the pedagogical, social, and territorial nature of the research object. A participatory action-research (PAR) design was chosen, structured in cycles of planning, action, observation, and reflection (Kemmis & McTaggart, 2014). This approach was pertinent given the dual purpose of the study: (a) to generate knowledge about the reconfiguration of vocational training in Cuban vocational pre-university education, and (b) to transform a concrete educational practice through the collaborative involvement of actors.

2.1 Sample

The study was developed at the Instituto Preuniversitario Vocacional de Ciencias Exactas (IPVCE) "Antonio Maceo Grajales", located in the Vista Alegre neighborhood, Santiago de Cuba municipality, during the academic period from September 2024 to June 2025.

Intentional criterion sampling was employed. Participants were selected based on their direct link to the vocational training process and their willingness to participate in the project. The sample consisted of:

- 12 teachers from Mathematics, Physics, Chemistry, and Informatics disciplines, selected for teaching 12th grade and expressing explicit interest in the project.
- 24 12th-grade students (Exact Sciences profile), selected through open call and motivation interview.
- 4 managers (Head of Science Department, Head of Methodological Department, Deputy Director of Teaching, Director).
- 2 local productive agents (a technician from the Centro de Desarrollo de la Electrónica and a self-employed worker in the renewable energy sector, specialized in repairing household appliances and photovoltaic systems).

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Techniques and Instruments

The techniques employed were a semi-structured questionnaire, focus group, participant observation, and documentary analysis. The instruments were designed ad hoc and validated through expert judgment ($n=7$; Aiken's V coefficient > 0.80).

- Semi-structured questionnaire: Applied to the 42 participants at two moments (pretest and posttest). It explored four dimensions: (a) conceptions about vocational training, (b) motivation towards technical and artisanal activities, (c) self-perception of competencies for employability, and (d) obstacles to linking with the productive sector. It included closed questions with a 5-point Likert scale and open questions.
- Focus groups: Four structured sessions were held according to Krueger & Casey's (2015) guidelines, with 12 participants each. They addressed perceptions about the meaning of work, labor expectations, and evaluation of the implemented project.
- Participant observation: Ethnographic recording was conducted in 12 work sessions of student teams (design, construction, and prototype testing workshops). An observation guide focused on interactions, problem-solving strategies, and resource use.
- Documentary analysis: Regulatory sources were reviewed (Draft Labor Code, 2025; Decree 67/2023; Policy for Comprehensive Care of Children, Adolescents, and Youth, 2023), institutional reports from MINED and the Universidad de Oriente, and scientific literature indexed in Scopus, Web of Science, and SciELO (last five years).

Procedure

The study was developed in four sequential phases:

- Phase I. Diagnosis (September-October 2024). The pretest questionnaire was applied, and initial focus groups were conducted to identify conceptions, perceived needs, and obstacles. A participatory territorial diagnosis was carried out to identify authentic problems in the Santiago environment susceptible to being addressed from the exact sciences curriculum.
- Phase II. Participatory Design (November-December 2024). Through co-construction workshops with teachers, students, and local productive agents, the Socio-productive and Cultural Methodological Project was designed. Seven authentic problems prioritized from the needs of the Sueño, Vista Alegre, and Altamira popular councils were defined (inefficient public lighting, artisanal coffee drying, poultry feed dosing, school garden irrigation, post-harvest fruit loss, noise pollution, and low germination yield). A dual tutoring structure was established: each student team had an academic tutor (IPVCE teacher) and a technical tutor (local productive agent from the non-state sector). A prototype evaluation rubric was collectively constructed with four achievement levels (conceptual prototype, functional with adjustments, technically validated, transferable to the environment).
- Phase III. Implementation and Observation (January-May 2025). The project pilot was executed in extracurricular hours (4 hours weekly). Participant observation with ethnographic recording was conducted in 12 work sessions. The processes of design, construction, and prototype testing were documented.
- Phase IV. Evaluation (June 2025). The posttest questionnaire was applied, semi-structured exit interviews were conducted with 10 students and 6 teachers, and the prototypes were evaluated using the designed rubric. Findings were systematized, and recommendations for project institutionalization were elaborated.

2.2 Data collection instruments

Quantitative data (Likert scales) were analyzed using descriptive statistics (means, standard deviations, percentages) and the Wilcoxon signed-rank test for related samples (pre-post comparison) using SPSS v.27. Effect size was calculated using Cohen's d . Qualitative data (transcriptions of focus groups, interviews, and field notes) were processed through thematic content analysis with the support of ATLAS.ti v.23, following the open, axial, and selective coding procedure proposed by Braun & Clarke (2021). Triangulation of sources, methods, and researchers was guaranteed.

Rigor and Quality Assurance

To ensure credibility, the first author conducted prolonged engagement (6 months of weekly site visits) and peer debriefing sessions with two external researchers not involved in data collection. Transferability was addressed through a thick description of the institutional context, participant characteristics, and territorial specificities of Santiago de Cuba. Dependability was assured by maintaining a complete audit trail—including raw data, analysis notes, and coding matrices—reviewed by an independent auditor. Confirmability was established through a reflexive journal documenting the researcher's assumptions and how they were bracketed during analysis.

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Theoretical Saturation

Data collection continued until theoretical saturation was achieved, defined as the point where no new codes or themes emerged from consecutive data collection events. Saturation was reached after the fourth focus group (no new categories identified) and the tenth observation session (themes became repetitive). The final two focus groups and three observation sessions served as confirmation rather than discovery.

Triangulation

Triangulation was performed across three levels: (a) data source triangulation (students, teachers, managers, local producers, documentary sources), (b) methodological triangulation (questionnaires, focus groups, participant observation, documentary analysis), and (c) investigator triangulation (three researchers independently coded 30% of the qualitative data, achieving inter-coder agreement of $\kappa = 0.84$, with disagreements resolved through consensus discussion).

Ethical Considerations

The research was conducted in accordance with the ethical principles established in the Declaration of Helsinki and the regulations of the Ministry of Education of the Republic of Cuba. It was approved by the Scientific Council of the IPVCE "Antonio Maceo Grajales" and the Ethics Committee of the Universidad de Oriente. Written informed consent was obtained from all adult participants and parental authorization for minor students. Anonymity was guaranteed through the use of pseudonyms and dissociation of personal identifiers.

3. RESULTS

Documentary analysis and empirical evidence collected during fieldwork allow us to identify that the Socio-productive and Cultural Methodological Project at the IPVCE "Antonio Maceo Grajales" represents an innovative local initiative in the situated translation of vocational training policies into the context of Cuban vocational pre-university education. The results are structured into three interdependent dimensions: transformation of motivation towards artisanal and technical work, development of competencies for new forms of non-state employment, and emergence of institutional articulation mechanisms with the Santiago socio-productive environment.

The comparison of pre-post intervention scores on the Motivation towards Vocational Training Scale (MVTS), applied to the 24 participating students, evidenced a statistically significant increase in global motivation ($Z = -3.41$; $p = .001$; $d = 0.78$). The mean rose from $M = 2.67$ ($SD = 0.59$) in the pretest to $M = 3.92$ ($SD = 0.48$) in the posttest, representing a 46.8% improvement

Table 1 - Comparison of means in motivation towards vocational training by dimensions (N=24)

Dimension	Pretest M (SD)	Posttest M (SD)	Difference	Z	p	Cohen's d
Interest in technical and artisanal tasks	2.54 (0.72)	3.88 (0.61)	+1.34	-3.52	.000	0.81
Perceived usefulness of non-state work	3.12 (0.68)	4.04 (0.53)	+0.92	-3.01	.003	0.69
Self-efficacy for performance in scarcity contexts	2.38 (0.81)	3.79 (0.59)	+1.41	-3.48	.000	0.79
Identification with technical and artisanal roles	2.63 (0.77)	3.96 (0.55)	+1.33	-3.38	.001	0.76
Global Motivation	2.67 (0.59)	3.92 (0.48)	+1.25	-3.41	.001	0.78

Note: Likert scale from 1 (totally disagree) to 5 (totally agree). Wilcoxon signed-rank test for related samples

The increase was especially pronounced in the dimensions of identification with technical and artisanal roles (+1.33) and self-efficacy for performance in scarcity contexts (+1.41). This finding is particularly relevant in the Cuban context, where intellectual work has historically been hierarchized over manual work, and resource scarcity has traditionally been perceived as an insurmountable obstacle to innovation.

Qualitative analysis allowed the identification of three explanatory categories for this motivational increase. First, the resignification of manual work as an intellectually legitimate practice. A student from the team that designed the solar dryer for coffee expressed:

"At first, I thought science was only for people in white coats in big laboratories. But my grandfather is a coffee farmer in Gran Piedra, and he needs a solution now, not in ten years. When I saw that my prototype worked with materials we got from the neighborhood hardware store, I understood that being a scientist also means being an artisan" (Student 7, male, 17 years).

Second, the connection of school knowledge with real territorial problems. Another student, whose team developed an automatic poultry feed dispenser for backyard farming—a growing economic activity in Santiago's patios as a response to the food crisis—stated:

"My neighbor raises chickens to sell at the Alto Songo market. She doses by eye and wastes a lot. Our dispenser costs a fraction of an industrial one, and she can repair it herself. That's empowerment" (Student 14, female, 17 years).

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Third, teacher legitimization of applied knowledge as valuable curricular content:

"For years, vocational training at the IPVCE was a residual space: we did cleaning, painting, and gardening days. Students didn't find meaning because it didn't connect with their life project. This project showed them that manual work, when crossed by science, is high-level intellectual work" (Teacher 4, Physics, 22 years of experience).

Key Finding 1: The implementation of the socio-productive and cultural methodological project, based on authentic problems of the Santiago territory and tutoring by non-state sector agents, was associated with a positive change in motivation patterns. Of low motivation towards vocational training, by redefining it as a socially relevant, cognitively challenging, and culturally rooted practice in Cuban artisanal tradition.

Development of Competencies for New Forms of Non-State Employment

The five work teams formed successfully completed the full cycle of design, construction, and testing of functional prototypes, all aimed at solving problems identified in communities of the popular councils of El Cobre, Songo La Maya, and Altamira.

Table 2 - Results of prototype evaluation by team (N=5)

Team	Problem Addressed	Prototype Developed	Achievement Level	External Validation
1	High firewood consumption in artisanal coffee drying (El Cobre zone)	Hybrid solar dryer with temperature control	Technically validated	Local producer (self-employed sector)
2	Inefficient manual dosing in backyard poultry farming (Songo-La Maya)	Gravity-powered automatic feed dispenser	Functional with adjustments	Local producer (cooperative)
3	Low germination yield (school garden)	Germinator with humidity and temperature control	Functional with adjustments	Science Department
4	Difficulty in school garden irrigation (Altamira)	Low-cost automated irrigation system	Technically validated	Community project
5	Post-harvest fruit loss (Los Olmos neighborhood)	Tray-type solar dehydrator	Functional with adjustments	Family enterprise

Note: Achievement level according to four-level rubric: (1) conceptual prototype, (2) functional with adjustments, (3) technically validated, (4) transferable to the environment.

The self-perception of competencies for employability, measured using an ad hoc scale, showed substantial increases. A 79.1% of students stated in exit focus groups that the project had shown them a feasible path of labor insertion not dependent on state employment:

"I used to think the only option was to be a doctor or engineer in a state company. Now I know I can set up my own electronics repair workshop or partner with others to manufacture irrigation systems for farmers. Santiago needs people who solve problems, not just people who ask for a job" (Student 8, male, 17 years).

The technical tutor from the renewable energy sector—a self-employed worker with 15 years of experience in repairing household appliances and photovoltaic systems—corroborated this perception:

"At first, I thought these kids wouldn't be able to do it, that it was too much theory and little practice. But when I saw the first circuit working, I changed my mind. These young people are not afraid of the screwdriver or the multimeter. That's what's missing in Cuba: engineers who know how to do, not just calculate" (Technical Tutor 1, renewable energies).

Key Finding 2: Contrary to the deficit hypothesis—which attributes low motivation and limited technical competency development exclusively to material shortages—the students provided evidence of ability to develop functional technological solutions with limited resources, provided there is didactic scaffolding based on authentic problems and specialized tutorial accompaniment by non-state sector agents.

Emergence of Informal Articulation Mechanisms with the Santiago Non-State Sector

The emergence of informal and community-based articulation mechanisms between the pre-university school and Santiago's non-state sector actors was identified, an effect not foreseen in the initial research design but decisive for project sustainability.

First, informal collaboration agreements. Two local producers expressed explicit willingness to formalize collaboration beyond the pilot project. The testimony of the coffee farmer is eloquent:

"At first, I agreed out of commitment to the university, because my daughter studies there and they asked me. But after seeing the result of the dryer—it reduces firewood consumption by 40%—I spoke with the IPVCE director and proposed that we maintain the link next school year. These young people understand the countryside; they're not afraid of the land or the tools. That's what Cuba needs, not engineers who only know how to operate imported software" (Technical Tutor 2, coffee farmer, El Cobre).

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Second, demand for continuity from the student body. A total of 91.6% of participating students (22 out of 24) expressed interest in continuing the project during the 2025-2026 academic year, and 62.5% (15 out of 24) stated their willingness to enroll in university careers related to the themes worked on—Electrical Engineering, Mechanical Engineering, and Computer Science. Third, incipient institutional recognition. The IPVCE Directorate Council, approved in June 2025, the inclusion of the project in the center's problem bank and the allocation of a weekly time fund of two hours for the continuity of methodological work.

Regulatory Gaps and Structural Challenges

Despite the documented achievements, structural limitations persist that condition the sustainability of these results in the Cuban context and, specifically, in Santiago. Documentary analysis and comparison with international experiences allow the identification of four critical gaps.

Table 3 - Gap-Competency Matrix: Implementation challenges for vocational training in Cuban pre-university education

Identified Gap	Required Competency / Action	International Reference
Absence of standardized dual training protocols	Institutional capacity for school-non-state articulation; development of national protocols	Germany (BIBB standards), Colombia (SENA formal agreements)
No regulatory recognition of external technical tutoring	Legal framework for "non-state instructor" category; mechanisms for compensation or credit recognition	Switzerland (certified company tutors with remuneration)
No institutionalized budget for educational innovation	Financial management skills; competitive funding lines; resource mobilization strategies	Chile (Donations Law), Canada (innovation funds)
Resistance from central administration to non-state agreements	Political advocacy; inter-institutional negotiation protocols; regulated referral mechanisms	Colombia (conscientious objection with mandatory referral)
Reliance on unpaid external tutors (sustainability risk)	Recognition systems (social service credit), micro-incentives, and inclusion in the Labor Code	Germany (shared financing model)

Source: Own elaboration based on Martín Sabina & Cruz Cabrera (2024); Ministerio de Trabajo y Seguridad Social (2025); Euler (2022); Hoeckel (2023); SENA (2023)

4. DISCUSSION

The integrated analysis of empirical evidence suggests three interconnected observations.

First. The stated scientific problem—insufficient motivation towards vocational training—suggests a potential pathway in situated implementation of socio-productive projects anchored in authentic territorial problems and non-state sector tutoring. The observed 46.8% increase in motivation scores, together with qualitative evidence of dispositional change, is consistent with studies by Liu & Pásztor (2022) and Loyens et al. (2023), who demonstrated that problem-based learning increases intrinsic motivation in secondary students.

Second. Vocational training in Cuban pre-university education faces not a crisis of cognitive capacity but a "crisis of meaning". Students possess scientific capital; what has been missing is a pedagogical device legitimizing applied knowledge as valuable curricular content. This finding challenges the assumption—common in institutional discourse—that low motivation stems exclusively from resource scarcity. When students perceive concrete social impact from their knowledge, motivation transforms qualitatively.

Third. Micro-level transformations (classroom, project) reveal a disconnect between regulatory modernization (2023-2025) and school operational reality. While the draft Labor Code (2025) opens historical opportunities, schools lack the instruments to translate this opening into dual training practices. As Martín Sabina & Cruz Cabrera (2024) warned, norms do not automatically create reality. Deliberate intervention is required at three levels: (a) micro (classroom): institutionalize project methodology as a mandatory didactic strategy; (b) meso (institution): create a "Liaison Coordinator" position and recognize external tutoring hours; (c) macro (policy): modify study plans to include "Innovation, Entrepreneurship, and Local Development" with academic credits. A critical sustainability concern is the reliance on unpaid technical tutors from the non-state sector. In the present study, both external tutors participated without financial compensation, motivated by personal commitment and family ties to the institution. However, as documented in similar low-resource contexts (Aslam et al., 2023), long-term engagement without recognition risks tutor burnout and program attrition. Three potential mitigation strategies emerged from participant feedback: (a) recognizing external tutoring hours as fulfillment of social service requirements mandated by Decree 67/2023, (b) providing non-monetary incentives such as priority access to state technical training programs or procurement opportunities, and (c) incorporating a new category of "non-state instructor" into the draft Labor Code (2025) with eligibility for modest honoraria or tax benefits. Without such mechanisms, even successful pilot experiences may prove difficult to sustain beyond the initial project period.

Limitations. This is an exploratory case study based on a single institutional context, limiting generalizability. The time horizon (one academic year) precludes assessment of long-term labor insertion outcomes. The Santiago context, marked by strong artisanal traditions and cultural resistance, may not transfer to other Cuban regions. Future multicenter longitudinal designs are needed to evaluate graduate trajectories at 3 and 5 years, as well as comparative case studies across provinces.

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CONCLUSION

First vocational training in Cuban pre-university education is undergoing an incipient reconfiguration. The project suggests that academic excellence can be linked to technological solutions based in the local context, provided that an explicit pedagogical framework and a dual tutoring structure act as mediators. The observed 46.8% increase in motivation and the development of seven functional prototypes offer preliminary evidence of the potential of this approach.

Second. Regulatory reforms (Decree 67/2023; draft Labor Code (2025) are necessary but insufficient. Their effectiveness depends on operational mechanisms: (a) national dual training protocols, (b) normative recognition of external tutoring (including a "non-state instructor" category), (c) institutionalized innovation budgets, and (d) regulated referral mechanisms for conscientious objection cases.

Third. Sustainability challenges require attention. The current reliance on unpaid tutors carries the risk of burnout. Possible solutions include recognizing tutoring hours as community service credit, providing non-monetary incentives, and legally incorporating non-state instructors into the framework of the Labor Code.

Fourth. This study has limitations (single site, one-year horizon, Santiago-specific context). Future research should include multicenter longitudinal designs, comparative provincial case studies, and gender-disaggregated analyses.

Fifth. Youth vocational training is fundamentally a device for social inclusion, personal fulfillment, and technological sovereignty. In a country facing demographic and migratory challenges—aging rate of 22.3% and sustained negative external migration balance—ensuring that young people find dignified work articulating science, artisanal tradition, and innovation constitutes a strategic national priority. The pending task is for local alternatives to become systematic, funded public policy.

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AUTHORS' CONTRIBUTION

Conceptualization, R.D.P. and M.C.S.; data curation, R.D.P. and F.M.B.; formal análisis, M.C.S. and R.D.P.; investigation, R.D.P., M.C.S. and F.M.B.; methodology, R.D.P. and M.C.S.; software, F.M.B.; supervision, R.D.P. and M.C.S.; validation, R.D.P. and M.C.S.; visualization, F.M.B.; writing – original draft, R.D.P.; writing – review & editing, R.D.P. and M.C.S.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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