

**AGROECOLOGY AND SUSTAINABLE ENTREPRENEURSHIP IN VOCATIONAL
EDUCATION: A REPORT ON PEDAGOGICAL EXPERIENCES WITH NATIVE CERRADO
SEEDLING PRODUCTION**

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Abstract

The integration of agroecology, ecological restoration, and sustainable entrepreneurship represents a promising pedagogical strategy for vocational education in threatened biomes. This chapter reports on and analyzes an integrated pedagogical pathway developed at the Formoso do Araguaia Campus of the Federal Institute of Education, Science, and Technology of Tocantins (Instituto Federal de Educação, Ciência e Tecnologia do Tocantins, IFTO), comprising two sequential teaching projects conducted with students enrolled in the Technical Program in Agriculture between September 2023 and August 2024. The Cerrado em Foco project trained students in propagation techniques for six species native to the biome: yellow trumpet tree, jacaranda, jatobá, fava-de-bolota, Cerrado cashew, and cagaita. Activities included collection, processing, dormancy breaking, sowing, and phytosanitary monitoring. The Projeto Semente

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project transformed this technical knowledge base into an object of entrepreneurial analysis through a participatory survey of the local seedling market and the group development of business plans. The approach was grounded in the principles of Project-Based Learning, experiential learning, and agroecological education, integrating teaching, research, and extension into a single educational pathway. Approximately 1,350 native seedlings were produced, a germplasm bank containing the six species studied was established, and nine business plans were developed. The results indicate that progressively integrating environmental conservation, technical training, and entrepreneurship enhances student engagement, fosters meaningful learning, and contributes to the sustainable socioeconomic development of the territory. The experience demonstrates the approach's potential for replication in other vocational education contexts in threatened biomes.

Keywords: Cerrado, Experiential learning, Native seedlings, Sustainable entrepreneurship, Vocational and technological education.

INTRODUCTION

Brazilian Vocational and Technological Education (Educação Profissional e Tecnológica, EPT) is undergoing a period of pedagogical transformation. The traditional model, focused exclusively on technical skills detached from their social and environmental context, no longer responds to contemporary demands concerning work and sustainability (Moura, 2007). The establishment of the Federal Institutes under Law No. 11,892/2008 introduced the comprehensive education of students as a guiding principle, integrating science, technology, culture, and work to prepare them to intervene critically in reality (Brasil, 2008). To accomplish this, EPT institutions must overcome the separation between theory and practice by adopting pedagogical approaches based on real situations and problems, with concrete outcomes that students can verify (Saviani, 2003).

This need for pedagogical renewal becomes even more urgent in light of the scale that EPT has reached in Brazil. The 2025 School Census recorded 3.18 million enrollments in this educational

modality, the highest figure in the historical series and an increase of 68.4% over five years (INEP, 2026).

This expansion highlights not only the social relevance of EPT, but also institutions' growing responsibility to ensure that this historically high enrollment translates into comprehensive education rather than technical instruction disconnected from the territory. It is amid this tension between quantitative expansion and pedagogical quality that active learning methodologies emerge as an organizing axis for curricula committed to student agency, meaningful learning, and the contextualization of technical knowledge in relation to the concrete demands of the local setting (Da Silva; Lima; Pontes, 2023).

Among the approaches that respond to this need, agroecology has emerged as a pedagogical framework of particular relevance to EPT, especially in agricultural technical programs (Vieira et al., 2024). Understood as a science, political movement, and social practice aimed at fostering fairer relationships between human beings and ecosystems (Marchetti et al., 2023), agroecology provides vocational education with a framework that integrates the territory's ecological, economic, and social dimensions from a dialogical perspective. This is what Freire (2014) defines as the capacity to begin with a critical reading of the world and return to it through transformative action. Pereira et al. (2024) identify substantial growth in scientific production on agroecology within the Federal Institutes since 2018, indicating its incorporation as a pedagogical orientation that integrates teaching, research, and extension and transforms fields, forests, and nurseries into living laboratories in which students develop a critical understanding of the territory.

Project-Based Learning (PBL) serves as the methodological link between this agroecological framework and technical classroom practice. By organizing teaching around real problems with verifiable impacts, PBL makes learning meaningful through students' direct experience (Da Silva; Lima; Pontes, 2023), while developing competencies that extend beyond technical proficiency, including autonomy, critical thinking, territorial assessment, and entrepreneurship. Pozzer and Neuhold (2024) emphasize that endogenous regional development is an organizing axis of the Federal Institutes, which requires education

attuned to the particularities of the territory. It is precisely through this relationship among active methodology, comprehensive education, and territorial development that agroecological pedagogical practices find their strongest justification.

Within this territory, the production of native-species seedlings emerges not as an ancillary curricular activity, but as a central pedagogical strategy. Educational nurseries containing native species are learning environments that simultaneously integrate multiple dimensions of education: technical, ecological, and social. Rodrigues, Silva, and Oliveira (2024) documented that the participatory establishment of nurseries containing native species in school settings significantly strengthens students' critical environmental awareness and their connection to the biome in which they live.

The entrepreneurial dimension completes this educational framework. Technical proficiency in producing native seedlings does not merely represent ecological competence; it also constitutes a tangible income-generating opportunity in a market with a substantial structural shortfall. According to the Brazilian Coalition on Climate, Forests and Agriculture (Coalizão Brasil Clima, 2024), Brazil's seedling supply covers only 6% of projected restoration demand through 2030. In this context, the educational nursery ceases to be merely a space for technical learning and becomes a microcosm of technical, ecological, economic, and civic education, in which students experience the multiple dimensions of sustainable work in a situated, real-world manner (Montenegro et al., 2024).

Despite the recent growth of literature on school nurseries, environmental education, and seedling production in educational settings, reports that simultaneously integrate agroecology, sustainable entrepreneurship, active methodologies, community extension, and regional development into a coherent, sequential pedagogical pathway within EPT remain rare. The available studies tend to address these dimensions separately, focusing either on technical aspects, generic environmental education, or entrepreneurship disconnected from the agroecological and territorial context (Vieira et al., 2024; Paiva; Aguiar, 2023). The systematic documentation and analysis of all these dimensions within a single educational pathway therefore represent a contribution that remains relatively unexplored.

This chapter seeks to address that gap by reporting on and analyzing an integrated pedagogical pathway designed in two complementary stages: the Cerrado em Foco project, conducted from September to December 2023 and aimed at building technical and agroecological knowledge through the production of native Cerrado seedlings; and the Projeto Semente project, conducted from April to August 2024, which transformed this knowledge into an object of entrepreneurial analysis through the preparation of business plans grounded in the local market. Together, the projects constitute a replicable model integrating environmental conservation, technical education, and regional development.

This chapter aims to report on and analyze this integrated pedagogical experience, discussing its contributions to sustainable technical education within Brazilian Vocational and Technological Education and highlighting the potential to replicate the adopted approach in other vocational education settings located in threatened biomes.

METHODOLOGY

CHARACTERIZATION OF THE PEDAGOGICAL EXPERIENCE

This study is a qualitative pedagogical experience report employing a descriptive and reflective approach, developed through the critical systematization of two educational practices undertaken within Vocational and Technological Education (Mussi; Flores; Almeida, 2021). This form of scientific production is recognized as a legitimate strategy for constructing and sharing knowledge in the field of education because it makes it possible to document, analyze, and share experiences developed in real educational settings, thereby contributing to the improvement of institutional pedagogical practices (Mussi; Flores; Almeida, 2021). The analysis does not focus on the agronomic outcomes of seedling production, but on the teaching and learning process structured around that production: the competencies developed, the relationships established between theory and practice, the connections forged among the school, territory, and community, and the educational outcomes observed throughout the pedagogical pathway.

The experience was conducted at the Formoso do Araguaia Campus of the Federal Institute of Education, Science, and Technology of Tocantins (IFTO), with students enrolled in the Technical Program in Agriculture, between September 2023 and August 2024. Two sequential and complementary teaching projects were developed: “Cerrado em Foco: Ecological Restoration and Awareness through Urban Tree Planting and the Recovery of Degraded Rural Areas,” conducted from September to December 2023, and “Projeto Semente: Cultivating Entrepreneurship in the Cerrado,” conducted from April to August 2024. The sequential organization of the projects was intentional: the first built students’ technical and agroecological knowledge base, while the second transformed this knowledge into an object of entrepreneurial analysis and territorial intervention, completing an educational arc extending from the seed to the business plan.

INSTITUTIONAL CONTEXT AND PARTICIPANTS

The Formoso do Araguaia Campus is located in the municipality of Formoso do Araguaia in southern Tocantins, on the banks of the Araguaia River and entirely within the Cerrado biome. The municipality has a tropical climate with a distinct dry season, classified as Aw under the Köppen system, average annual precipitation of 1,400 mm, and an elevation of approximately 237 m. Authorized by the Ministry of Education in 2015, the campus offers upper-secondary-level technical programs in Agriculture and Information Technology aligned with the local socioeconomic profile. It also has infrastructure that enabled the project activities to be conducted with technical rigor and broad pedagogical scope: an approximately 80 m² educational nursery covered with 50% shade cloth, a full-sun hardening area, a sprinkler irrigation system, an agricultural laboratory, and field areas for collection and outdoor activities.

This campus operates within a territory that makes the relationship between technical education and environmental awareness both urgent and fertile. Located in the Matopiba region, which accounted for 70% of Cerrado deforestation in 2025 and 40% of the entire area deforested in Brazil during the same

period (MAPBIOMAS, 2026), the campus is situated along one of the biome's most heavily pressured frontiers. Formoso do Araguaia is the largest municipality in Tocantins by land area and has an economy structurally dependent on agriculture and livestock farming, which account for 77.8% of the value added to its GDP. Pressure on the biome is reflected in the figures: in July 2025, the municipality recorded 156 fire hotspots, ranking among the three municipalities in Tocantins and the ten municipalities in Brazil with the highest incidence of fire hotspots during that period, in a month when the Cerrado accounted for 54% of all hotspots detected in the country (INPE, 2025).

Both projects were coordinated by an instructor from the Technical Program in Agriculture and supported by two scholarship students from the same program, who dedicated 12 hours per week outside regular class hours. The Cerrado em Foco project recorded the participation of approximately 40 students per session, while the Projeto Semente project included classes of approximately 35 students per session. Participants were young people between 15 and 18 years old undergoing initial technical education, most of whom lived in the municipality or in nearby rural and Indigenous communities. The students' backgrounds gave the field and territorial-analysis activities a biographical dimension: they knew the biome and the local market not as curricular abstractions, but as lived realities. Both projects were funded by IFTO through institutional calls for teaching projects.

DIDACTIC AND PEDAGOGICAL ORGANIZATION OF THE EXPERIENCE

The pedagogical design of the two projects was guided by three deliberately adopted principles: experiential learning, territorial contextualization, and the integration of teaching, research, and extension. The first is supported by Dewey (1976), for whom genuine experience is the most fruitful condition for learning, meaning not just any experience, but one that prompts reflection and the reconstruction of knowledge. Kolb (1984) translated this principle into a four-stage sequential model extending from concrete experience to reflective observation and from abstract conceptualization to active

experimentation. The projects completed this entire cycle, from field seed collection to the presentation of business plans at a scientific event.

The activities were structured according to the principles of Project-Based Learning (PBL), a methodology that positions students as central agents in the educational process and organizes the curriculum around real problems that generate concrete and socially relevant products (Da Silva; Lima; Pontes, 2023). In the Cerrado em Foco project, the central product was the production of native-species seedlings for urban tree planting and the restoration of degraded areas, a real problem with a real destination in a real municipality. In the Projeto Semente project, the product was a business plan for marketing these seedlings in the local market, likewise grounded in an actual gap identified by the students themselves through a participatory survey. This correspondence between pedagogical activities and the territory's concrete demands is what Freire (2014) calls problem-posing education: education that begins with a critical reading of the world and returns to it through transformative action.

Interdisciplinarity was another organizing element of the pedagogical design. Within a single educational pathway, the projects mobilized content from applied botany, Cerrado ecology, plant propagation, phytosanitary management, business management, market analysis, and scientific communication. This integration was not externally imposed on the curriculum; it emerged from the nature of the proposed problem, which itself required multiple disciplinary perspectives for proper understanding and resolution. The integration of teaching, research, and extension likewise occurred organically: teaching took place in lectures and practical classes; research occurred through the participatory survey of the seedling market and the photographic documentation of pests; and extension took place through seedling donations to the community and the presentation of results at a scientific event organized by IFTO. Pozzer and Neuhold (2024) demonstrate that this triad constitutes an organizing axis of the Federal Institutes' mission, and the experience reported here implemented it not as institutional rhetoric, but as documented pedagogical practice.

DEVELOPMENT OF THE PEDAGOGICAL ACTIVITIES

The Cerrado em Foco project was organized into eleven weekly four-hour sessions, totaling 44 hours, divided between interactive lectures, which accounted for 30% of the workload, and practical field and laboratory activities, which accounted for 70%. This distribution was deliberate. In keeping with Bacich and Moran (2018), who argue that active methodologies should ensure that students spend most of their time doing, experimenting, and creating rather than merely listening, the decision to devote more than two-thirds of the workload to practical activities reflected the understanding that the nursery and the field were the most effective pedagogical spaces available on campus.

The pedagogical pathway began in natural areas on and around the campus with the supervised collection of seeds from the six selected species, which are identified and named in the Results section. Species were selected according to three integrated criteria: their natural occurrence in the Cerrado and the Formoso do Araguaia region; their potential use in urban tree planting and the restoration of degraded areas; and their representation of the different types of seed dispersal found in the biome, namely anemochory, barochory, and zoochory. This ensured that the Cerrado's ecological diversity was incorporated into the experience from the outset. Collection was performed with pruning tools attached to telescopic poles, kraft paper bags, and personal protective equipment. Technical guidance was provided on identifying seed trees, determining the ideal collection stage, and handling the material appropriately.

The pathway then moved from the field to the laboratory, where the seeds were processed according to the characteristics of each species. Winged seeds from yellow trumpet trees and jacarandas were manually sorted and cleaned; the dry fruits of jatobá and fava-de-bolota were opened, and their seeds were subjected to mechanical scarification with 80-grit sandpaper on the side opposite the hilum, a procedure that overcame physical seed dormancy and enabled germination; and the fleshy fruits of Cerrado cashew and cagaita were processed by manually separating the pulp. Each dormancy-breaking technique was preceded by a discussion of the biological mechanisms underlying it, ensuring that the technical procedure was not performed mechanically, but understood in terms of its ecological rationale.

Sowing was performed in the educational nursery using containers filled with a substrate composed of 70% commercial growing medium, 30% sieved Cerrado soil, and 100 g of magnesium thermophosphate per 10 L, at a depth equivalent to 1.5 times the diameter of each seed. The substrate composition was determined jointly with the students following a discussion of the physicochemical properties of Cerrado soil, transforming a technical choice into an opportunity for the collective construction of knowledge. Over the following weeks, students monitored seedling emergence, observed the operation of the sprinkler irrigation system, tracked seedling development, and conducted preventive phytosanitary management using a neem (*Azadirachta indica*) solution at 10 g/L. As an assessment instrument, each student prepared an individual photographic report documenting the principal pests and diseases identified in the seedlings and their respective control methods. This technical output replaced the conventional written examination and required systematic observation, accurate documentation, and analytical ability. In parallel with seedling production, a seed bank was established, and some of the seedlings produced were donated to the community, giving the projects a concrete extension dimension, the impacts of which are detailed in Section 3.4.

The Projeto Semente project, conducted from April to August 2024, drew on the technical knowledge developed in the preceding project and repositioned it as a starting point for entrepreneurial education. The activities were organized into six weekly sessions totaling 24 hours and began with a participatory survey of the local seedling market in Formoso do Araguaia through visits to commercial establishments in the municipality. Students then revisited seedling-production techniques, emphasizing commercial quality criteria such as standard height, leaf vigor, and root systems. They were organized into nine groups of three to four members to develop business plans for producing and marketing native seedlings. Each plan included a business description, a market analysis surveying competitors and local prices, a cost structure, revenue projections, and a sales strategy. The groups concluded the project by presenting their plans in five-minute pitches assessed with a four-criterion rubric totaling ten points. The

pathway concluded with participation in a scientific event organized by IFTO, at which the scholarship students presented two scientific posters and an oral communication synthesizing the project results.

LEARNING-MONITORING STRATEGIES

Learning assessment in both projects was designed as a continuous, multimodal process integrated into the pedagogical activities themselves. Hoffmann (2014) refers to this as mediating assessment: assessment that does not interrupt the learning process to measure it, but accompanies it from within, identifying progress, difficulties, and opportunities for deeper learning in real time. Four complementary assessment instruments were used, each activating different competencies and providing the coordinator with a different perspective on student learning.

A ten-question multiple-choice diagnostic questionnaire was administered immediately before and after the lecture-based classes in each project, making it possible to identify students' prior knowledge, verify their understanding of the content covered, and guide any necessary adjustments to the subsequent practical activities. Direct observation, documented in field journals by the coordinator and scholarship students, accompanied every session and recorded participation, the quality of interactions, progressive mastery of technical procedures, and moments of difficulty requiring specific attention. The student outputs, comprising the individual photographic report in *Cerrado em Foco* and the group business plan in *Projeto Semente*, constituted the most complex assessment instruments because they required knowledge integration, technical decision-making, and communication skills. Finally, attendance sheets completed at every session provided a quantitative indicator of engagement over time, revealing the consistency of participation as objective evidence of students' involvement in the pedagogical proposal.

SYSTEMATIZATION OF THE EXPERIENCE

This chapter was prepared through the reflective systematization of information produced over the course of the two projects, a procedure characteristic of pedagogical experience reports in the field of

education (Mussi; Flores; Almeida, 2021). The sources used in constructing the analysis were the projects' Electronic Information System (Sistema Eletrônico de Informações, SEI) case files, which include work plans, financial-execution reports, and administrative records; the diagnostic questionnaires administered before and after the lecture-based classes; the photographic reports prepared by students during phytosanitary monitoring; the business plans developed by the nine groups in Projeto Semente; the photographic records produced during field and nursery activities; the extended abstracts published in the Proceedings of the VI Integra IFTO (2024); and the observations documented in field journals by the coordinator and scholarship students.

These sources were analyzed according to an interpretive framework guided by two central questions: What did the students learn throughout the pedagogical pathway, and how did the structure of the projects contribute to this learning? This dual perspective, addressing both educational outcomes and the pedagogical design that made them possible, distinguishes an experience report from a simple description of activities and also justifies its contribution to the literature on pedagogical practices in Vocational and Technological Education. The data were not treated statistically. They were interpreted in light of the literature on active methodologies, experiential learning, agroecology as an educational practice, and the integration of teaching, research, and extension, with the aim of extracting from the records of the experience their implications for Agricultural Sciences Education and technical education in threatened biomes.

RESULTS AND DISCUSSION

NATIVE-SEEDLING PRODUCTION AS AN ORGANIZING AXIS OF LEARNING

The projects deliberately began in the field rather than in the classroom. Before undertaking any nursery activity, students were taken to natural areas on and around the campus to identify, collect, and process seeds from the six selected species, presented with their scientific names in Section 2.4. This pedagogical choice was not arbitrary. By beginning the educational pathway through direct recognition of

the biome, the Cerrado em Foco project established from the outset a concrete relationship between students and the territory in which they live, making the Cerrado not merely an object of study, but a subject of pedagogical practice. Freire (2014) identifies this condition as the point of departure for genuinely problem-posing education.

Collection activities required the progressive mastery of different technical procedures for each species according to their respective dispersal methods. Winged yellow trumpet tree and jacaranda seeds were collected using pruning tools attached to telescopic poles and placed in kraft paper bags; the dry fruits of jatobá and fava-de-bolota required manual opening and sorting; and the fleshy fruits of Cerrado cashew and cagaita required pulp separation and immediate processing to prevent fermentation. This mosaic of procedures, applied to species with different reproductive strategies, functioned as an implicit curriculum on the Cerrado's biological diversity. By handling each species according to its specific characteristics, students internalized principles of reproductive ecology that would be difficult to convey with equal effectiveness in an exclusively theoretical environment. In their investigation of pedagogical interventions with upper-secondary students that combined field classes and an educational nursery containing native species, Rodrigues et al. (2024) found that seed-collection and nursery-maintenance activities encouraged student cooperation, promoted practical learning and social interaction, and stimulated reflection on the importance of local flora to environmental conservation. These findings are consistent with the engagement observed during the Cerrado em Foco field activities. Figure 1 documents this initial pathway, from supervised field collection to manual laboratory processing, and clearly illustrates the experiential nature of the adopted approach.

Figure 1

A: Students collecting seeds in a campus field area; B: collection of jacaranda seeds using a pole pruner with a telescopic handle; C: students manually processing seeds from native Cerrado species; D: Cerrado cashew (Anacardium humile) seeds after processing; E: jatobá (Hymenaea courbaril) seeds after processing, showing the diversity of species collected. Cerrado em Foco Project, IFTO, 2023.



Source: Prepared by the author.

Within this pathway, the dormancy-breaking stage constituted the most conceptually demanding moment. By applying mechanical scarification with 80-grit sandpaper to the region opposite the hilum of jatobá and fava-de-bolota seeds, students did more than perform a technical procedure. Through the act itself, they came to understand the evolutionary protection mechanisms that prevent premature germination and their relevance to large-scale seedling production. This understanding has direct

implications for ecological-restoration programs because the prevalence of seeds with physical dormancy among woody Cerrado species represents one of the principal technical bottlenecks limiting the expansion of production nurseries (Pilon et al., 2023). By experiencing the procedure and understanding its rationale, students developed one of the most critical competencies required by the ecological-restoration sector in Matopiba.

The images show not only the performance of technical procedures, but also students' engagement with the biological material: their body positioning when collecting with the pole pruner, their attention while separating seeds at the workbench, and their careful handling of the fruits. This record extends beyond the mere documentation of an activity; it constitutes evidence that learning took place in a real setting, with real instruments and consequences that the students themselves could verify. Da Silva, Lima, and Pontes (2023) argue that approaches centered on students' actions as active agents in the learning process, in conjunction with Rogers's humanistic perspective, Freire's emancipatory perspective, and Ausubel's theory of meaningful learning, foster comprehensive education in which the development of technical competencies and agency in decision-making are inseparably constructed.

THE EDUCATIONAL NURSERY AS A SPACE FOR AGROECOLOGICAL EDUCATION

As students moved from the field to the nursery, their pathway gained continuity and greater technical depth. The growing-medium formulation, decided collectively with the students based on discussions of the physicochemical characteristics of Cerrado soil, as described in Section 2.4, exemplifies how the nursery functioned not as a space for following predetermined instructions, but as a laboratory for technical decision-making in which every choice was preceded by an understanding of its agronomic and ecological rationale. Over eleven weekly sessions, students monitored seedling emergence and the operation of the sprinkler irrigation system, photographically identified and documented evidence of pest and disease attacks, and applied a neem (*Azadirachta indica*) solution at 10 g/L as a preventive phytosanitary measure.

Phytosanitary monitoring deserves particular attention as a pedagogical instrument. Preparing individual photographic reports documenting the main pests and diseases identified in the seedlings and their respective control methods required systematic observation, accurate documentation, and synthesis, competencies that form the basis of field agronomy. By replacing the conventional written examination with an original technical product, this assessment instrument transformed assessment into an extension of learning rather than an interruption of it. In their investigation of pedagogical interventions with upper-secondary students in an educational nursery containing native Caatinga species, Rodrigues, Santana, and Silveira (2024) found that seedling-production and care activities encouraged cooperation among students, promoted social interaction, and stimulated reflection on the importance of local flora. They also demonstrate that combining theory and practice strengthens students' relationship with the environment in which they live. A similar outcome was observed at the Formoso do Araguaia Campus, where the collective maintenance of the nursery over several months fostered a sense of shared responsibility for the living organisms under the students' care.

By the conclusion of the two projects, the nursery had produced approximately 1,350 seedlings: 750 during the Cerrado em Foco project and 600 during Projeto Semente. Although the initial target of 1,600 seedlings for the first project was not fully achieved because of natural losses during germination, an expected outcome in an educational nursery managed by students undergoing training, the volume produced represented a substantial result. More important than the absolute number, however, was the fact that every seedling produced passed through every stage of the process under the students' direct supervision: from seed to container, from growing medium to irrigation, and from germination to the stage at which it was ready for planting. This vertical integration of the production process is precisely what distinguishes an educational nursery from a commercial one and also what makes it pedagogically irreplaceable.

Figure 2 documents this learning environment at different points in time: rows of seedlings at different developmental stages beneath 50% shade cloth, a scholarship student monitoring the plants,

students identifying species in an outdoor setting, and a practical class attended by the entire group.

Beyond the physical environment, the images reveal the quality of the interaction between the students and the living material: there is no passivity in their posture and no separation between those who learn and what is learned.

As documented in the images, the nursery simultaneously constitutes technical infrastructure, a space for social interaction, and a setting for the formation of professional identity. An agricultural worker who has learned to produce native seedlings in an agroecological nursery carries an understanding of their work that extends beyond crop yields.

In parallel with seedling production, a seed bank containing seeds from the six species studied was established in the campus agricultural laboratory and stored in suitable containers for future teaching, research, and extension activities. From an ecological standpoint, this outcome transcends the immediate pedagogical experience. The *ex situ* conservation of genetic material from native Cerrado species represents a concrete contribution to the strategy of maintaining the biome's genetic diversity, which Brancalion, Rodrigues, and Gandolfi (2015) recognize as a fundamental component of modern ecological-restoration programs. The use of native species as the central focus of the activities also enhanced students' understanding of the importance of conserving the biome, an outcome consistent with the findings of Rodrigues, Silva, and Oliveira (2024), who identified a significant increase in critical environmental awareness among students participating in school nurseries containing native Cerrado species.

Figure 2

A: Educational nursery at the Formoso do Araguaia Campus containing native Cerrado seedlings at different developmental stages; B: scholarship student monitoring and maintaining seedlings in the nursery; C: students participating in a practical activity involving the identification and management of native Cerrado plants on campus; D: practical class with students from the Technical Program in Agriculture, integrating theory and fieldwork. Projeto Semente, IFTO, 2024.



Source: Prepared by the author.

From this perspective, agroecology was not merely content that was taught; it was the rationale guiding every decision in the process: the selection of species based on their ecological representativeness, the growing medium incorporating local soil, and the neem solution as a low-environmental-impact phytosanitary alternative. Marchetti et al. (2023) emphasize that agroecology,

understood as a science, political movement, and social practice, connects ecological, economic, and social dimensions within an educational model that overcomes the dichotomy between productivist technique and environmental awareness.

FROM TECHNICAL EDUCATION TO SUSTAINABLE ENTREPRENEURSHIP

While the Cerrado em Foco project built students' technical knowledge base, Projeto Semente transformed that knowledge into the raw material for a higher-order form of learning: understanding that technical expertise has economic value, that this value can be organized, and that organizing it can contribute to the development of the territory. This transition from seedling producer to seedling entrepreneur was not trivial in a context in which agricultural technical education frequently limits its horizons to the farm gate.

The experience began with a participatory survey of the local seedling market in Formoso do Araguaia, conducted by the students themselves through visits to commercial establishments in the municipality. The result was revealing: the absence of local suppliers of native and ornamental seedlings forced the municipality to depend on suppliers from Brazil's Central-West and Southeast regions, increasing the cost of urban tree-planting and environmental-restoration projects. For the students, this finding transformed what might otherwise have been an academic exercise into a diagnosis grounded in reality: the technique they had learned responded to an existing, measurable demand in the place where they lived. This progression from territorial diagnosis to entrepreneurial proposal is aligned with the guidelines governing comprehensive education in the Federal Network of Vocational and Technological Education, which emphasize educating young people who are capable of identifying opportunities and transforming knowledge into concrete productive initiatives rooted in the territory (Brasil, 2008).

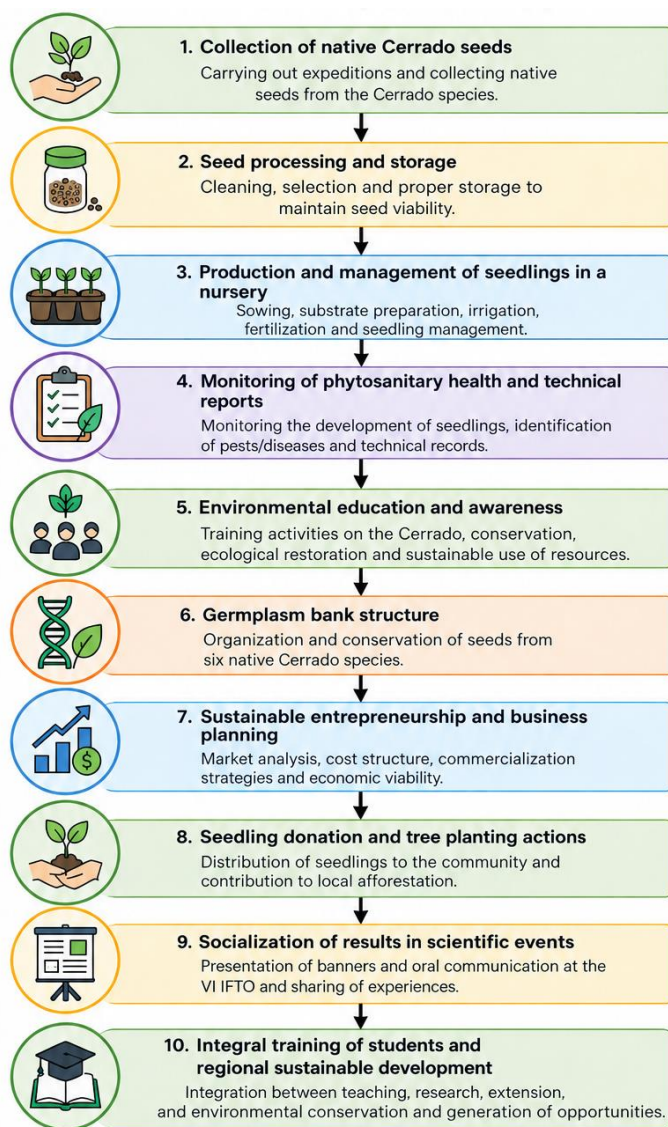
Based on this diagnosis, students were organized into nine groups of three to four members to prepare business plans for producing and marketing native Cerrado seedlings. Each group prepared market analyses surveying competitors and local prices, cost structures, revenue projections, pricing

strategies, and promotional plans, including the creation of a simulated social media post. The presentation of the plans as five-minute pitches, evaluated using a four-criterion rubric totaling ten points, completed the educational cycle. The students who had collected seeds in the field eight months earlier were now defending before a panel the economic viability of a sustainable business based on those same seeds. This narrative arc represents the pedagogical synthesis that Paiva and Aguiar (2023) describe as the integration of traditional knowledge, production techniques, and entrepreneurship: a process in which empirical knowledge of the territory is integrated with formal learning and generates new possibilities for sustainable economic participation.

Figure 3 graphically represents what the results narrate in textual form: a progressive and integrated pedagogical pathway guided by a clear internal logic, extending from the seed to the seedling, from the seedling to the market, and from the market to the territory. The figure demonstrates, and the project narrative confirms, that none of the illustrated stages could have been eliminated without compromising the stages that followed: entrepreneurship would have been meaningless without technical mastery, while technical mastery would have lacked direction without entrepreneurship. This interdependence among the educational axes is precisely what distinguishes the experience reported here from isolated school-garden or entrepreneurship-fair initiatives. Together, the two projects formed a coherent and replicable pedagogical pathway.

Figure 3

Pedagogical pathway adopted in the Cerrado em Foco and Projeto Semente projects, showing the integration of agroecological education, technical education, sustainable entrepreneurship, and extension activities developed with students from the Technical Program in Agriculture at the IFTO Formoso do Araguaia Campus.



Source: Prepared by the author.

The quality of the work presented by the nine groups revealed something that the numerical results alone cannot capture: the students not only mastered the technical tools required to prepare a business plan, but also developed the ability to connect those tools to the productive and environmental realities of the Cerrado. By conceptualizing native-seedling production not only as an ecological practice but also as a viable business, they simultaneously developed intellectual autonomy, synthesis skills, and a

sense of territorial responsibility. According to Da Silva, Lima, and Pontes (2023), these competencies are characteristic of comprehensive educational models in which students are recognized as protagonists of their own educational pathways. In this sense, Projeto Semente was not merely an extension of Cerrado em Foco; it was its logical consequence, the point at which environmental conservation encountered the economy and the young technical student discovered their potential to become an agent of territorial transformation.

IMPACTS OF THE EXPERIENCE ON THE COMMUNITY AND STUDENT EDUCATION

The projects directly involved students from the Technical Program in Agriculture at the Formoso do Araguaia Campus, with the levels of participation described in Section 2.2 sustained throughout the implementation period from September 2023 to August 2024, indicating continuous rather than sporadic engagement. Attendance sheets completed at all sessions and diagnostic questionnaires administered before and after the lecture-based classes documented this involvement as an ongoing process, making it possible to monitor changes in participation and learning over time.

As detailed in Section 3.2, a significant proportion of the 1,350 seedlings produced was donated to rural producers, residents of the urban area of Formoso do Araguaia, and communities in neighboring municipalities, directly contributing to urban tree-planting initiatives and the restoration of degraded areas in the region. Another portion was planted on the campus itself, enabling students to see the concrete results of their work. This aspect was pedagogically relevant because seeing the plants they had produced grow strengthened their sense of competence and belonging within the territory. The seedlings donated to the community extended the initiative's reach beyond the campus, transforming a teaching activity into an extension initiative with a verifiable environmental impact in the municipality with the largest land area in Tocantins.

The establishment of the seed bank containing seeds from the six species studied represents a long-term legacy that transcends the projects from which it originated. Stored in airtight containers in the

campus agricultural laboratory, this collection of local genetic material will remain available for future teaching, research, and extension activities, ensuring the continuity of the pedagogical approach independently of institutional funding cycles. Strictly speaking, this constitutes an applied-research outcome embedded within a teaching project, accurately illustrating the potential to integrate the academic functions of the Federal Institutes when teaching projects are designed with ambitions extending beyond the classroom.

The most visible manifestation of this integration was participation in the VI Integra IFTO (2024), the institution's teaching, research, and extension seminar, at which the scholarship students presented two scientific posters and one oral communication. Preparing the posters required students to synthesize the process they had experienced over the previous eight months: selecting data, organizing results, constructing arguments, and presenting them publicly to an audience of researchers and instructors. In their analysis of the participation of students enrolled in an integrated technical program in a scientific initiation project involving the public presentation of results, Almeida et al. (2026) identified substantial gains in investigative, collaborative, and scientific-communication competencies, as well as motivation, personal satisfaction, and a stronger social commitment to the knowledge produced. Participation in the VI Integra IFTO fulfilled precisely this function: it concluded the educational cycle by transforming students from performers of activities into communicators of the knowledge they had produced, a change in position with lasting effects on self-confidence and professional identity.

Taken together, the results of the two projects demonstrate that using native Cerrado seedling production as the organizing axis of pedagogical practices fostered an educational experience that extended far beyond the acquisition of technical competencies. The progressive integration of agroecological education, active methodologies, sustainable entrepreneurship, and community-extension activities enabled students to develop knowledge, skills, and attitudes aligned with the contemporary demands of Vocational and Technological Education and with the central objective of this chapter: to report on and analyze an integrated pedagogical experience capable of connecting environmental

conservation and regional development within a single educational pathway. The pathway that began with seed collection on the banks of the Araguaia River and concluded with a scientific presentation at the VI Integra IFTO demonstrates that this integration is not merely possible: it is replicable, documentable, and necessary.

CONCLUSION

The Cerrado em Foco and Projeto Semente projects demonstrated that progressively integrating ecological restoration, native-seedling production, and sustainable entrepreneurship constitutes a robust and replicable pedagogical approach to vocational education in threatened biomes. The projects' intentional sequence, extending from technical and ecological learning to a territorially grounded entrepreneurial perspective, proved to be an organizing condition for the progressive construction of competencies connecting technical proficiency, environmental awareness, and the capacity for economic intervention within the territory.

The concrete outcomes achieved, namely the production of native seedlings, the establishment of a germplasm bank containing six Cerrado species, the preparation of nine business plans, the donation of seedlings to the community, and the presentation of papers at a scientific event, demonstrate that active methodologies, when integrated into a coherent and sequential pedagogical pathway, foster student agency and strengthen the organic integration of teaching, research, and extension, moving beyond institutional rhetoric to materialize as documented pedagogical practice.

The experience reinforces the strategic role of the Federal Institutes as spaces connecting technical education, environmental conservation, and regional socioeconomic development. In a context in which the Cerrado lost 40.5 million hectares over four decades, educating young people capable of reconciling production, ecological restoration, and income generation constitutes not only a pedagogical choice, but also a strategic necessity for the sustainable development of the territory. Nevertheless, the limitations inherent in this report must be acknowledged: the absence of a control group precludes causal claims

concerning the isolated effects of the approach; learning data were interpreted qualitatively, without the use of validated psychometric instruments; and the experience took place within a specific institutional context where nursery infrastructure and institutional funding were available, requiring caution when directly transferring the model to other contexts. Future studies could investigate the approach's replicability on campuses with less infrastructure, examine its long-term effects on graduates' professional trajectories, and develop validated instruments for assessing agroecological competencies in Vocational and Technological Education settings. Instructors and administrators at other Federal Institutes are advised to begin the adoption of similar pedagogical pathways by mapping locally relevant native species and concrete territorial demands, conditions that served as the starting point for the entire educational process in this experience.

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