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ACTIVE LEARNING AND ENTREPRENEURIAL EDUCATION FOR A SUSTAINABLE ANALAND[1]

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Abstract: The article presents the execution of the Sustainable Analândia Integrator Project. This project used the "Project-Based Learning" (PBL) teaching method with the application of Objectives 3 (health and well-being), 6 (drinking water and sanitation) and 12 (responsible consumption and production) of the Sustainable Development Goal (UN SDGs). The students were asked to learn about the problem, define the problem, research solutions and present the solution within the context of rural basic sanitation in the city of Analândia. As a result, the students chose, based on technical, socioeconomic and environmental factors, the implementation of a biodigester septic tank on a rural property in the city of Analândia. Therefore, it is concluded that the use of PBL brought benefits to the training of students and the community of Analândia.
Keywords: Integrative Project, Problem-Based Learning, rural basic sanitation, rural sewage treatment, biodigester septic tank, sustainability.

INTRODUCTION

The municipality of Analândia, in the State of São Paulo, with an area of 325.93 km2 and an estimated population of 5115 people in 2021, is located in an environmental protection area (APA), on the perimeter of Corumbataí. According to data from the United Nations Development Program (UNDP) from 2010, the Municipal Human Development Index (IDHM) of Analândia is 0.754, within the "high" classification, and close to the average of 0.783 for the state of São Paulo (UN, 2010). Considered a climatic resort, it has a remarkable landscape area, with springs that are still well preserved and numerous watercourses (FERNANDES, 1994; FERREIRA, 2005). The region has great potential for growth in relation to geotourism. According to Valente (2001), the Corumbataí River Basin has regional importance for water supply, in terms of quality and quantity. Furthermore, there is constant concern about the level of deforestation and pollution in springs, which is one of the factors that most affects the region's biodiversity.

Based on the understanding of entrepreneurship ecosystems in teaching and students as actors in the training process, the Analândia Sustainable project applied the Entrepreneurial Education (EE) and Project-Based Learning (PBL) methodologies. It thus sought to introduce maker culture, transdisciplinarity and the teaching of innovation and entrepreneurship in Undergraduate courses in Mechanical and Civil Engineering (FAYOLLE, 2001).

The project introduced educational methods to encourage students to work in multidisciplinary teams, to have the ability to learn, identify, model and solve problems (BOULD, FELETTI,1999), to have knowledge of the relevant legislation and to adapt to new and complex situations, such as, for example, sizing and integrating physical, human and financial resources aiming for continuous improvements (ESCRIVÃO FILHO, RIBEIRO, 2009). In addition to designing or improving systems and processes taking into consideration, the communities involved, it was based on the four pillars of UNESCO that underpin 21st century learning: knowing how to be, knowing how to live together, knowing how to know and knowing how to do (DELORS, 2012).

1 In this context, the general objective of this work was to carry out a preliminary survey of secondary data (IBGE, cartographic bases, rural production, river basins, especially the Corumbataí River Basin and its sub-basins), emphasizing its vocation for ecotourism, with the following specific objectives: i. characterize the basin and its sub-basins using landscape ecology indices; ii. map existing and potential

geological attractions in the region in order to guide ecotourism planning in the upper Corumbataí river basin region, in addition to supporting the sustainable management of regional geotourism; iii. expand the skills and professional attitudes desirable for the practice of engineering and iv. develop practical activities to solve complex problems with multidisciplinary teams with students.

METHODOLOGY

This section presents a description of the Sustainable Analândia Integrator Project, its objectives, methodologies, the challenges of implementing solutions, and student evaluation in the year 2022, highlighting the work development stages carried out in the second semester by Civil Engineering students - Aeronautics. The project incorporated concepts from the subjects Notions of Law (HUM-20), Sustainability of Manufacturing Processes (MTP-46) and Construction Planning and Management (EDI-48) from the Undergraduate courses in Mechanical-Aeronautical Engineering (MEC) and Civil -Aeronautics (CIVIL), whose objective was to integrate knowledge from different areas in resolving a problem situation related to Sustainable Analândia through the challenge "Incorporate technological and sustainable innovations as a local development strategy and reduce the impact imposed on the environment." The solutions focused on challenges related to water and sanitation and were guided by Sustainable Development Goals 3, 6 and 12 (SDGs) and the United Nations (UN) 2030 Agenda, as shown in Figure 1. Finally, the project integrated multidisciplinary knowledge to outline local development strategies in the municipality of Analândia-SP.

Figure 1 – Sustainable Development Objectives guiding the project

Source: United Nations (UN)

APRESENTAÇÃO DO PROJETO INTEGRADOR

The "Sustainable Analândia" integrative project was based on the use of technologies applied in the areas of sustainable agriculture and ecotourism. The project sought to provide a multidisciplinary and transversal learning experience using the municipality of Analândia/SP as a space for experimentation and prototyping. The idea was to stimulate the training of citizen engineers, through the solution of real problems, with the aim of multiplying it in the context of a sustainable municipality.

The Integrator Project introduced, in 2022, the teaching method known as "Project-Based Learning" (PBL) with the application of Sustainable Development Goals 3, 6 and 12 (SDG). The introduced PBL method provided students with the understanding of contextualized scenarios to face situations that are part of everyday life and their future professional career (ESCRIVÃO FILHO, RIBEIRO, 2009). The project involved 22 students from Mechanical-Aeronautical Engineering (MEC) and 8 students from Civil-Aeronautical Engineering (CIVIL), managed by three professors from three different divisions: Fundamental Sciences, Mechanical Engineering and Civil Engineering. The integrative project involved a mentor, four workshops, two speakers and thirty students, and was structured as follows: (1) six groups with a maximum of five people were organized; (2) the challenge focused on the

theme of Sustainability was presented and (3) the groups were enrolled in the same subjects with partial integration of content. Table 1 shows the scope of the Integrator Project, which resulted in thirty students working on six projects, with each project involving at least four students.

Class	Number of students involved	Number of projects
MEC	22	04
CIVIL	08	02

Table 1 – Quantitative information about the scope of the Project.

Fonte: Autores

In the first semester, Mechanical-Aeronautical Engineering students worked on 4 axes: i. water; ii tourism; iii. rural production and iv. environmental education taking into consideration, resource management (sustainable use), sustainable processes aimed at agriculture or ecotourism. After collecting secondary data for the maintenance of natural and cultural attractions, it was observed the need for greater commitment to the management, conservation and sustainability of spring spaces and with the potential for exploring ecotourism through the effective participation of local rural communities with the aim of increasing the source of income for the population of Analândia. Furthermore, they highlighted infrastructure deficiencies, such as the lack of basic sanitation in rural areas.

In the second semester, seeking to address the issue of improving basic sanitation, Civil-Aeronautical Engineering students and teachers defined rural environmental planning as their scope and began developing the project in partnership with the city of Analândia with the aim of proposing technical solutions and socioeconomic aspects of sanitation in these regions, specifically on the topic of rural sewage treatment. The methodology included carrying out technical visits, meetings with residents and the administration of Analândia, the formation of partnerships with bodies such as Embrapa, incorporation of the rural sewage treatment solution on a rural property in Analândia, the development of a questionnaire applied to rural residents, and planning for the future of the project. The scope of this work is to analyze the solutions found in the second semester.

ACTIVITIES CARRIED OUT IN THE INTEGRATOR PROJECT

The project aimed to outline economic, technological and sustainable alternatives for the municipality of Analândia, based on the use of natural and historical-cultural resources found in the region. The idea was to explore some business modalities and/or technologies ranging from ecotourism to the use of technological tools from the perspective of Bioeconomy/Biotechnology and sustainable development. Table 1 presents a description of the stages of the learning cycle carried out in the Integrator Project, in which students learned about and defined the problem, moving on to research and present solutions.

The activities in relation to rural environmental planning, carried out in the second semester, were carried out by the groups and divided into three work stages:

i) Socio-territorial context of the municipality of Analândia and legal mapping for the project's viability: the groups identified the legal restrictions and technical standards applicable to the project; defined the type of sewage treatment based on technical data on the population, region and technology, seeking a sustainable nature. The groups evaluated ways of implementing rural sanitation, interviewed and participated in workshops with community

Steps	Goal	Activity	Requirement
1ª Step	Know the problem	Presentation of the challenges of the municipality of Analândia (MEC/CIVIL classes).	Secondary data collection (IBGE, cartographic bases, rural production, river basins, among others)
2ª Step	Define the problem	Identification of active and passive stakeholders and study of scenarios for rural sanitation.	Presentation of the project to the community, technical visits, interviews with residents, mayor and mayor
3ª Step	Search for solutions	Mentoring, workshops and events focused on the themes of the challenge.	Define requirements, functions and legal limitations for rural environmental planning
4ª Step	Present the solution	Integration of areas guided by teachers and mentors with actions, partnerships and sustainable solutions to Rural Environmental Planning	Bring a technical and/or business solution with the installation of a biodigester septic tank in Analândia

Table 1 – Description of the stages of the learning cycle

Source: Authors

CRITERIA ADOPTED	CHARACTERISTICS OF THE CHOSEN PROPERTY
Slope	The chosen property has a negative slope between the initial point of installation of the septic tank and the final point. This contributes to more efficient operation, facilitating the conduction of liquids between the boxes and consequently in downstream systems.
Effluent to the orchard	The effluents produced by the septic tank are odorless and can be used as fertilizer. On the property where the septic tank will be implemented, there is an orchard very close to the installation point and, therefore, it can be seen that such effluents can be used in the operation of part of the orchard and thus saving resources and time in management.
Resident interest	The owner showed interest in carrying out the biodigestion pit installation project and also demonstrated proactivity in offering to create the holes where the three boxes will be installed. It is in accordance with the steps necessary to create the project: fundraising, implementation, environmental education and necessary system maintenance.
Regulation	The chosen property complies with all tax and regulatory obligations, eliminating the possibility of future complications in this regard.

Table 2 - Description of the criteria adopted to choose the property

Source: Entrepreneurial Education project file (Group 2)

STEPS	ACTIVITIES
Preparing the boxes	With the help of drills and hole saws, holes are made in the boxes that will receive the pipes.
Excavation	3 circular holes must be dug 50 cm apart
Settlement	The bottoms of the holes must be manually compacted in order to seat the boxes, respecting an edge of 10 cm above ground level.
Connection of Boxes; Preparation of the two fermentation modules Preparation of the collector module Seal Protection of the pit area	The boxes must be connected by PVC pipes, which must be previously prepared with the help of a saw and must be sealed and protected.
Septic tank activation	The first box must be loaded with a mixture of 20 liters of water and manure in a 1:1 ratio. Bacteria contribute to the biodigestion of organic matter, thus carrying out the sewage treatment process.
Maintenance	The biodigester septic tank requires easy maintenance, which consists of a monthly supply with a mixture of 5 liters of cattle manure and 5 liters of water. Before insertion into the pit, it is important to mix these items so that the solution is diluted. Insertion is carried out through the maintenance valve without the need to lift the pit lid.

Table 3 - Implementation and maintenance project phases

Source: Embrapa Instrumentation, 2017

representatives (Mayor and Municipal Secretaries, residents of the municipality of Analândia/SP, Secretary of the Environment of São Carlos/SP, team from the PCJ Consortium - the Intermunicipal Consortium of the Piracicaba, Capivari and Jundiaí River Basins);

ii) Minimum detailing of solutions within the scope of the disciplines involved. The groups of students presented technical details of solutions within the scope of founding a sewage treatment plant, such as the treatment stages, technologies used, estimated location and area of implementation, treatment potential and waste generated. Furthermore, the groups provided a proposal for the use of solid, liquid and gaseous waste during sewage treatment;

iii) Implementation of the sewage treatment solution and training of residents.

Aiming at the effectiveness and viability of the solutions, data collection processes, benchmarking research, mentoring and interviews with local stakeholders were carried out. During the development of the project, 3 main problems were identified: springs, accelerated soil erosion and rural sanitation. Due to the considerable difficulties and barriers of financial resources, types of spheres that act or can act on each type of problem, the focus of the projects chosen by the groups was rural environmental planning. The resolution of the problems covered the themes of agricultural technology, value chains and sustainability, in accordance with the Master Plan of the municipality of Analândia (BRASIL, 2006). Figure 2 records the 1st technical visit by the students who learned about and defined the problem, based on the meeting with local stakeholders.

Figure 2 - Photo of the 1st technical visit to Analândia carried out by ITA students and teachers.

Source: Entrepreneurial Education project archive

STUDY OF THE SOLUTION FOR RURAL SEWAGE TREATMENT

According to a report by the National Rural Learning Service (SENAR, 2019), basic sanitation is the set of initiatives or actions that aim to ensure people's health, through sanitary sewage systems, water supply and waste disposal. (solid waste), which avoid environmental pollution.

The main technical factors for choosing an appropriate sewage treatment system are: type of sewage, number of people served, available area, current legislation, among other factors. Social, environmental and economic issues also influence the decision. Therefore, two groups were created: the first used a more technical approach, while the second focused on a socioeconomic approach to the impacts of this solution. To assist with the social issues of implementing the solution, the students presented the solution focused on rural sewage treatment with stakeholders from Analândia. At the end of each of the two presentations, the floor was given to the stakeholders who presented their respective feedback, among which we highlight: i. that the social acceptance of the solution by rural owners depends on external investment, given that they have no interest in investing

their own capital, ii. the maintenance of the solution must be simple, so that it is viable and durable, iii. rural producers would possibly accept to participate in a prototype as long as there were no costs involved. After previously studying the technical issues and meeting with stakeholders, the students developed a solution proposal in the technical and socioeconomic areas with the support of EMBRAPA, which culminated in the implementation of rural sewage treatment on a property in the municipality of Analândia.

STUDENT ASSESSMENT AND FEEDBACK PROCESS

The student evaluation process consisted of three mandatory stages: i) oral presentation in the first two months; ii) oral presentation and written work in the second two months; iii) oral presentation and written work in the exam. In the first two months, the content requirements were related to the collection of relevant data and preliminary proposals for solutions to the problem presented. In the second two months, the students' content requirement was to present a minimum detail of the solution adopted. Finally, in the exam, students presented their final work after studying for the semester. After each stage, students received feedback from teachers and tutors on what was presented during the assessment period in order to continually improve the work carried out.

Regarding the evaluation criteria for the oral presentation stages, students were evaluated on the following aspects: relevance of the topics presented, knowledge of what was presented, connection of the presentation, quality of information sources and proper use of presentation time. With regard to the criteria for the written work, the main points evaluated were: introduction covering the general overview of the topic, definition of problems and needs, presentation of technical and legal solutions, conclusions of the work and quality bibliographic references used.

After the end of the semester, a meeting was held with the students so that they could evaluate how the Integrator Project was carried out by the teachers, in which the students evaluated the workload, the scope of the work, support for developing the work and distribution of activities.

RESULTS AND DISCUSSION

PROPOSED AND IMPLEMENTED SOLUTION FOR RURAL SEWAGE TREATMENT

The technical, socioeconomic and environmental survey carried out by the students resulted in the choice of a solution created by Embrapa Instrumentation (Embrapa, 2017): the Biodigester Septic Tank. The Biodigester Septic Tank, developed by Embrapa Instrumentation (2017), is an anaerobic biodigestion system that aims to replace rudimentary septic tanks, potential contaminants of the soil and groundwater that are widely used on rural properties that do not have access to basic sanitation. adequate. The system has the advantages of treating sanitary sewage efficiently and at low cost for rural producers, in addition to producing effluent that can be used as high-quality fertilizer in agriculture. The Biodigester Septic Tank only treats sewage from the toilet (human feces and urine), and no other waste can be incorporated into it. "Black waters", if released inappropriately, cause environmental impacts and the spread of water-borne diseases.

After interviews with stakeholders, in particular with the Mayor of Analândia, 5 candidate properties were chosen for the implementation of the Biodigester septic tank system and received technical visits. Four of these properties failed some technical requirement or were not favorable to the

selection criteria. The chosen property proved to be the best considering the choice criteria, which were discretized in Table 2, prepared by the group responsible for the socioeconomic approach with the support of the group responsible for the technical part of the project.

The property chosen for implementing the solution was the ``Orquidário Tico e Teco`` property, located on Estrada Orlando Tendolini KM 2.5, Analândia - SP, 13550-000. The view of the property is represented in figure 3.

Figure 3 – Technical visit 18.11.22 at the rural property

Source: Entrepreneurial Education project archive

Defined the location and necessary materials. The implementation was separated into stages, using as a reference the Descriptive Memorandum: Assembly and operation of Embrapa's biodigester septic tank, as shown in Table 3.

After the initial interview with the residents of the ``Orquidário Tico e Teco`` property, a date was set for demarcating the ditch where the water tanks were located (11/18) and another for the placement and installation of the biodigester septic tank (11/25), (Figure 4).

Figure 4 – Installation of the biodigester septic tank.

Source: Entrepreneurial Education project archive

STUDENT ASSESSMENT AND FEEDBACK

During the mandatory assessment stages, in relation to the oral presentation, it was mainly noted that students improved in approaching the importance of the topic presented, defining the problem and detailing the solutions presented. This evolution was achieved by students due to the PBL method, as students had great interest and motivation in how to apply the method when dealing with real problems, and also access to feedback from teachers and tutors with regular meetings, and, through observations, sought a more in-depth approach to the topics raised in the meetings. With regard to the written presentation, the evolution observed was similar to what occurred in the oral presentations, highlighting, mainly, the importance of the theme and definition of the problem. As feedback, students reported being extremely satisfied with PBL. The method and conduct of the work allowed students to observe issues little explored in other classroom methods, such as socioeconomic and environmental importance, in addition to technique, to develop solutions. As points for improvement, students had difficulty defining the initial scope of work, adapting the distribution of activities and correlation with the content of each subject, and adapting support from teachers and tutors. These issues observed by students are of great importance for better adapting activities with the PBL method in the coming years.

FINAL CONSIDERATIONS

The Sustainable Analândia Integrator Project brought benefits to students and the municipality of Analândia. Students actively participated in their own learning through the "Project-Based Learning" (PBL) teaching method with the application of Sustainable Development Goals 3, 6 and 12 (SDG), in which this participation brought knowledge of technical issues, socioeconomic and environmental issues through solving real problems. The main benefit of the municipality of Analândia was the implementation of a sustainable solution, the biodigester septic tank, in the treatment of rural sewage from a residence, so that it was relevant data for a more sustainable city.

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