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Environment

Plastic: Recycling as a Potentiator of Science Teaching in Basic Education

Plástico: a reciclagem como potencializador do Ensino de Ciências na Educação Básica

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ABSTRACT

Three Pedagogical Moments were carried out in the context of a sixth-grade class Elementary School at a private school in the municipality of Santa Maria, Rio Grande do Sul state. It aimed to promote sustainability through plastic cap recycling with an emphasis on Science and Technology in order to build environmental awareness in Basic Education, as proposed by the Circular Movement. The activity was developed at PlastiMaker's laboratory at Franciscan University in Santa Maria. As a result, it was observed that as they systematized information about plastic cap recycling, students were stimulated to collaborate on strategies to minimize environmental damage caused by plastic. Another relevant aspect was the ability of students to promote a more responsible approach in their context related to residues, focusing on education for sustainability purposes.

Keywords: Learning; Recycling; Sustainability

RESUMO

O trabalho consiste em um relato de experiência referente à abordagem metodológica dos Três Momentos Pedagógicos aplicada em uma turma do 6º ano do Ensino Fundamental de uma escola da rede privada, do município de Santa Maria - RS. O objetivo foi incentivar a sustentabilidade, pela reciclagem de tampinhas de plástico, com ênfase na Ciência e Tecnologia, a fim de construir consciência ambiental na Educação Básica, nos moldes preconizados pelo Movimento Circular. A atividade foi desenvolvida no laboratório PlastiMaker da Universidade Franciscana de Santa Maria. Nos resultados percebeu-se que ao sistematizar as informações sobre a reciclagem de tampinhas de plástico, os estudantes foram inspirados a colaborar nas estratégias para minimizar o impacto ambiental causado pelo consumo de

plástico. Outro aspecto relevante foi a capacidade dos estudantes de promover uma abordagem mais responsável, nos ambientes em que transitam, em relação aos resíduos, com foco na educação para a sustentabilidade.

Palavras-chave: Aprendizagem; Reciclagem; Sustentabilidade

1 INTRODUCTION

Considering the presence of plastic in virtually all economic sectors, its impact on human activities, Science, technology and waste management, it is essential to stimulate sustainability and to promote environmental care and protection. In this sense, the present study is justified by the necessity to deepen the applicabilities of plastic recycling concerning Science and Technology, producing didactical resources and artifacts in a way that promotes the development of critical and scientific thinking, spreading and announcing Science to society.

PlastiMaker Project, then, developed within the Graduate Program in the Teaching of Science and Mathematics from Franciscan University (UFN) aims to promote sustainability through plastic caps recycling, intending to bridge the pedagogical knowledge between university and school. It is worth noting that PlastiMaker Project is supported by CNPq's and FAPERGS' scholarship holders who research about the topic within their own areas of interest alongside with UFN professors aiming to share with the school's community.

Therefore, the preset report consists of a proposal inspired by a project called Precious Plastic (Dave Hakkens, 2019), a technique and tool sharing project for plastic recycling encompassing collaborative teaching and learning forms based on learning by doing, as defended by Makers' movements.

In this context, the present article aims to promote sustainability through plastic caps recycling with emphasis on Science and Technology in order to build environmental awareness in Basic Education as proposed by the Circular Movement.

First, it was sought to understand the Three Pedagogical Moments as a facilitatory

methodology to the growing of student's knowledge. Thus a review of the importance of plastic studies in the final years of Elementary School was carried out considering the perspective of the Circular Movement and the guidelines from Common National Curricular Basis.

The proposal was applied to 80 students from sixth grade of Elementary School at a private school from Santa Maria, Rio Grande do Sul state, in order to contextualize the issue of sustainability in the context of school, once it is a basic condition to the future of the next generation.

2 THEORETICAL FRAMEWORK

2.1 In the Three Pedagogical Moments' dynamics

The dynamic called Three Pedagogical Moments was proposed by Delizoicov and Angotti (1990) and further investigated by Delizoicov, Angotti and Pernambuco (2002) during the process of teachers' formation in Guinea Bissau region. Originated by the transposition of the conception by Freire (1987) to a formal education context, it stresses a dialogical education in which teacher must mediate a connection between what students are learning, scientifically and in classes' context, with the reality of their everyday life. In this aspect, Delizoicov and Angotti (1990) characterize the Three Pedagogical Moments approach in three stages, which are: initial Problematization, knowledge Organization and knowledge Application.

In this dynamic, teacher initially presents real situations, so students are able to know and make the experience that they are being introduced to scientific knowledge. Thus they are challenged to expose what they think about the subject. In the second stage, students deepen the knowledge chosen by teacher, realizing it as necessary for their understanding of themes and the initial problematization.

In the final stage, knowledge is systematically approached. This knowledge is integrated, analyzed and interpreted by students, as well as the situations that

determined their study. In this stage, students are enabled to employ their knowledge as well as to articulate the scientific conceptualization within real situations.

2.2 Plastic recycling

High plastic consumption, especially the disposable ones, along with one of its most advantageous characteristics which is its durability, has turned them into a major environmental issue. As a consequence of its structure, plastic can take many decades to be degraded in nature. Besides that, a great deal of plastic is not biodegradable and the degradation process by the breakdown of their molecules produces increasingly smaller fragments of this material, called microplastics (Piatti & Ferreira, 2005).

Therefore, it can be stated that recycling is the conversion of plastic residues by conventional processing technologies into products with similar performance characteristics to those products manufactured by industries. Thus, plastic residues recycling is a possible alternative to be implemented in society, but this recycling must be scientifically based, aiming to reduce plastic waste and to adopt a lifestyle with less waste.

Consequently, recycling instruments make the physical and chemical process of plastic recycling possible. A plastic shredder machine is used to reduce a material to smaller pieces, the microplastic. This process is greatly useful for the transportation of the material and to simplify its recycling. The process of extrusion of the extruding machine consists in melting thermoplastic resin granules and then processing this material, so it can be used to produce solid products such as plastic films, pipes, profiles among others.

2.3 Circular Movement and the Common Nacional Curricular Basis

Circular Movement is a multisectorial initiative that gathers people and organizations committed to spread the concepts of Circular Economy. Thus, it is sought to give orientations about how to transition from a linear economy to what is proposed

by the Circular one. The tools for this transition are education and culture, encouraging sustainable development of new processes, products and attitudes towards a society with no waste. In this context, Circular Movement aims to invert linear logic, reusing to the fullest the resources that are already in circulation (Movimento Circular, 2023).

In this manner, for the economy to belong to the circular era, it is required that products never turn into waste and that the recycling process facilitate the production of new materials, resources and artifacts with diverse ends. Thus, Circular Economy can be regarded as the one that restores and seeks to ensure that fewer residues are created during the process of production and life of the product.

Murray, Skene and Haynes (2017) state that the Circular Economy as a concept has its principle in historical, economical and ecological fields. These concepts contribute to the comprehension of the applicability of the concept in practice, seeking to achieve sustainability in all its dimensions, resulting in environmental quality, economical prosperity and social equity for the sake of the current and future generations. Therefore, Circular Economy is a strategy and a model that minimizes the use of new resources, projecting a fewer residue creation, using clean production practices and end-of-life materials as a new resource by reusing, remanufacturing or recycling (Geissdoerfer et al., 2017, Kalmykova, Sadagopan, & Rosado, 2018).

In this sense, the project has been applied to qualify the pedagogical proposals, strengthening bonds between university and school in the search for new experiences for students as well as to reaffirm the Report of the International Commission about the future of education, Unesco when it states:

> to imagine a greater diversity of possible futures beyond the present, research and innovation cannot afford to exclude the many ways in which diverse human populations, cultures and traditions have read and understood the world. (Unesco, 2022, p. 124)

According to the Common National Curricular Basis (BNCC), in order to understand Science it is necessary to organize learning situations, starting with matters of challenging character which recognize cultural diversity, stimulate scientific interest

and curiosity of students and allow issue definitions, raising, analyzing and representing results; communicating conclusions and intervention proposing (Brasil, 2017). In light of this, in the final years of Elementary School exploration of experiences, knowledge, interests and curiosity of students about the natural and material world continues to be central. In this context, it is important to motivate students with challenges increasingly overarching, which allow the questions that are being presented to them, as well as those that they themselves produce, to be more complex and contextualized.

In addition, BNCC (Brasil, 2017, p. 323) affirms that:

> during Elementary School, Natural Science area is committed to the development of scientific literacy, which involves the ability to understand and interpret the world (natural, social and technological), but also to transform it based on the theoretical and procedural framework of Science. (Brasil, 2017)

In this perspective, the pedagogical intention is that students of sixth grade of Elementary School feel engaged in and about the world, with perspectives of contributive action for their overall development as citizens. In addition, it allows access and interaction with the diversity of scientific knowledge as it was proposed by PlastiMaker Project, which has contributed to responsible interventions based on sustainability and respect for the Planet.

Thus, the guided visit has contributed to bring theory and practice together once students truly need to visualize and understand the knowledge process to the transformation of collective life.

In this sense, Brasil (2017, p. 324) addresses the development of the investigative process mentioning that:

> the investigative process must be understood as a central element of students' formation in a broader sense and whose development must be associated with didactic situations planned during the entirety of basic education in a way that enables students to reflexively revisit their knowledge and their understanding of the world in which they live. (Brasil, 2017)

Understanding their living place is important to know how to point out solutions to issues that are being faced, to enhance their knowledge approaching the scientific

field, to develop solutions for their community's improvement amongst many other situations in which knowledge of this field can transform.

The Report of the International Commission about the future of education supports some concepts that integrate the activity proposal for students' development:

> essential educational activity happens in many spaces, but space and time of public school are unique. School's space facilitates social relationships. Education and learning stimulate human interactions, dialogue and exchange, and schools must be designed to promote it. (Unesco, 2022, p. 93)

In this alignment of intentions, Table 1 describes thematic units, objects of knowledge and abilities for sixth grade of Elementary School concerning the curricular component Science, according to BNCC (Brasil, 2017).

Table 1 – Thematic units, objects of knowledge and abilities for sixth grade of Elementary School concerning the curricular component Science

Thematic Units	Objects of knowledge	Abilities
Matter and energy	Synthetic materials	(EF06CI04) To relate medication production and other synthetic materials with scientific and technological development, acknowledging benefits and evaluating socio-environmental impacts.
Matter and energy	Chemical transformations	(EF06CI02) To identify evidence of chemical transformations out of the result of mixtures of materials that result in products different from those mixtured.
Matter and energy	Recycling	(EF05CI05) To build collective proposals for a more responsible consumption and to create technological solutions for appropriate disposal and reuse or recycling of materials consumed at school or in daily life.

Source: Authors (2023), adapted from Brasil (2017)

3 METHODOLOGICAL ASPECTS

The present study was carried out with 80 students from sixth grade of Elementary School from a private school in Santa Maria city, Rio Grande do Sul state, in

the first school semester of 2023. Therefore, Table 2 shows the pedagogical moments and the activities that were developed.

The activities from the 1st and 2nd moment were carried out at the school's space. The 3rd moment activity (knowledge application) was developed at PlastiMaker's laboratory at Franciscan University, in Santa Maria - RS.

Table 2 – Pedagogical moments and developed activities

Pedagogical moment	Activities
1st moment: Initial problematization	Visit the school in order to present PlastiMaker Project. Investigative questionnaires to the students (What is the amount of plastic that is wasted during one year in Brazil? Do you know what recycling is? How can plastic be recycled?) Presentation and handing of a folder as shown in Figure 1, related to the project. Figure 1 - Presentation folder of PlastiMaker  Source: Authors (2023)
2nd moment: Knowledge organization	Theoretical-expositive class about recycling and sustainability.
3rd moment: Knowledge application	Visit to PlastiMaker's laboratory at Franciscan University.

Source: Authors (2023)

The activities from the 1st and 2nd moment were carried out at the school's space. The 3rd moment activity (knowledge application) was developed at PlastiMaker's laboratory at Franciscan University, in Santa Maria - RS.

4 RESULTS AND DISCUSSION

Thereafter, Table 3 shows a description of the results of each pedagogical moment.

Table 3 – Pedagogical moments and results

Pedagogical moment	Results
1st moment: Initial problematization	During the visit at school for the project's presentation, students had the opportunity to know the proposal. The project's general objective was explained, relating it with some recycled objects produced at PlastiMaker's laboratory. Curiosity, engagement and interest in the project were observed, including several questions.
2nd moment: Knowledge organization	In knowledge organization, the main concern was to structure information, to promote metacognitive reflection and to stimulate the construction of responsible and technological solutions. Thus, students were guided by the class' head teacher to relate plastic caps recycling with scientific and technological development, acknowledging its benefits and socio-environmental impacts, correlating it with the ability EF06CI04 (Brasil 2017). In addition, chemical transformation plastic caps was explored in terms of how it contributes to the production of new materials such as textile fibers, decorative objects, didactical games and even components for house constructions. In organizing such knowledge, students not only were able to understand the relevance of recycling for the preservation of the environment, but also discern its implications in a broader perspective. In examining the conversion of caps into different products after the process of recycling, students could also identify evidence of chemical transformation, recognizing the characteristic evidence of that process, seeing recycling as a concrete example of applied chemical transformation. Finally, it was also possible to lead students to think, reflect, debate and build collective proposals for a more responsible consumption and a use of technologies that aims to preserve the environment and appropriate waste of solid residues we produce, choosing to reuse and recycle consumed materials, according to the ability EF05CI05 (Brasil, 2017).
3rd moment: Knowledge application	In the pedagogical activity at PlastiMaker's Laboratory, at Franciscan University, students were able to understand the process of plastic recycling, from the environmental awareness campaign, collection of caps, to the development of new products. Students saw, explored and touched different products developed by plastic caps recycling. Later they were introduced to the exposition of crafted objects. At the end of the activity, they were gifted with a keychain produced at PlastiMaker.

Source: Authors (2023)

As required to students after their visit at PlastiMaker's laboratory, an experimental report (Table 4) presents some considerations regarding the results through written record. Some fragments chosen out of many highlight the experience.

Table 4 – Account of some students in the report

Student	Highlight
Student A	Discussions have made us come to the result that recycling caps create jobs and reduce the pollution caused by this kind of material.
Student B	Environmental results and impacts are great and excellent because they turn caps into other products and when these products become less interesting they can return to the shredder, turning in a cycle almost infinite. Environmental impacts are diverse because caps used in the project get a useful end, they are not thrown into the litter bin and consequently do not pollute the environment.
Student C	Plastic caps collection is a way to contribute to environmental preservation, reducing the environmental impact caused by inappropriate waste. Caps collection is the socio-environmental project that aims to promote positive changes to society.
Student D	It was super fun and cool to visit Plastimaker's laboratory. I think it managed to complement Science classes, bringing nice content for learning in an enjoyable way.
Student E	It was concluded that there are a variety of manners in which plastic can be employed in order not to harm the environment.

Source: Authors (2023)

Furthermore, the production of reports enabled the development of abilities based on BNCC such as scientific, critical and creative thinking, aesthetical sense and cultural repertoire, communication, responsibility, citizenship and reasoning. By these means, report writing sought to foster students' scientific initiation, which was their first contact with this reality. The evaluative process was based on criteria established with students with stress on the requested structures, as well as cohesion, coherence and thematic communication.

4 FINAL CONSIDERATIONS

PlastiMaker Project aims to promote sustainability through plastic caps recycling,

intending to bridge pedagogical knowledge between school and university, which is a proposal inspired by a project called Precious Plastic (Dave Hakkens, 2019), a tools and techniques sharing project for plastic recycling which encompasses collaborative forms of teaching based on learning by doing.

In this context, the present study, whose objective was to promote sustainability through plastic caps recycling with emphasis on Science and Technology in order to build environmental awareness in Basic Education as proposed by the Circular Movement, provided students an unique opportunity to see in practice subjects and contents approached in theoretical classes, so that they could make everlasting and meaningful associations. The proposal performed a key role in the structuralization and systematization of information, allowing students to build a deeper and more connected understanding of the content.

In exploring scientific, technological and socio-environmental aspects of recycling, students were able to build a deeper and more engaging comprehension of the theme, in addition to being provoked to develop creative solutions for contemporary socio-environmental challenges as described in the results.

BNCC discusses that education must affirm values and promote actions that contribute to social transformation, turning it more human, socially just and also focused on the preservation of nature (Brasil, 2017).

Therefore, the carriedout activity corroborates with this view since the developed proposal is also in accord with the abilities from Common National Curricular Basis for the component of Science of sixth year of Elementary School.

It has been seen that education has a character essentially formative, that through its actions it develops the pedagogical praxis based on the educational foundations and assumptions, and that plastic may enhance Science Teaching in Basic Education.

In addition, we consider that the research may continue due to challenges found because it will develop new educational perspectives intertwined with the Circular Movement once it establishes relations directly to Science's knowledge. However,

a greater engagement with the addressed themes was observed as an aspect of contribution to the research line since unfamiliarity about the subject concerning the impacts in the environment and society in general was observed.

The development of the proposal alongside with PlastiMaker Project was of great relevance considering that it was observed through the report a qualitative performance of writing, increase of abilities and progressively inclusion in scientific initiation. Another important aspect that deserves emphasis concerns students' expectations in continuing the research for the next year, establishing and tightening connections with future contents and promoting forms of contextualizing the subject in the school community.

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