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Mobile Science Project: Promoting Active Methodologies through Environmental Workshop in Schools

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Abstract- The main objective of this project is to investigate how active methodologies, based on workshops with environmental themes, can help high school students to learn subject matter in the area of the chemistry, physics and mathematics sciences and enhance their awareness of the importance of the preservation of the planet. In this study, 13 schools were visited in 4 years. During this time they participated in workshops that involved the use of residues to produce new materials, to provide environmental education regarding the reuse of waste and concepts embedded in the chemistry, physics and mathematics sciences. The results highlight that most of the students (98%) found the Mobile Science project interesting, 97% enjoyed participating in the workshops. Regarding the content of the workshops, 92% of the students answered positively; that is, the workshops were related and helped to understand the exact sciences. The Mobile Science project is part of the Unisul´s actions aligned to sustainable development goals (SDGs), UN 2030 Agenda.

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I. Introduction

According to the PISA (International Program for Student Assessment) 2015 report, which evaluates the knowledge of 15-year-old students in mathematics, reading and science, in 72 countries, Brazil has not advanced in recent years, reaching 63rd in science, 59th in reading and 66th in mathematics. Given this scenario, developing initiatives, such as new pedagogical practices is necessary to improve these results in future evaluations.

In schools in the UK the Rotherham THAW project was developed (Taking Home Action on Waste), being the first to seriously attempt to systematically measure the impact of school-based waste education on levels of recycling and residual waste in homes in neighborhoods of the schools. The results have provided conclusive evidence that such education programs can play a key role in developing children's knowledge regarding sustainable waste management (Maddox et al., 2011).

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Yeung et al. (2017) have identified factors in these teaching approaches that lead to success. In terms of knowledge acquisition and behavioral changes, the quantitative results suggest that the pre/post-test in-group differences were significant in both groups. More importantly, a significant positive change in attitude was observed in the gaming simulation group only. In the interviews, participants attributed effective knowledge acquisition to the active learning element in class, while the characterization of cognitive dissonance triggered in the gaming simulation induced subsequent effective changes.

It is important to understand and analyze the conceptions that the teachers have at different levels of education (primary, secondary, and higher education), regarding the paradigm in which environmental education (EE) is treated as a methodology strategy and designed for this practice. The researchers sought to detect possible reductionism, determinism and fragmentation in the conceptions of these teachers. The results show that there is interest in a reflexive view that is closer to complex thought in the treatment of EE. However, reductionism was associated with the difficulties inherent in its practice in which the treatment of EE is placed as well as the methodological strategies used and/or designed for this practice (Valderrama-Hernández and Limón, 2017).

Stegmann & Westhuyzen (2014) highlighted an initiative called Remida in Hamburg, Germany. This project collected residues and wastes from small and large companies to be used by schools, or other institutions, for creative projects. In this activity, school classes of all ages visited the center to select materials and gather inspiration for their work. In this way, the children learned essential life skills of good recycling skills and how to contribute towards a cleaner environment, both being essential life skills.

In their studies on the theme "Development of Ecological Place Meaning" in Bronx Borough of New York City, observed that urban environmental education helps students to recognize ecological features and practices in cities. Through narrative research with educators and students in urban environmental

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education programs, the value and practice of developing this meaning of ecological place is understood. So, the project help students appreciate the ecological aspects of cities and develop their imagination in terms of how their environment could be improved (Russ et al., 2015).

In Vietnam, they developed a project related to the environmental education of elementary school students. The study surveyed 247 students in January 2014 at two primary schools to assess the students' knowledge regarding solid waste management. Students had a basic understanding of the environment, but their knowledge of this theme was limited. A year later, an environmental education workshop was held with the students. The results showed that 96% of the students were interested in activities involving solid waste management. Also, the study found that there were changes in the students' knowledge before and after the environmental education activities (Hoang and Katoh, 2016).

Karatekin (2013) studied the perception of elementary students regarding environmental problems via the mind mapping technique. The research involved 88 students in 5th, 6th, 7th, and 8th-grade classes at an elementary school in Ankara, they were asked to draw their own mind maps related to environmental problems. These maps were then qualitatively analyzed through documental review. The results showed that elementary students were most concerned about environmental issues, 'such as air and water pollution, waste issues, and global warming. Students had a low level of confidence regarding solutions to environmental problems.

In Israel, the "green school certification" took place, which is a sustainability program that which is a sustainability program that contemplates changes in school operations, introducing sustainability content into the school curriculum and building links with local communities, seeking to change students' attitudes (Goldman et al., 2018).

Environmental education (EE) is a way to promote coastal literacy among elementary school students by applying an integrated and interdisciplinary approach. They examined the collaborative process of creating interdisciplinary and participatory EE activities in a public elementary school in São Sebastião (Brazil), a place with rich and diverse ecosystems but subjected to severe anthropogenic stressors. This collaborative process of approaching socioenvironmental problems aimed to give students an integrated and interdisciplinary view, potentially contributing to future coastal management decision processes through public participation, to empower stakeholders and activists (Santos et al., 2017; Roczen et al., 2014).

Considering the International Student Assessment Program (PISA), according to Tokarnia (2016), the 15-year-old students assessed obtained a score that placed them below level 2, considered 'appropriate' in the three areas assessed by PISA. On separating the results, it was observed that in the sciences 56,6% of the students were below level 2 and only 0,02% were at level 6 (the maximum level in the evaluation). In reading, 50,99% were below level 2 and 0,14% reached the maximum level. In mathematics, 70,25% were below the appropriate level and 0,13% reached the highest level in total; 23141 students from 841 schools around Brazil participated. Most of these (77%) were enrolled at high schools, with 73,8% in-state networks and 95,4%in urban schools.

The University of Southern Santa Catarina approved a project with the CNPQ (National Council for Scientific and Technological Development) with the aim of investigating how active methodologies based on workshops can affect students' learning in relation to chemical, physical and mathematical sciences and to increase students' awareness of the need to preserve the planet. Human behavior has become a threat to environmental sustainability, principaly during the last three decades, one of the most influential initiatives towards environmental protection and increased environmental consciousness is the solidification of environmental education (Ntanos et al. 2018).

UNISUL, founded in 1964, is a university established by the Municipal Government of Tubarão, Santa Catarina, Brazil. It aims to promote education, science, culture, sustainable social development with the creation and diffusion of technology, primarily in the region in which it is located, through a series of projects related to the growth and local capacity building, aiming for a more sustainable future. Prioritizing actions involving teaching, research and outreach, UNISUL promotes Environmental Education in different social centers, such as classrooms, virtual environments, administrative offices, and thus guarantees an important role for the improvement and maintenance of environmental quality.

UNISUL, in its Institutional Development Plan, has Sustainable Development as one of its premises, aiming the institutional growth, ensuring a balance between social, environmental and economic dimensions. Environmental awareness is a topic of great discussion in society, especially in educational organizations. The principle of this policy is the permanent and continuous environmental education, in line with the federal, state and municipal EE law sand norms, focused on the environmental conservation, what is essential to the life quality and sustainability, considering the aspects of the 5R: rethinking, reduce, return, reuse and recycle.

UNISUL, concerned with environmental conservation, life quality and sustainability, reinforces its commitment to society by joining the National Movement for Sustainable Development Goals. Although it is a global mission, Unisul believes that it is

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necessary to take local actions so the SDGs are achieved. According to Zamoro-Polo et al (2019), the Sustainable Development Goals (SDGs) constitute a work agenda for the local, regional and international community to ensure a better world for future generations. It is important to highlight that Unisul has a partnership with other international HEIs, within the scope of the SDGs, through a project "Change the Climate: Assuring the Quality of Environmental Strategies in Latin-American Higher Education" (QualEnv), of the Erasmus Program from the European Union. The QualEnv research project has as the main objective implementing environmental practices aligned with the UN SDGs.

Menezes and Minillo, already in 2016, and more recently Sonetti and Lombardi (2020) pointed out that Universities can play a significant role and present themselves as relevant actors in generating knowledge and promoting development. They can also contribute to the implementation of the SDGs, through the actions and activities developed within these environments, which involve teaching, research and outreach with great transformative potential.

With the adoption of the 2030 Agenda for Sustainable Development, Education for Sustainable Development (ESD) is embraced by Goal 4, Target 4.7 of this plan " By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, through Education for Sustainable Development and sustainable lifestyles, human rights, gender equality, peace, culture and nonviolence, global citizenship and appreciation of cultural diversity to sustainable development (UN, 2015). (UN, 2015). ESD is a dynamic concept that includes all actions and challenges towards sustainable development and is at the core of global goals for a sustainable future (Shulla et al. 2019). A decade of education for sustainable development between 2005 and 2014 was declared worldwide by the United Nations. The intended purpose is to promote and more thoroughly focus education as a crucial tool preparing young people to be responsible future citizens, so that our future generations can shape society in a sustainable manner (Burmeister et al. 2012).

In this article, Unisul, besides seeking to achieve quality education for its students, also extends its efforts to give quality to basic education in needy schools in its surroundings.

II. Methods

The research sample was selected by the Regional Education Management, associated with the Santa Catarina State Education Secretariat, with the aid of the research team from the Universidad e do Sul de Santa Catarina (UNISUL). The selected sample comprised of 13 schools, which required innovative pedagogical practices in the area of the chemistry, physics and mathematics sciences, and involved 13 cities and towns (one school per city/town)in the region of Greater Florianópolis (Fig. 1). The work team included six professors from the university who teach undergraduate courses in the areas of environmental and sanitary engineering, chemical engineering, production engineering, and academics from the areas of engineering, information technology and public relations.



Fig.1: Greater Florianópolis region encompassing 13 cities and towns. Source: Google maps adapted.

The data collection was carried out in 2014, 2015, 2016 and 2017. The Mobile Science project has reached 3000 students, of these, 300, from 14 to 17 years old, worked in the workshops and was invited to answer a questionnaire for evaluation purposes.

In this first study, we first located relevant studies based on the following keywords: environmental education, pedagogical practices, mobile science, waste treatment and waste reuse. The databases Web of Scopus, Science Direct and Google Scholar were used as a basis for the literature search. In the second part of the study, the instruments used were photographic records, videos and audio recordings of the students participating in pedagogical activities in the workshops.

In the following paragraphs, the pedagogical activities were carried out in the workshops involving different prototypes of sustainable solutions for environmental issues. The workshops took place in a modified truck designed by engineering students under

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the supervision of a team of professors at UNISUL. The workshops dealt with different prototypes of sustainable solutions for environmental issues.

The truck (figure 2 A) was funded the National Council of Scientific and Technological - CNPq), the trailer (figure 2 B) was equipped with lab benches to perform the workshop protocols and cabinets to store the lab materials, lighting and sinks with faucets.



Source: Authors.

Fig. 2: Mobile Science truck (A) and the internal area of the truck (B).

In this study, 13 schools were visited over a period of 4 years. The students had access to the 4 truck workshops. The workshops covered are described below.

A) Production of biodiesel (Fig. 3): in this workshop the students produced biodiesel from residues of saturated frying oil and short-chain alcohols, concepts of chemistry in the reactions of alcohol with oil (transesterification) and environmental education were worked out in relation to the fate suitable for cooking oil residues and the respective environmental impacts caused by incorrect disposal were discussed (Moecke et al., 2016; Maddikeri et al., 2012; Nair et al., 2012).



Source: Authors.

Fig. 3: Biodiesel production workshop.

B) Soap production (Fig. 4): Students fabricated soap from the waste generated during the production of biodiesel (glycerin), and residual oil saturated with high-fat fat-free acids. This workshop addressed the concepts of environmental science related to the reuse of glycerin and frying oil to produce soap, chemistry concepts were introduced, such as the theory behind the saponification reaction called alkaline hydrolysis, and the detergent action of soap, particularly the elimination of fats, and the environmental issue involved were discussed. Bars of soap was obtained from the saponification by mixing the following ingredients: saturated frying oil (high acidity), caustic soda, water, glycerin, and disinfectant.

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Source: Authors.

Fig. 4: Students are participating in the soap production workshop.

C) Production of biofilm (Fig. 5): In this workshop, students produced biodegradable films from waste (glycerin) generated during biodiesel production. The students noted that this product could replace conventional plastic produced from petroleum, decreasing the degradation time in the environment. Principles of organic chemistry related to polymerization were also introduced (Liu et al., 2012). Also, the students learned how to produce a biofilm. The polymerization reaction was performed using the following mixture: distilled water, maize starch, glycerin (used as a plasticizing agent), and food coloring. The reaction was performed in a beaker under constant stirring and heating (90°C). The mixture was then poured into Petri dishes, left to dry under ambient conditions, and the obtained biofilm was removed.



Source: Authors.

Fig. 5: Students are participating in the biofilm production workshop.

D) Solar heating workshop (Fig. 6): In this workshop, the students produced a water heater with long-life milk packaging waste (Tetra Pak cartons comprised of paperboard, polyethylene film and aluminum) and PET bottles (from soft drinks). Subjects related to mathematics (trigonometry) and geography (geographical coordinates) were also discussed in this workshop (Xue, 2016). The cartoons were painted black, to retain the heat from the sun and the PET bottles were used to protect from external influences, such as wind and rain. Water pipes were also painted black and passed inside the bottles to allow the transfer of heat from the packs to the water. With this system it is possible to heat the water to 55 degrees Celsius.



Source: Authors.

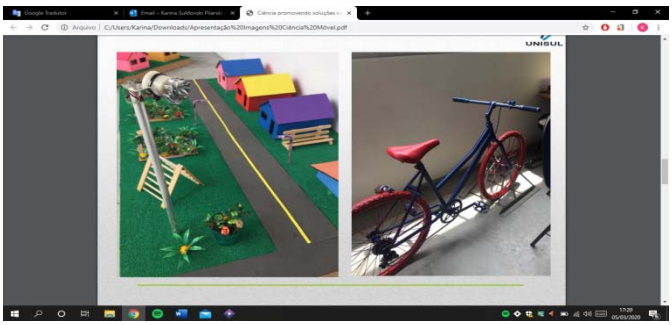
Fig. 6: Students are participating in the solar water heating workshop.

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After the pedagogical activities, was applied a questionnaire to gain information on the students' perceptions regarding the activities. So, asked the following questions: Did you find the Mobile Science project interesting? Did you enjoy participating in the workshop? Was this workshop related to knowledge of the subject addressed? This workshop helped you understand the contents of the subject addressed? Do you intend to go to university? If you answered yes to the previous question, would you like to graduate in environmental sciences, chemistry, physics and mathematics sciences? If you answered yes to the previous question, did the workshop influence this decision? Did the project help you to comprehend the importance of separating waste? Did the project help you to comprehend the reuse of waste to produce new products? The answers to the questionnaire are presented in the results section.

There was a second data collection in 2019 that covered 11 schools located in the Greater Florianópolis region, specifically the cities of Florianópolis, Palhoça, São José, Biguaçu and Antônio Carlos, with a reach of approximately 1000 students. The students had access to the truck's first three workshops and to an additional workshop on renewable energy.

E) Renewable energies (Fig. 7): In this workshop, concepts about renewable energies are presented, citing examples and definitions of the three main types (wind, solar and hydraulic), as well as their advantages for the environment. This workshop has three models with LED lights for demonstration; each model has a device for functionality, being a pinwheel, a photovoltaic plate, and a bicycle.



Source: Authors.

Fig. 7: Models for renewable energies.

In this second data collection, a questionnaire was not carried out; only testimonies were heard from students who participated in the pedagogical activities, which had positive evaluations about the subjects covered. Instruments such as photographic records and videos of the participating students were also used.

Regarding the limitations of the study, we recognize that our findings may be specific because they relate to pedagogical practices involving the environmental issues observed in this state in Brazil. Contributions from other Brazilian states would allow us to extend the empirical configuration and to understand whether the results obtained can be generalized. Another limitation, that represents an opportunity for new research is that the monitoring of the grades obtained by the students during the five years of the research project would provide useful information regarding whether there was enhanced learning on the part of the students. The study can also be expanded to include other types of pedagogical content and not just those related to the chemistry, physics and mathematics sciences.

III. Results and Discussion

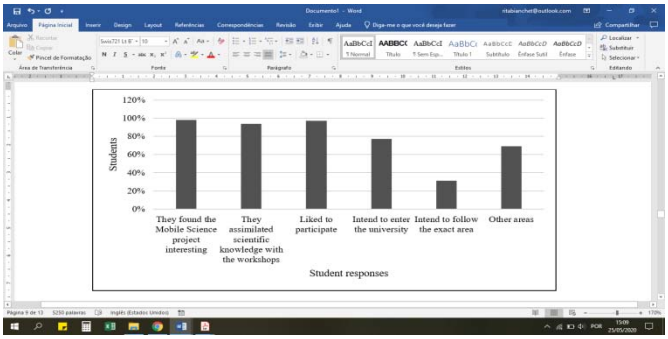
This project allowed public school students to understand and explore the concepts of environmental science and the basic principles of the exacts sciences corroborating the Sustainable Development Goals, specifically Objective 4, which provides for ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all (Moyer & Hedden, 2020).

Simsekli (2015) also examined the effect of environmental education practices on the awareness of students in elementary education, focused on the environment in general and the specific environmental problems in the region. The findings of the study revealed that, after the implementation of the practices, there was an increase in the number of students who became aware of the problems in their environment and their causes, and they were able to propose solutions for these problems. Also, there was an increase in the number of students who volunteered to take part in environmental activities within or outside the school.

We sought to organize the workshops in such a way that the students could create prototype or product

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from residues. These products or prototypes remained at the schools for the teachers to make use of them in the teaching of their subjects and exhibit them at science fairs. Graph 1 shows the main responses given by students participating in the Mobile Science project in the period from 2014 to 2017:



Source: Authors, 2019.

Graph. 1: Student responses regarding the mobile science project.

There is a predominance of students who found the project interesting (98%) in the same way as those who assimilated scientific knowledge with the workshops (94%), consequently they liked to participate in the offices (97%). A higher percentage was expected. However, 77% of students intend to enter the university. For those who answered that they intend to take a course in the areas of environmental or chemical sciences, physics, and mathematics, 36% considered that the workshops influenced this choice. 81% of the students said that the workshops helped to understand the importance of waste separation and 80% understood that the waste could be reused to produce new products, most students (98%) found the project interesting to enjoy the workshop. The importance of addressing both practice and theory was confirmed by the fact that 94% of students connected knowledge of the exact theory of scientific disciplines with workshops. Although most schools visited have laboratories, they have not been used frequently, and teachers have said that there is a shortage of materials available for practical classes.

Many cities where the schools visited are located do not have higher education institutions, yet 77% of students intend to continue their studies, 31% in the areas of environmental or chemical sciences, physics and mathematics. The workshops with chemical content involved reactions and the students were enthusiastic when they saw the transformation of frying oil into biodiesel or soap, or the production of biofilm from corn, and glycerin (a waste product from biodiesel production).

After verifying the analysis of the questionnaires and the testimonies reported by the students orally, it was observed that the activities carried out during the workshops sensitized the students to the importance of preserving the planet. Recycling is perceived as the main means to achieve environmentally responsible behavior and students do not see the relationship between their materialistic consumption and the environmental consequences. Achieving sustainable development will require joint global actions to advance from "light green" sustainability education to combat consumption, as an important issue in modern society, to the most fundamental transitions required in lifestyles and values (Goldman et al., 2018).

According to Mello and Lemos (2019), environmental education has the role of making human beings aware of their integration and dependence with Nature, to make them understand the true principle of sustainability, that is, live without compromising the current generation as well as the future ones. Thus, the presence of these pedagogical activities directly contributes to a favorable view of sustainability by the students; it also helps to ensure that knowledge is disseminated to more people, whether in the community or family environment.

Aydın-Güç et al. (2014) carried out research to create awareness of the importance of mathematics for the prevention of environmental pollution, an issue which science teachers need to address. The results obtained from the study indicated that prospective teachers were unable to associate the prevention of environmental pollution with mathematics before the task-process developed. In contrast, their ideas changed for the better towards the end of the study and they were surprised by the importance of the use of mathematics for the prevention of environmental pollution.

A study on teaching versus the environment highlighted that when environmental preservation is used in an integrative context for teaching, students perform better than their peers in assessments on reading, mathematics, and social studies. Most students, also to achieving higher grades, were more involved and enthusiastic about the learning process. Environmental education plays a crucial role in children's education, familiarizing them with the concept

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of sustainability and developing their environmental consciousness. Also, teachers need to live in an environmentally conscious way and to represent the standpoint of sustainable development and its practice, to motivate the students. A curriculum that incorporates natural science and methodological elements contributes to the successful development of positive attitudes toward sustainability, as well as the formation of adequate skills and key competencies (Stronck, 2005; Major et al., 2017).

In this study, the students observed real products being produced during the workshops from waste, that is, biodiesel, which fuels the bus that takes them to school (in Brazil 8% of vehicle fuel is biodiesel), soap for hygiene purposes, biofilm used to pack food, and a solar system to heat water.

IV. Conclusion

This project was able to verify that active methodologies applied through workshops with environmental themes have a positive influence on students in terms of learning subjects related to the chemistry, physics, and mathematics sciences and can enhance their awareness and appreciation of the importance of the preservation of the planet. Also, the university can improve its dialogue with the surrounding community, as observed with the Mobile Science project, enabling better contact between academic researchers and high schools. The results obtained in this project are important for both the university and the schools, mainly benefitting the high school students, who gained knowledge from the workshops, making them rethink their perception of materialistic consumption and re-explore the possibility of continuing their studies in higher education. The team of university professors and the students strengthened the Mobile Science project, which involved extension into the community and research activities, working on interlinking themes, aimed at the complete training of a citizen in matters including environmental education. Unisul sought through this project to contribute to the achievement of SDG number 4, which deals with quality education. The activities involved high school students and Unisul students, with the theme of preserving the planet. Studies show that strategies to promote sustainability are developed successfully in projects that unite university team (professors and students) and high school time (professors and students), bringing advantages to both sides, being able to improve its dialogue with the surrounding community, enabling better contact between academic researchers and high schools (Berzosa, 2017; Berchin, 2018; Berchin 2017; Casarejos, 2017).

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