SUSTAINABLE CONCRETE WORKSHOP TO PROMOTE STEAM DISCIPLINES AMONG PRESCHOOL AND PRIMARY SCHOOL CHILDREN

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Abstract

This experience involves an initiative aimed at awakening and promoting scientific vocations in the fields of Science, Technology, Engineering, Arts, and Mathematics (STEAM disciplines) among children in Preschool Education and Primary Education, aged between 4 and 9 years old. To this end, several workshops linked to different research projects in the field of civil engineering and materials science have been developed, with the aim of introducing children to the possibility of using recycled construction materials in engineering works. The final goal is to involve them from an early age in the importance of reusing and recycling all types of materials across all economic sectors. These workshops aim to strengthen the participant's curiosity and confidence in the technological field, providing them with the necessary tools to explore their creativity and develop technical skills.

The workshops are structured in four steps, all of them with the active participation of the children, in which they are encouraged to share their experiences and knowledge on the topics covered. In the first stage, they are introduced to the world of civil engineering, learning what kind of activities a civil engineer performs. Then, they delve into the study of concrete, its usefulness and manufacturing process, emphasizing the importance of incorporating recycled materials, such as construction and demolition waste, steel slag, and even wind-turbine fibers, to preserve the environment and avoid the overexploitation of natural resources. The next phase consists of a practical activity, where each child makes their own concrete mix with recycled aggregates, filling prismatic molds to produce recycled concrete blocks. Finally, using the blocks previously prepared, the children build their own structures such as buildings, towers, and bridges, thus fostering their imagination and creativity. Feedback from the participating children showed that this activity allowed them to learn more about the construction materials around them and to awaken in them a spirit of sustainability.

Keywords: STEAM, sustainability, concrete, preschool, primary school, workshop, civil engineering.

1 INTRODUCTION

The World Commission on Environment and Development, in the *Brundtland Report*, defines sustainable development as the ability to meet the needs of present generations without hindering future generations from meeting their own needs [1]. Sustainable development encompasses various dimensions, including social, environmental, and economic aspects, and require the involvement and dedication of all relevant parties to successfully reach it. Education is widely acknowledged as a fundamental instrument in advancing sustainability goals [2].

Education for Sustainability empowers individuals with the knowledge, values, and skills necessary to engage them in decision-making processes that enhance the current quality of life while safeguarding the future of the planet [3]. It is imperative that education is committed to a sustainable future at all educational stages, starting from early childhood [4]. In this phase of growth and personal development, individuals' thoughts, perceptions, understanding, and actions undergo formative processes, laying the foundation for their attitudes towards the environment and the world in general [5].

The United Nations outlined the Sustainable Development Goals (SDGs) in its 2030 Agenda in 2015 [6], among which is Goal 4. This goal highlights the imperative of ensuring inclusive, equitable, and high-quality education for all, alongside the promotion of lifelong learning opportunities. Essentially, it advocates for making quality education accessible to everyone. Goal 4.7 further emphasizes the commitment to acquiring the knowledge and skills necessary to promote sustainable development, including education for sustainability and the adoption of sustainable lifestyles. Additionally, ensuring access to quality early childhood development, care, and preschool education for all girls and boys is deemed crucial, as stated in Article 4.2. Building upon these principles, an educational-expert panel

convened in Rome in 2018 [7] highlighted the interdisciplinary approach to education encompassing Science, Technology, Engineering, Arts/Humanities, and Mathematics (STEAM) as an appropriate strategy to achieve the SDGs. A quality STEAM education, designed to foster global citizenship through international project-based collaboration, emerges as the most effective educational approach to address both local and global challenges in achieving the SDGs.

STEAM education is an interdisciplinary learning approach that enables students to integrate various fields of study to tackle problems in creative, innovative, and critical ways. It emphasizes learning in technological areas through problem-solving or project-based methods. This educational approach is closely associated with engineering, as evident from its designation [8]. Therefore, the STEAM approach is particularly suitable for teaching construction-material science, which is a fundamental aspect in disciplines such as civil engineering, agri-food engineering, and building engineering.

Introducing STEAM approaches during Early Childhood Education or Primary Education enables children to engage with these concepts from an early age, laying the groundwork for more robust learning in later stages. STEAM experiences not only enrich training in technological aspects during basic education but also cultivate the emergence of vocations and interests in young individuals. This encourages them to question the why of things and fosters attitudes beneficial to society, such as awareness of the imperative for sustainability [9].

Concrete stands as the construction material *par excellence*, employed in a wide range of buildings projects and civil engineering works [10]. Its widespread usage can be attributed to its cost-effectiveness compared to other materials and its versatility in its fresh state, facilitating multiple applications. These two aspects are complemented by its high compressive strength, while its relatively low tensile strength is typically addressed through the incorporation of steel bars, creating what is known as reinforced concrete. Concrete is a composite material [10], primarily comprised of three components: aggregates, cement, and water. Aggregates and cement collectively confer strength to the concrete, with aggregates forming a robust skeleton that is bound together by the cement matrix. Water saturates the aggregates and hydrates the cement, bringing them together into a unified whole.

However, the composition of concrete based on these three components poses a significant environmental challenge [11]. Firstly, the extraction of aggregates contributes to environmental degradation and visual pollution. Secondly, the cement industry ranks among the most polluting sectors globally, as each ton of ordinary cement produced is estimated to emit between 0.9 and 1 ton of CO_2 within the atmosphere. In response to this issue, numerous research efforts in recent years have focused on developing concrete using sustainable raw materials. Instead of relying on natural aggregates and conventional cement, the emphasis has moved towards utilizing industrial waste and by-products as aggregates and binders [12]. Various initiatives have explored the use of materials such as slag from iron or copper manufacturing, recycled concrete aggregates, plastic, or shredded tires as alternatives to traditional aggregates. Additionally, substitutes for cement, such as fly ash, silica fume, or ground granulated blast furnace slag, have been employed [13]. Indeed, the incorporation of these three components into cement production is now standardized [14].

Figure 1. Recycled concrete aggregate.

Researchers in the field of concrete have extensively examined the utilization of recycled concrete aggregate as a viable option. This material is derived from the crushing of concrete elements that have

reached the end of their service life or are no longer deemed suitable for use [15]. The resulting granular material (Figure 1) exhibits lower density and higher water absorption compared to natural aggregate. However, by considering these characteristics in the design process, its substitution for natural aggregate becomes entirely feasible. With an appropriate proportion of recycled concrete aggregate, a suitable for various applications can be produced with this sustainable raw material.

2 METHODOLOGY

Members of the Recognized Research Group of the University of Burgos SUCONS (SUstainable CONStruction research group) have developed various STEAM workshops to introduce children from 4 to 10 years old concrete science, the importance of this material, and how it is possible to produce it more sustainably. These workshops were linked to different research projects carried out by SUCONS research group.

In total, 6 workshops have been conducted over two academic years, all under the auspices of activities organized by the Science and Technology Station. The Science and Technology Station is a project promoted by the Unit of Science Culture of the University of Burgos and the Burgos City Council, with the collaboration of the Foundation for Science and Technology (FECYT) - Ministry of Science and Innovation, Spanish Government. This project aims to promote scientific and technological culture among the citizens of Burgos. The workshops were performed in the following calls:

- XII Women and Science Week (February 6-13, 2023). Workshop name: *"I want to be a sustainable engineer"*. Edition 1. Two age groups: a group of 12 students from 2nd and 3rd year of Early Childhood Education and 1st year of Primary Education, and a second group of 12 students from 2nd to 4th year of Primary Education, with a duration of 90 minutes each group. Activity held at the Science Station (Burgos).
- 17th FIRST® LEGO® League (February 25, 2023). Workshop name: *"I want to be a sustainable engineer"*. Edition 2. Three sessions of half an hour each were held, with an average of 25 children *per* workshop, aged between 4 and 9 years old. The event took place at the Higher Polytechnic School of the University of Burgos.
- European Researchers' Night (September 29, 2023). Workshop name: *"Let's get to work: we make sustainable concrete!"* Edition 1. A 1-hour workshop for 12 students from 3rd year of Early Childhood Education to 3rd year of Primary Education. Activity held at the Science Station (Burgos).
- Science Week (November 9-18, 2023). Workshop name: *"Let's get to work: we make sustainable concrete!"* Edition 2. Duration of 60 minutes, aimed at students from 3rd year of Early Childhood Education to 4th year of Primary Education. Activity held at the Science Station (Burgos).
- Maker Girls Program, workshop held on January 31, 2024, as part of the annual course activities. Workshop name: *"Let's get to work: we make sustainable concrete!"* Targeted towards a group of 12 girls from 2nd and 3rd year of Primary Education, lasting for one hour. Activity held at the Science Station (Burgos).
- XIII Women and Science Week (February 5-16, 2024). Workshop name: *"Let's get to work: we make sustainable concrete!"* Edition 3. Designed for 12 children from 2nd year of Early Childhood Education to 2nd year of Primary Education, with a duration of 60 minutes. Activity held at the Science Station (Burgos).

The workshop structure was similar in all editions and was adapted to the age of the attending students and the available time according to the activity in which they are involved. The workshops were structured into four stages, all of them with active participation of the children, as they are encouraged to share their experiences and knowledge about the topics discussed.

- In the first stage, an introduction to the world of civil engineering was provided, acquainting the children with the types of activities that civil engineers undertake. This explanation was supported by a PowerPoint presentation (
- Figure 2) featuring images of large engineering works, interspersed with more local projects that they may be familiar with.
- The second stage delved into the study of concrete, its utility, and manufacturing process, emphasizing the importance of incorporating recycled materials, such as construction and

demolition waste, steel slag, and even fibers from wind turbines, to preserve the environment and avoid the overexploitation of natural resources.

- The third stage involved a hands-on activity, in which children experiment with concrete manufacturing formulas and the necessary materials to produce it. Each child created their own concrete mix using the specified proportions of recycled aggregates, cement, and water. Additionally, to make it more playful and encourage creativity, they added colorants to the mix to obtain concrete of different colors (blue, red, green, yellow, or black) (Figure 3). With the concrete they had made, they filled small prism molds, and once the concrete had set, they would have obtained their own bricks (Figure 4).

Figure 2. PowerPoint presentation at the first stage of the workshop.

Figure 3. Concrete mix with recycled aggregates, cement, water, and colorants.

Figure 4. Filling the prism molds to create the color blocks.

- Finally, in the fourth phase, multiple identical concrete blocks of different colors were provided to the children, similar to the ones they had manufactured, and they were encouraged to build their own structures such as buildings, towers, and bridges (Figure 5). This way, participants became familiar with the uses of concrete, developed their manual skills, and fostered their imagination and creativity.

Figure 5. Construction of concrete block structures.

3 RESULTS

The collection of evidence of outcomes and results in these workshops is not systematized, due to the young age of the participants, and satisfaction surveys have not been considered yet. However, a relaxed dialogue is conducted with them during the workshop, mainly at the end of the session, when they are asked for their impressions after the activity. Three aspects are emphasized: (1) what they have learned and their opinions on recycling; (2) what they have discovered about concrete and its utility; and (3) the impact that this workshop has on their potential interest in engineering.

Regarding the first aspect, children generally answered very favorably, understanding that recycling is something that everyone should do for the benefit of the hole society and the world. They actively participate in recycling and reusing tasks in their daily lives, knowing the basic procedures available to citizens to contribute to this end.

The participants' prior knowledge and understanding of concrete is usually scarce or non-existent. Nevertheless, by the end of the workshop, they are able to successfully list the main components of concrete, and to identify constructions in which this material has been used. Furthermore, they have

learned some technical terms related to the topic.

Finally, in terms of vocational orientation for their future education, it was found that the participating children gained a better understanding of the work of civil and construction engineers. These workshops at an early age serve to introduce specific professions, in this case closely related to STEAM education, with the long-term goal of encouraging and incentivizing them to become future engineers, thanks to the lasting impact these playful workshops leave on them.

A quantifiable indicator of the results of these STEAM workshops is the high demand for them in different editions. Every time they have been offered, they have been fully booked very quickly. Parents, educators, and organizers have conveyed the positive reception and interest they have sparked in children.

4 CONCLUSIONS

Conducting STEAM workshops with young children offers an invaluable opportunity to foster learning in the technological sphere. This approach has proven to be highly effective in educating children, in this case, between 4 and 10 years old, on aspects related to materials science, specifically concrete, within the context of civil engineering and construction, as well as on how to manufacture this material in a more sustainable way.

According to feedback provided by the participating children, the workshop provided them with a clear understanding of what concrete is and its uses. Furthermore, they gained a deep understanding regarding the importance of sustainability across all the productions areas and the need to reduce environmental impacts. Additionally, the workshop allowed them to deepen into the work of civil and construction engineers, sparking the interest of some of them in this profession.

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