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2ND INTERNATIONAL WORKSHOP

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BOOK OF PROCEEDINGS

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Editors:

João da Rocha e Silva, Instituto Politécnico de Bragança, Portugal

João Eduardo Pinto Castro Ribeiro, Instituto Politécnico de Bragança, Portugal

Jorge Santos, Instituto Politécnico de Bragança, Portugal

Rui A. Lima, Universidade do Minho, Portugal

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WELCOME

In recent years, the manufacturing processes have undergone a profound transformation, driven by the rapid evolution of additive manufacturing (AM) technologies. What began as a tool primarily for prototyping through stereolithography has now expanded into a versatile and innovative field capable of producing functional, end-use components across a wide range of industries. From fused deposition modeling (FDM) to selective laser melting (SLM) and beyond, AM has unlocked new possibilities in design, material utilization, and production efficiency. Today, additive manufacturing encompasses an extensive array of materials, including metals, polymers, paper, and even biological tissues, enabling applications that span from the mechanical industry to the biomedical sector.

One of the most compelling aspects of additive manufacturing is its potential to drive sustainability in modern production processes. Unlike traditional subtractive methods, which often generate significant material waste, AM builds components layer by layer, minimizing excess material and promoting resource efficiency. Furthermore, the ability to use eco-friendly and recyclable materials aligns with global efforts to reduce environmental impact. AM also supports the production of complex, customized parts on demand, reducing the need for large inventories and long-distance transportation, thereby lowering carbon emissions. By optimizing resource use and enabling more efficient production cycles, additive manufacturing is emerging as a cornerstone of sustainable manufacturing practices.

This proceeding book arrests the latest advancements, challenges, and opportunities in the field of additive manufacturing, with a particular focus on its transformative potential and contributions to sustainability. The works presented here reflect the interdisciplinary nature of AM, showcasing innovative techniques, materials, and applications that are shaping the future of manufacturing. From cutting-edge research to real-world case studies, this collection aims to inspire further exploration and collaboration, driving the adoption of additive manufacturing as a key enabler of sustainable industrial progress. We invite readers to probe into these pages and discover how AM is not only redefining manufacturing but also paving the way for a more sustainable and efficient future.

The IWAM 2024 Organizing Committee,

João Rocha

João E. Ribeiro

Jorge Santos

Rui Lima

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Awareness of sustainability practices in construction: Learning in a real context

F. Silva[1,2,3*], A. Santos[1], Y. Rios[1], P. M. Barros[4]

[1]ESTiG, Instituto Politécnico de Bragança, 5300-253, Bragança, Portugal

[2]GICoS, Instituto Politécnico de Bragança, 5300-253, Bragança, Portugal

[3]GeoBioTec, Universidade da Beira Interior, 6201-001, Covilhã, Portugal

[4]Centro de Investigação em Educação Básica, Instituto Politécnico de Bragança, 5300-253, Bragança, Portugal

(*)***Email:*** flora@ipb.pt

ABSTRACT

As part of the Higher Professional Technical Course in Civil Construction at a Polytechnic Higher Education Institution, a teaching experience was proposed in which the Technical Installations and Sustainability Practices in Construction course units were taught interconnectedly. The students mobilized the knowledge acquired in the first-course unit to carry out practical work on more sustainable solutions in buildings as part of the second-course unit. This experience allowed the students to apply their knowledge in scenarios close to their professional reality and to reflect on the complex issues of sustainability in construction.

Keywords: Hydraulics, Sustainability in construction, Higher education.

INTRODUCTION

Higher Professional Technical Courses (HPTC) are taught within the scope of Polytechnic Higher Education and include general and scientific training, technical training, and work-based training. It is important that the course units of HPTC promote, whenever possible, a greater connection to practice and that the teaching and learning contexts encourage the active involvement of students in their learning process. Silva, Barros, and Ribeiro (2018a, 2018b, 2021a) and Silva, Ribeiro, and Barros (2019, 2021b) concluded, based on experiments they carried out with HPTC students, that when learning with a strong link to practice is promoted, namely in the laboratory context, there is evidence of a positive impact on student learning.

The HPTC in Civil Construction at the School of Technology and Management (ESTiG) of the Polytechnic Institute of Bragança (Portugal) is part of the Technology training area. It includes the course units Technical Installations (Hydraulics Installations - 5 weeks) (TI) and Sustainability Practices in Construction (SPC) in its study plan. In the 2022/2023 academic year, a teaching experiment was carried out that involved teaching the two course units in an interconnected way, in which the knowledge acquired in TI was applied in SPC. The following stages were followed in this teaching experience:

- Stage 1: Preliminary study of concepts (TI);
- Stage 2: Flow measurement and proposal of efficient solutions for devices in ESTiG's sanitary facilities (SPC) (see, e.g., Silva-Afonso & Pimentel-Rodrigues, 2017);
- Stage 3: Analysis of the water network specialty of a building at the design stage (TI);

- Stage 4: Study visit to the rainwater harvesting system of the building analyzed in the project (TI);

- Stage 5: Participation in seminars and lectures on sustainable construction and research support (SPC);
- Stage 6: Study of sustainable solutions involving buildings integrated into an urban allotment (SPC) (see, e.g., Kibert, 2022).

RESULTS

The students carried out different tasks in stages throughout the process. Stage 1 covered the following content: Water distribution systems; Sewage drainage systems; Firefighting systems; Regulatory testing of building networks and applicable legislation. The knowledge gained in Stage 1 was applied in Stage 2, and a solution was proposed to replace conventional taps with efficient taps for ESTiG's sanitary facilities. Thus, the knowledge gained in the TI course unit was applied in the PSC course unit. In Stage 3, the water networks in the project were analysed, and in Stage 4, a study visit was made to the rainwater harvesting system of the building analysed in the project (Figure 1). The knowledge gained in TI was applied in PSC.

Figure 1 - Study visit to the rainwater harvesting system.

In Stage 5, students attended seminars and lectures on sustainable construction and research support. Thus, the knowledge acquired in the IT and the participation in the events allowed to apply it in the PSC. In Stage 6, sustainable solutions were studied with buildings integrated into an urban allotment, and the previously acquired knowledge was applied (Figures 2 and 3).

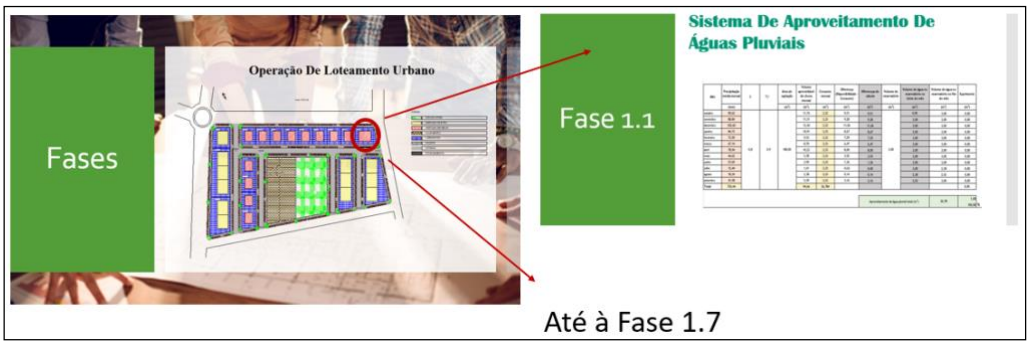

Figure 2 - Extract from the practical work - Phase 1.1: Rainwater harvesting system.

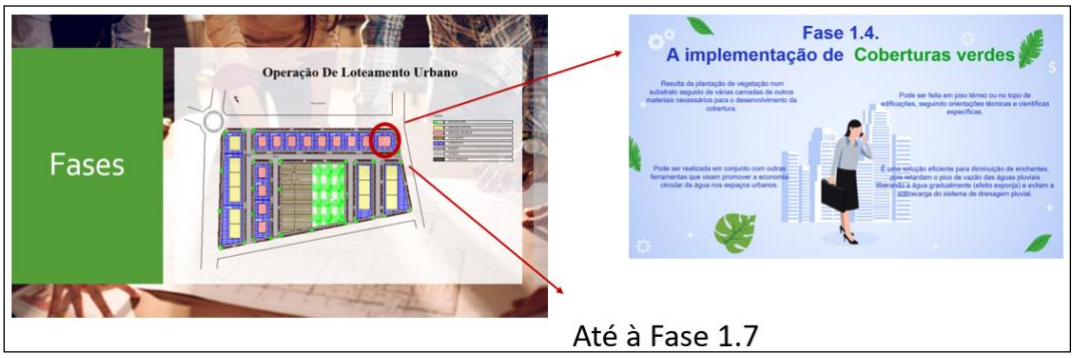

Figure 3- Extract from the practical work - Phase 1.4: Green roofs on buildings (role in stormwater management).

The knowledge gained throughout the experience enabled all students to complete the final task – "Points in a building where it is possible to choose more sustainable solutions". According to student A1, "It was a task that required dedication. Coming up with valid ideas to implement in the work was stressful, but the main points were clearly explained, making the work interesting and very productive".

As sustainability is a complex issue and students were at an early stage in their learning, some students needed help to interpret and select relevant information to complete the tasks. However, with the guidance provided by the teacher, the students were able to overcome these challenges. Student A2 said, "I had some difficulties, maybe because of the level of study we had at the time, we lacked some knowledge. However, with the explanations and guidance, we completed the activity and overcame all the obstacles.

CONCLUSIONS

The way the experience was designed allowed the students to explore the content related to sustainability practices in construction in contexts similar to those they might face in a real working environment. The link between the two curricular units and the motivational aspect also helped to complement and enrich the learning.

REFERENCES

Kibert, C. J. (2022). Sustainable Construction Green Building Design and Delivery (5.ª ed.). John Wiley & Sons Inc.

Silva, F., Barros, P. M., & Ribeiro, J. E. (2018a). Hazards and risks of machine-tools: an experience in the mechanical technology and vehicles course. In L. G. Chova, A. L. Martínez, & I.C. Torres (Eds.), *ICERI2018 - 11th International Conference of Education, Research and Innovation* (pp. 6260-6266). IATED Academy. 10.21125/iceri.2018.2474

Silva, F., Barros, P. M., & Ribeiro, J. E. (2018b). Aprender segurança e higiene: e se o nosso cenário de aula for o laboratório?. In J. B. Lopes, J. P. Cravino, & C. Costa (Eds.), *Relatos e investigação de práticas de ensino de Ciências e Tecnologia - Atas do Encontro internacional "A Voz dos Professores de C&T" (VPCT 2018)* (pp. 249-254), Universidade de Trás-os-Montes e Alto Douro. http://hdl.handle.net/10198/18286

Silva, F., Barros, P. M., & Ribeiro, J. E. (2021a). Interaction between course units: An experience in higher education. In L. G. Chova, A. L. Martínez, & I. C. Torres (Eds.), *ICERI2021 - 14th International Conference of Education, Research and Innovation*, (pp. 4473-4478), IATED Academy. 10.21125/iceri.2021.1031

Silva, F., Ribeiro, J. E., & Barros, P. M. (2019). Aprendizagem contextualizada: cenários no ensino superior. In M. V. Pires, C. Mesquita, R. P. Lopes, E. M. Silva, G. Santos, R. Patrício, & L. Castanheira (Eds.), *IV Encontro Internacional de Formação na Docência (INCTE): Livro de atas* (pp. 982-991), Instituto Politécnico de Bragança. http://hdl.handle.net/10198/19504

Silva, F., Ribeiro, J. E., & Barros, P. M. (2021b). Learning exchange: a collaborative work between course units. In L. G. Chova, A. L. Martínez, & I. C. Torres (Eds.), *INTED2021 - 15th International Technology, Education and Development Conference* (pp. 9892-9898). IATED Academy. 10.21125/inted.2021.2059

Silva-Afonso, A., & Pimentel-Rodrigues, C. (2017). *Manual de Eficiência hídrica em Edifícios*. ANQIP.