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SUSTAINABILITY IN THE CURRICULUM: AN EXPERIENCE REPORT IN CIVIL ENGINEERING

SUSTENTABILIDADE NO CURRÍCULO: UM RELATO DE EXPERIÊNCIA EM ENGENHARIA CIVIL

SOSTENIBILIDAD EN EL CURRÍCULO: UN RELATO DE EXPERIENCIA EN INGENIERÍA CIVIL

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ABSTRACT

The article presents a report of experience on the application of Project-Based Learning (PBL) in the Sustainability course of the Civil Engineering program at the Federal Institute of Piauí (IFPI). With the growing environmental concern and the need for sustainable practices, training qualified professionals becomes essential, supported by public policies such as the National Policy on Environmental Education. The study analyzes how PBL was implemented, engaging students in practical activities that integrated theory and practice, promoting the development of sustainable proposals. The methodology included the instructor's observations of student performance, who demonstrated strong engagement and innovation by presenting solutions such as water reuse and solar energy. In the end, all students achieved the highest grades, highlighting the effectiveness of active methodology in promoting meaningful and practical learning, preparing them for the challenges of the job market in an increasingly demanding context regarding sustainability.

Keywords: Project-Based Learning. Sustainability. Education. Civil Engineering.

RESUMO

O artigo apresenta um relato de experiência sobre a aplicação da Aprendizagem Baseada em Projetos (ABP) na disciplina de Sustentabilidade do curso de Engenharia Civil do Instituto Federal do Piauí (IFPI). Com a crescente preocupação ambiental e a necessidade de práticas sustentáveis, a formação de profissionais capacitados se torna essencial, respaldada por políticas públicas como a Política Nacional de Educação Ambiental. O estudo analisa como a ABP foi implementada, envolvendo os alunos em atividades práticas que integraram teoria e prática, promovendo o desenvolvimento de propostas sustentáveis. A metodologia incluiu observações do docente sobre o desempenho dos alunos, que demonstraram forte engajamento e inovação ao apresentar soluções como reuso de água e energia solar. Ao final, todos os alunos alcançaram nota máxima, evidenciando a eficácia da metodologia ativa em promover um aprendizado significativo e prático, preparando-os para os desafios do mercado de trabalho em um contexto cada vez mais exigente em relação à sustentabilidade.

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Palavras-chave: Aprendizagem Baseada em Projetos. Sustentabilidade. Ensino. Engenharia Civil.

RESUMEN
El artículo presenta un relato de experiencia sobre la aplicación del Aprendizaje Basado en Proyectos (ABP) en la asignatura de Sostenibilidad del programa de Ingeniería Civil del Instituto Federal de Piauí (IFPI). Con la creciente preocupación ambiental y la necesidad de prácticas sostenibles, la formación de profesionales calificados se vuelve esencial, respaldada por políticas públicas como la Política Nacional de Educación Ambiental. El estudio analiza cómo se implementó el ABP, involucrando a los estudiantes en actividades prácticas que integraron teoría y práctica, promoviendo el desarrollo de propuestas sostenibles. La metodología incluyó observaciones del docente sobre el desempeño de los estudiantes, quienes demostraron un fuerte compromiso e innovación al presentar soluciones como la reutilización de agua y la energía solar. Al final, todos los estudiantes alcanzaron la máxima calificación, destacando la efectividad de la metodología activa en la promoción de un aprendizaje significativo y práctico, preparándolos para los desafíos del mercado laboral en un contexto cada vez más exigente en relación con la sostenibilidad.

Palabras clave: Aprendizaje Basado en Proyectos. Sostenibilidad. Educación. Ingeniería Civil.

1 INTRODUCTION

The growing concern with environmental issues and the need for sustainable practices have led educational institutions to reevaluate their pedagogical approaches. In this context, the teaching of Sustainability in the Civil Engineering course is essential to train professionals capable of facing the challenges of sustainable development. This alignment is supported by public policies, such as the National Policy for Environmental Education (PNEA), which aims to integrate environmental education at the various levels of education and foster the formation of critical citizens in relation to environmental challenges.

At the Federal Institute of Piauí (IFPI), the teaching policies of the Institutional Development Plan (PDI) 2015-2019 seek to expand the institution's operations, invest in teacher qualification, improve infrastructure and update courses. These guidelines are essential for the training of professionals committed to sustainability. In the Civil Engineering course, this is materialized through mechanisms for monitoring students, strengthening the Collegiate and the Structuring Teaching Nucleus, updating the Pedagogical Project and encouraging participation in scientific events.

However, often the curricular structures of exact sciences courses aimed at the construction market, such as Architecture and Urbanism and Civil Engineering, do not adequately address the concept of sustainability. Sustainability has been addressed in university extensions or in disciplines that focus mainly on environmental issues (QUEVEDO, 2022; SANTANA, 2016; UNIP, 2020). This issue is urgent, since civil construction is one of the sectors that generates the most air pollution and urban waste, making it necessary to transform this sector into a more sustainable area (ROCHA, 2022).

It is essential to study the teaching-learning relationships for sustainability in the courses of Architecture and Urbanism and Civil Engineering, aiming to improve the training of graduates so that they become sustainable professionals (VALOTO; ANDRADE, 2011; RABANNI et al., 2020). This paper analyzes the conception of sustainability of students in the tenth period of the Civil Engineering and Architecture and Urbanism courses in the last four years, based on observations made by professors in specific disciplines. The study seeks to understand students' perception of sustainability when entering the disciplines and the changes that occurred throughout the semester.

Students explored the importance of producing projects in areas such as Architecture and Installations, emphasizing their interactions to promote sustainability. Aspects such as material specifications, sustainable construction processes, energy efficiency and water

reuse were discussed. The intention of this article is to record the experience of the teacher and the students, observing the application of active methodologies and the evaluation process through the defense of sustainable project proposals.

The choice of this study is justified by the need to insert concepts of sustainability in the fields of study and in the market. The experience enabled the theoretical experience of the concepts learned and encouraged critical reflection on the importance of sustainability in civil construction. By developing individual projects, students were challenged to integrate acquired knowledge, preparing themselves for an increasingly demanding job market that is aware of environmental issues.

This article aims to report the experience of the Sustainability discipline in the ninth period of the Civil Engineering course at IFPI, where students already had a solid training for the practical application of projects. The course syllabus covers essential topics such as the concept of Sustainability, evaluation methods and the impact of construction on the environment. The theme is an important guideline in the Pedagogical Project of the Civil Engineering Course (PPC) and is manifested in several disciplines, such as Water Resources Management and Sustainable Constructions.

2 THEORETICAL FRAMEWORK

Sustainability has become a central concept in contemporary discussions on development, especially in the context of civil construction, one of the sectors with the greatest environmental impact. The need to train professionals who understand and integrate sustainable practices into their work is urgent, considering the challenges posed by climate change and environmental degradation. In this sense, environmental education emerges as a fundamental pillar, supported by public policies that encourage the inclusion of sustainability-related content in the curricula of undergraduate courses.

Civil Engineering training, in turn, faces significant challenges in addressing sustainable issues. Often, existing curriculum frameworks are not sufficient to provide a comprehensive understanding of sustainability. The inclusion of active methodologies in teaching, such as project-based learning, has been shown to be an effective strategy to engage students and promote more meaningful learning, allowing them to develop practical skills while discussing the importance of sustainability in their future professions.

In addition, the relationship between theory and practice is crucial for the training of engineers who are aware of their social and environmental responsibilities. Laboratory and

field practice, combined with an up-to-date and interdisciplinary curriculum, enables students not only to absorb theories, but also to apply knowledge in real situations, reflecting on the impact of their choices on the environment and society.

2.1 DEVELOPING SUSTAINABLE COMPETENCIES IN CIVIL ENGINEERING

Environmental education is essential to form critical and conscious citizens, enabling them to act for sustainability in its various dimensions. In the context of Civil Engineering, this approach is even more relevant, as professionals in this area have a significant role in the construction and maintenance of the infrastructure that sustains urban and rural life. Therefore, training in Civil Engineering must transcend the simple transmission of technical knowledge, incorporating a vision that considers the social, economic, and environmental aspects of engineering practices.

At the Federal Institute of Piauí (IFPI), the Pedagogical Project of the Civil Engineering Course (PPC) reflects this concern, establishing guidelines to integrate environmental education into the curriculum. The PPC emphasizes the training of professionals who master construction techniques, but who also understand and evaluate the impacts of their decisions on the environment and society. Thus, the guidelines promote the inclusion of disciplines that address natural resource management, energy efficiency, and sustainable building techniques.

In view of the responsibilities of the civil engineer and the interventions of the construction industry in the environment, the challenge arises to adapt teaching to better prepare graduates. As Lima (2024) states, "educational systems need to reflect, together with the world of work, the demands necessary for the qualification of these professionals." This alignment is essential to ensure that future civil engineers are able to face the challenges of sustainability and act responsibly in their projects.

The National Curriculum Guidelines (DCN) for Engineering and Architecture and Urbanism establish that these courses must train professionals committed to sustainable development, balancing the built and natural environments and acting with social and economic responsibility. The Pedagogical Projects in the HEI analyzed aim to train professionals with technical-scientific capacity and a critical and holistic view that meets the requirements of sustainability in their practices.

Lima (2024) also highlights the need to review the development paradigm focused exclusively on economic growth, emphasizing that "the pressures for results that encourage

competition and reduce opportunities for cooperation" must be reconsidered. This new perspective is crucial for curricula to offer teachers autonomy and support, promoting an integrative and sustainable learning environment.

The PPC outlines competencies and skills that students should develop, including critical analysis of the environmental and social conditions of engineering projects. The proposal seeks to prepare future civil engineers to develop solutions that respect the principles of sustainability, minimizing negative impacts and promoting social well-being.

In addition, the PPC of the Civil Engineering course at IFPI values active learning methodologies, which encourage student participation in practical projects and case studies. These approaches not only facilitate theoretical learning, but also allow students to apply the concepts of sustainability in real situations, developing a critical and integrative vision essential for professional performance in engineering. Environmental education, therefore, becomes an ethical commitment of professionals trained by IFPI, preparing them to actively contribute to the construction of a sustainable future.

2.2 INTEGRATING INNOVATIVE PRACTICES AND TECHNOLOGIES

Construction plays a crucial role in urban development, but it is also one of the industries that contributes the most to environmental degradation. In this context, sustainability in civil construction has become a necessity, seeking efficiency in the use of resources and minimizing environmental impacts throughout the life cycle of projects. Adopting sustainable practices involves integrating concepts such as energy efficiency, waste management, and the use of eco-friendly materials.

An effective approach to promoting sustainability in construction projects is the use of Building Information Modeling (BIM) tools and software. BIM al-lows for more efficient and collaborative planning, providing a comprehensive view of all aspects of the project from conception to execution. According to Mattana and Librelotto (2017), the evaluation of the sustainability of the buil-ding requires the analysis of several variables, and the use of BIM enables in-formed decisions in the design phase.

In the sustainability course, some students used Autodesk Revit to deve-lop complementary projects. As a BIM tool, Revit integrates information from different disciplines, making it easier to create sustainable solutions. The archi-tectural base project was made available in formats such as AutoCAD and SketchUp, promoting collaboration and exploration of different aspects of de-sign and sustainability.

BIM also facilitates life cycle analysis (LCA), which assesses the envi-ronmental impact of a project from the extraction of raw materials to disposal. This analysis is critical for informed decisions about materials and strategies to minimize environmental impacts (Gonzalez et al., 2019). Integrating data on energy consumption and emissions during the life cycle allows engineers and architects to develop more sustainable solutions.

Sustainable practices, such as water reuse, biodigesters, filter gardens, and solar heating systems, are essential in civil construction. Water reuse re-duces the demand for drinking water, and biodigesters convert organic waste into biogas, promoting waste management (Silva & Almeida, 2021; Pereira et al., 2020). However, the implementation of BIM faces challenges, such as the established design culture and the need for training professionals. Training in sustainable practices should be part of the curricula of Civil Engineering and Architecture courses, preparing future professionals for environmental chal-lenges. In short, sustainability in civil construction requires the integration of innovative technologies and the adoption of practices that minimize environ-mental impacts, contributing to a healthier and more balanced urban environ-ment.

2.3 ACTIVE METHODOLOGIES IN ENGINEERING EDUCATION

The role of active methodologies in higher education has gained promi-nence, especially in the training of engineers, since these approaches promote more engaged and meaningful learning. Active methodologies, such as Pro-ject-Based Learning (PBL), encourage students to be protagonists of their own learning process, integrating theory and practice in a more effective and rele-vant way.

Project-Based Learning (PBL) is a methodology that allows students to work in real or simulated situations, where they must apply theoretical knowle-dge to solve practical problems. This approach not only encourages the deve-lopment of technical skills, but also competencies such as teamwork, critical thinking, and problem-solving. PBL stands out for its positive impact on the training of engineers, as it allows students to see the practical application of the concepts learned, promoting a deeper and more lasting understanding.

Case studies on the application of active methodologies in engineering disciplines show that this approach can lead to a significant increase in stu-dent motivation and performance. By working on real projects, students not on-ly learn the theory, but also the importance of collaboration and effective communication in a work environment. Laboratory

and field practice, coupled with active methodology, provides a space where students can explore and experiment, further solidifying the relationship between theory and practice.

The interface between theory and practice is essential for the training of engineers who are not only technically competent, but also aware of their soci-al and environmental responsibilities. The implementation of active methodo-logies, such as PBL, allows students to connect with the reality of the job mar-ket, developing an innovative and sustainable mindset. This connection is key to preparing future engineers to face contemporary challenges, where sustai-nability and social responsibility are increasingly valued.

Therefore, the adoption of active methodologies in engineering educa-tion not only enriches the learning experience but also strengthens the rela-tionship between theory and practice. By fostering a collaborative, student-centered learning environment, educational institutions can prepare better-prepared professionals to contribute meaningfully to society and sustainable development.

3 METHODOLOGY

The methodology of this article outlines the procedures used to conduct the research, focusing on the experience of the teacher in the application of active methodologies in engineering education, especially Project-Based Le-arning (PBL) in the discipline of Sustainability of the Federal Institute of Piauí. A detailed description of the procedures is essential to ensure the transparency and reliability of the results, as well as to provide a solid basis for the interpreta-tion of the findings.

3.1 TYPE OF STUDY

This study is characterized as an experience report, where the focus is on the application of PBL during Sustainability classes. The objective is to share the practices, observations and reflections of the teacher on the implementation of the methodology, contributing to the discussion on the integration between theory and practice in the training of engineers.

3.2 SAMPLE SELECTION

The sample consisted of students who participated in the Sustainability disci-pline during the academic semester at the Federal Institute of Piauí. The pro-fessor observed the

performance of students from different semesters and spe-cializations, allowing a comprehensive evaluation of the effectiveness of the PBL methodology.

3.3 DATA COLLECTION METHODS

Data collection was done through participant observation, where the teacher closely followed the practical and theoretical activities in class. During this process, he recorded his impressions of the class dynamics, the interac-tions between students, the participation in group activities, and the results of the projects. This approach allowed us to analyze the level of engagement of the students, the application of the concepts of sustainability and the ability to work in a team.

3.4 ETHICAL CONSIDERATIONS

All stages of the study were conducted in accordance with the ethical guidelines of academic research. The teacher committed to respecting the pri-vacy of the students, ensuring that their observations did not affect the lear-ning process. The information collected was used exclusively for academic purposes and pedagogical reflection.

4 RESULTS AND DISCUSSIONS

An experience report is a document that describes in a systematic and reflective way the experiences of a group or individual in a given context, with the aim of sharing learning, challenges and results obtained throughout the process. In the educational sphere, experience reports are important to record and analyze pedagogical practices, providing a critical view of the methodology adopted and its impact on student learning (SILVA, 2016). In the context of the Sustainability discipline at the Federal Institute of Piauí, the experience report becomes a valuable tool to reflect on the application of Project-Based Learning (PBL). This methodology was chosen for its ability to promote active learning, where students not only absorb information but also engage in the construc-tion of knowledge through practice.

4.1 IMPLEMENTATION OF PBL

The structure of the course was divided into four parts, starting with the theoretical basis. In this initial phase, students were introduced to the funda-mental concepts of sustainability in civil construction, which served as a basis for the development of their

projects. The knowledge acquired at this stage was essential for the students to understand the importance of sustainable cons-truction and the different practices that could be adopted.

The second part consisted of the presentation of the house project, whe-re the students had the opportunity to propose their work ideas. Each of the six students presented a different sustainable solution for the construction of the house, encouraging diversity of thought and creativity. This phase was marked by an open dialogue, where students were able to discuss the feasibility of their proposals and explore the possibilities of applying the theoretical con-cepts they learned.

Subsequently, an in-depth discussion was held on the proposals pre-sented, culminating in the approval of the chosen project. This step was crucial as it allowed students to reflect on the practical implications of their ideas and how they could implement sustainable solutions in a real project. The interac-tions during this phase were enriching, as each student had the chance to cri-ticize and improve the proposals of their colleagues, promoting a collaborative environment.

The development of the project was the fourth stage, where the students worked as a team to prepare the approved proposals. This phase involved the technical presentation of the projects and the defense of each one of them be-fore the class and the teacher. The PBL methodology was fundamental in this process, as it not only encouraged active learning, but also provided a space for students to apply their knowledge in a practical way. The defense of the projects allowed them to develop communication and argumentation skills, es-sential for any professional in the area.

Throughout the process, PBL proved to be an effective methodology, as it promoted significant learning, where students became protagonists of their own education, integrating theory and practice in a harmonious way. The ex-perience strengthened students' understanding of the importance of sustaina-bility in civil construction and stimulated innovation, preparing them for the challenges of the job market.

4.2 STUDENT PERFORMANCE

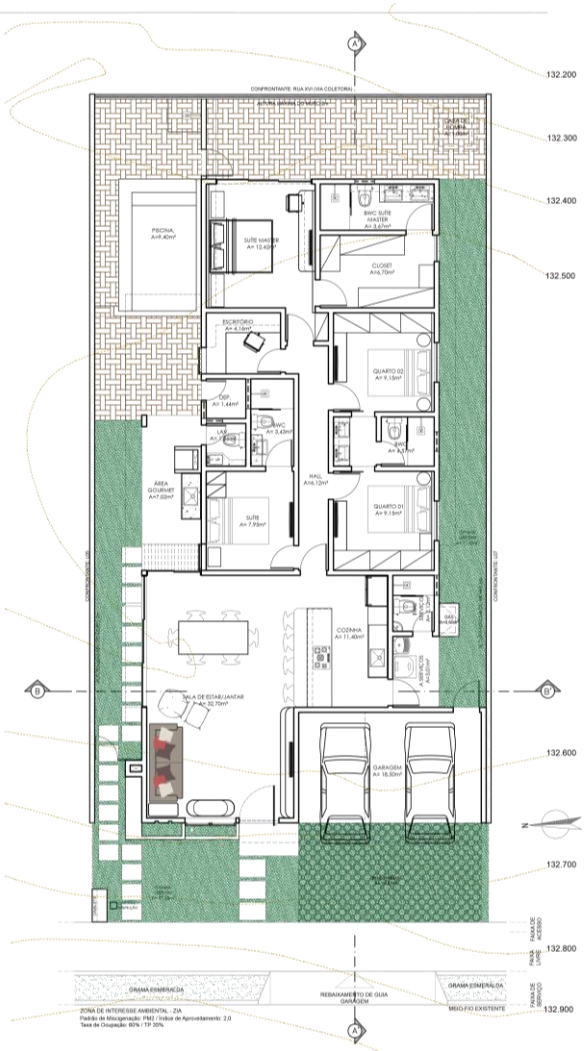
The performance of the students in the Sustainability discipline was a central aspect that deserves to be highlighted. During the theoretical foundation phase, the dynamics of a small group allowed everyone to feel comfortable to actively participate in the moments of discourse and discussion. This interaction resulted in a collaborative and engaging environment, where students were able to express their ideas and ask questions in an open

way. The enthusiasm shown during the planning of the activities was evident, reflecting a significant commitment to learning.

After this initial stage, the teacher presented the project of the house (Figure 1), which is a single-storey building with 167.61 m², located on a plot of 300 m². The project includes a two-car garage, a living room, an integrated dining room and kitchen, as well as a service area, a service bathroom, a suite, two demi-suites, an office, a master suite, a storage room, a toilet, a gourmet area and a swimming pool. This moment was crucial for the students to visualize their ideas in a concrete format.

Figure 1

Floor Plan of the House Project



Source: Prepared by the author.

Then, a technical visit was made to the construction of the house (Figure 2), where they were able to observe in practice some of the strategies of bioclimatic architecture. During the visit, they noticed the use of materials such as thermoacoustic tiles (Figure 3) and natural stone coatings on the west façade (Figure 4), which contribute to the cooling of the house. Students analyzed the structures and spaces, taking measurements and understanding how sustainable practices apply in construction.

Figure 2

Technical Visit: Front Façade

Source: Samuel Resende, 2024.

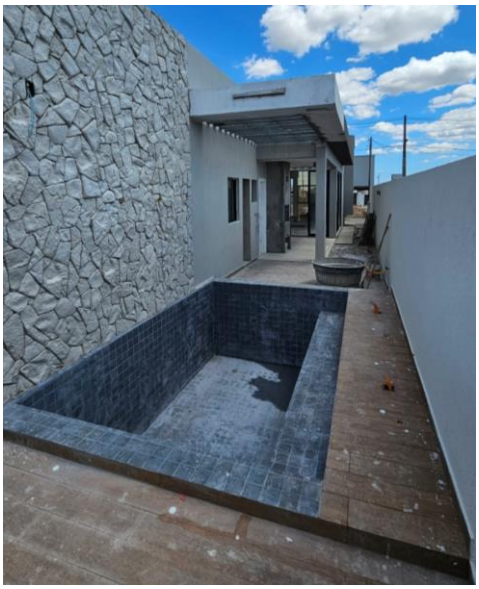
Figure 3

Technical Visit: Thermoacoustic tiles

Source: Samuel Resende, 2024.

Figure 4

Technical Visit: Gourmet Area

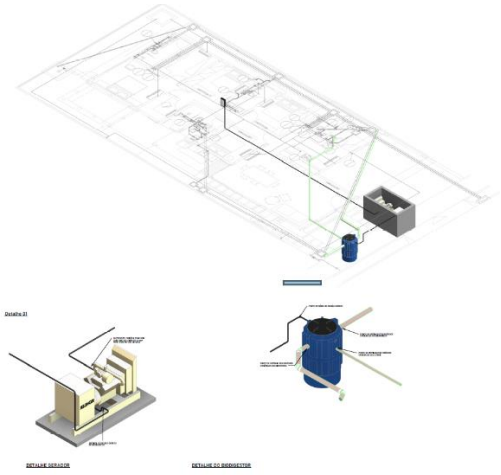


Source: Samuel Resende, 2024.

Back in the classroom, the students were introduced to the zoning and limitations of the lot where the house was built, which is located in a ZIA according to the PDOT of Teresina. The condominium, called Petrópolis Residence, has its own rules for project approval and, in addition, has no connection with basic sanitation. In view of this reality, two students suggested the implementation of a biodigester system (Figure 5), one focused on the use of gas and the other on energy generation.

Figure 5

Class activity: Biodigester Project

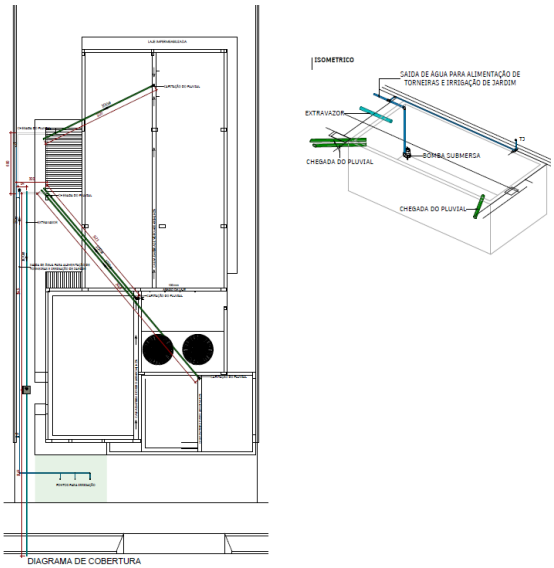


Source: Students participating in the survey, 2024.

Other innovative proposals emerged, such as a project to capture rainwater for reuse (Figure 6) and the reuse of water from air conditioning (Figure 7). The students who chose reuse tactics discussed the issue of sewage taxation, emphasizing the need to preserve water in a context of scarcity and rising costs. In addition, they presented a solar energy project focused on comfort and water heating, emphasizing that this solution not only saves energy but also contributes to long-term eco-efficiency.

Figure 6

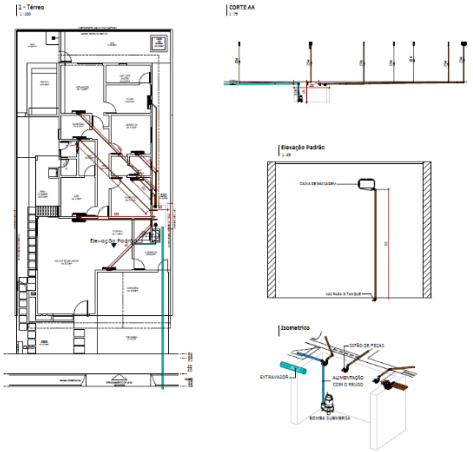
Class activity: Rainwater harvesting for reuse



Source: Students participating in the survey, 2024.

Figure 7

Class activity: Reuse of air conditioning water

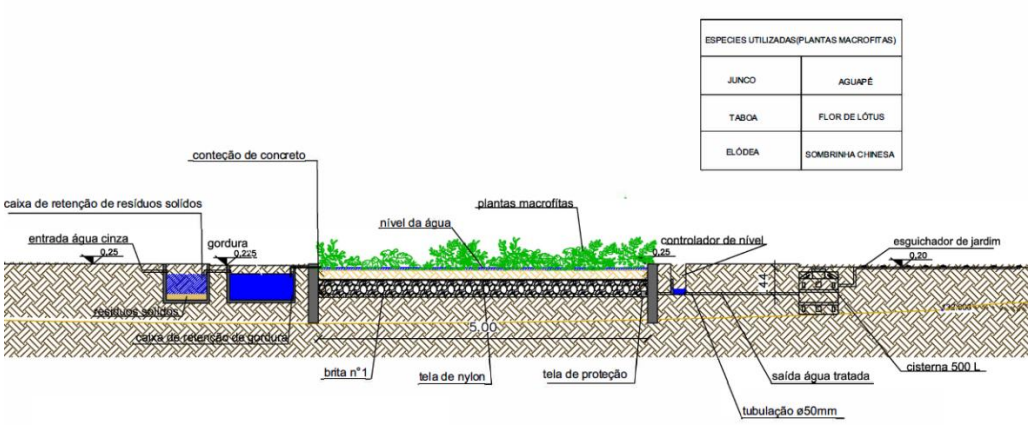


Source: Students participating in the survey, 2024.

For the development of these projects, the students had the freedom to choose which software to use for the drawings. Those who focused on reusing water from air conditioning, rainwater harvesting, and draining garden (Figure 8) opted for AutoCAD. These students did not feel the need for complex representations of the installations in the floor plan and schematic sections, considering that this level of detail was sufficient for the clarity of the projects. The students who worked on the biodigester and water heating systems used Revit. Due to the complexity of the ideas, the representation in schematic isometric perspective helped in the presentation and understanding of the projects.

Figure 8

Class activity: Draining Garden



Source: Students participating in the survey, 2024.

After the presentation of the approved ideas, the students entered the development phase of the projects, with the classes organized in a studio format. In this environment, the students worked on the reproduction of the projects independently, with the monitoring and guidance of the teacher. At the end, all students presented their projects simulating delivery to a client. The result was that everyone finished the course with the highest grade, evidencing the success of the methodology applied and the students' commitment to learning. This trajectory, from active participation in discussions to the completion of projects, demonstrates how the methodology adopted was effective in promoting meaningful and practical learning.

5 CONCLUSION

In conclusion, the research analysis suggests that the implementation of active methodologies, especially Project-Based Learning (PBL), has proven to be an effective approach in teaching Sustainability in Civil Engineering cour-ses. The results obtained, evidenced by the positive performance of the stu-dents, highlight the importance of this methodology in facilitating meaningful and engaging learning, allowing students to integrate and apply theoretical knowledge in concrete practices, thus reflecting the quality of the training re-ceived.

Observing that the students are at the end of the journey of the Civil En-gineering course, it was valuable to verify the effectiveness of the basic disci-plines throughout the training. The students demonstrated mastery of the con-tent already learned and were able to effectively assimilate the new concepts presented. The projects, developed with the guidance of the teacher, were exe-cuted with a high level of detail, highlighting the students' ability to integrate and apply theoretical knowledge to practical reality.

The results of this research have significant implications both for aca-demic society and for the training of future professionals. The training of civil engineers and architects who are aware of and committed to sustainable prac-tices can contribute to the construction of a more balanced urban environment that has less impact on the environment. For the academic society, the survey reinforces the importance of including active methodologies in curricula, pro-moting not only technical training, but also the development of critical and practical skills in students, better preparing them for the challenges of the job market.

However, this research has limitations that should be considered. The sample was restricted to students from a single course at a specific institution, which may limit the generalizability of the results. In addition, the analysis fo-cused predominantly on the quantitative aspects of student performance, without exploring in depth the individual perceptions of students about the le-arning experience. For future work, it is recommended to carry out studies that include a broader sample, covering different institutions and contexts, as well as qualitative investigations that explore students' perceptions of their learning experiences and the relevance of sustainability content in their professional trajectories, thus enriching the debate on the training of trained professionals who are aware of environmental issues.

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