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Abstract

This work reports a didactic experience through the assumptions of Project-Based Learning, Interdisciplinarity and Significant Learning in the teaching-learning process in years initials of Elementary School, using the Design Science Reseach methodology. The study contextualizes the reflection about the necessary promotion of sustainable actions with the intention of mitigating environmental impacts. The general aim is to associate the concerns related to the Environment with the construction of events (Science Fair) and promote the integration between the curricular components and the school community. The analysis of the data showed that the student has a greater participation and involvement in daily activities when he builds his own knowledge. It can be concluded that the results obtained in this work prove the effectiveness of the adopted methodologies, which consequently contributed to the achievement of the proposed aims.

Keywords: Sustainability, Science, Experiments, Science Fair.

1. INTRODUCTION

The contemporary educational scenario is composed of several challenges, among them, making sense of the school in view of the ease of obtaining information, knowledge sharing and access to practices, specialists and collections from around the world through the internet. Bacich and Moran (2018) state that school makes sense when it follows the students' own lives and not only teaches them how to live it. The school must go hand in hand with the experience of the student and his community, collaborating with psychological relationships, generating knowledge and, mainly, protagonism. Fazenda (2008, p. 20) states that "we are referring to issues such as: aesthetics of the act of learning, space of learning, intuition in the act of learning, design of projecting, time to learn and the symbolic importance of learning".

Based on this assumption, it is evident the need to take to school questions related to the students' daily lives, as well as using resources that are within their reach, creating meaning for the classes. This change in educational paradigm can be developed through the use of active methodologies and differentiated pedagogical practices that, in addition to generating knowledge, encourage the creation of skills and competences, both technical and transversal. Capri et al (2014) state that Project Based Learning (ABPj) is one of these methodologies, as well as Fazenda (1998) which indicates Interdisciplinarity and,

Ausubel (2000) indicating Learning by Significant Reception or, commonly called here in Brazil, Significant Learning.

Thus, the present work was developed in a public school, in the interior of the state of São Paulo, in the school and family context, providing opportunities to students to carry out some reflections on the necessary promotion of sustainable actions with the intention of mitigating environmental impacts.

This study aimed to associate information on the necessary concerns with the Environment through the construction of Events (Fairs) and Laboratories, generating a possibility to promote a work of interaction and integration between the curricular components and the school community, in order to disseminate all debates to society.

In a more specific context, there is a conjunction of factors that point clearly the contemplation of other objectives: promoting dialogical interactions and conclusions that occurred in the classroom, developing technical skills on the subject (sustainability and environment) and transversal skills, such as teamwork, resolution of conflicts and oral communication.

The interdisciplinary work "1st Science Fair - Sustainability!" it was justified because part of the initiative to work on the Environment theme, a subject present in the National Curriculum Parameters (PCN) and in the National Common Curricular Base (BNCC) for students in the 5th year of elementary school. Considering that the Science Fair is a scientific event, which aims to implement inside the classroom and, outside of it, works and activities that allow to students to leverage their knowledge, through projects that qualify their learning and also, can share their knowledge (BRASIL, 2006; BRASIL, 2017).

The methodology used for this work was the DSR (Design Science Reseach) which, according to Sarmento (2017), refers to knowledge about how to develop and create solutions to improve existing systems and that contribute to a better human performance, both in front of the community and in institutions. Bax (2015, p. 111) states that DSR is a "meta-theory that investigates the generation of knowledge in the artifact design process" and "should be seen as one of the most appropriate methodologies to guide the conduct of scientific research" in management information and knowledge.

Although DSR is commonly applied to the management and engineering area, Dresch et al (2015) states that this is a research method that has been applied in several areas of knowledge, including education. Also according to the authors, this methodology used prescribed methods, employed the concept of Design Science (project science) and also considered interdisciplinarity, which could provide a broader view of what was studied, increasing the relevance of the research.

2. THEORETICAL FOUNDATION

2.1. PROJECT-BASED LEARNING

According to Bacich and Moran (2018) methodologies are specific guidelines and techniques that guide the teaching and learning processes, whereas active methodologies are teaching strategies centered on the effective participation of students in the construction of this process, in a flexible, interconnected and often hybrid. The application of an active methodology can be developed in several ways: Flipped Classroom, Think Pair Share (TPS), Research Based Learning (ABIn), Problem Based Learning (ABPro), Project Based Learning (ABPj), among others.

The ABPj methodology, according to Bender (2014) is one of the most effective ways to engage students with the didactic subject, since this method normally uses real projects and with meaning for students.

According to the author, the starting point of ABPj is a guiding question or challenging task, with which it is recommended to identify students to guide the final product of the methodology. It is convenient for the student to generate a product (not necessarily tangible, it can be an idea, a campaign or even an explanatory video).

Then, an anchor was provided to the students, in which Bender (2014, p. 32) states that it is the "introduction and basic information to prepare the ground and generate the interest of the students", which can come in the form of an expository class, narratives by expert professionals, newspaper or magazine articles, technical visits or resources that support the intended concepts.

However, Bender (2014) and the Buck Institute for Education (2008) guide the following structure: the elaboration of a well-defined plan, which contains a schedule, a type of evaluation that will be applied, information about the group and the product Final.

For the authors, the present structure was crucial for this methodology was successful, since, it is up to this structure to guide its own development.

Bender (2014, p. 129) states that "many evaluation alternatives are provided in almost all discussions" of ABPj, and they propose the inclusion of self-reflection, product / work evaluation, peer and teacher evaluation. Two tools widely used in ABPj evaluations are the Analytical Rubric and the Likert Scale.

Next, the Buck Institute for Education (2008) advises the development of a Project Map, which guides students and teachers in relation to the sequence of activities. In general, the Project Map is composed of Support Activities, Schedule and the Project Launch Event.

Now regarding the importance of the teacher, Bender (2014, p. 39) ensures that "instead of serving as providers of information, in ABPj the teachers must act as facilitators and educational advisors, according to students evolve in their project activities ".

In other words, for the author, the main importance of the professor is to mediate the administration of the work and, before starting it, it is fundamental to have a reasonable notion of the size of the same, its importance and their students, as shown in Tables 1 and 2 (highlighted the characteristics that surround this study).

Table 1. Scope of the Project (*Buck Institute for Education*, 2008).

	Small project	Ambitious project
Duration	Five to Ten days	Mosto f the semester
Amplitude	One topic	Multiple subjects
	One standard	Multiple standards
Tecnology	Limited	Extensive
Reach	Classroom	Community
Partnership	One Teacher	Multiple teachers and Community members
Public	Class or School	Team of experts

Table 2. The formulation of the project and the importance of students (*Buck Institute for Education*, 2008).

Limited student participation		Maximum student participation
Professor selects topic	Teacher asks students to participate	Students select a topic
Teacher defines learning results	Teacher and students negotiate learning resuls	Students define learning results

2.2. INTERDISCIPLINARITY

Based on the thinking of Fazenda (2008), interdisciplinarity cannot be defined only as the union of two or more disciplines, the term interdisciplinary is much greater than that, it is attitude, it is boldness, it is believing in the search for knowledge. It is the relationship of epistemological concepts and procedures of the disciplines involved, which will lead "to the search for disciplinary scientificity and with it the emergence of new epistemological motivations, new existential frontiers" (FAZENDA, 2008, p. 18).

The author highlights the need for a meticulous review of the disciplines included in the method, as well as the knowledge they attend and train, which often makes the teacher to reconsider his own practices and skills. Fazenda (1998) states that it is necessary to abdicate the colloquial way of the teacher to conduct his discipline and to overcome the deviations from this change.

Of equal importance, Tavares (2008, p. 136) lists interdisciplinarity in contemporary times, stating that it is one of the requirements of the modern world. The author highlights dialogue as the basic assumption of the method and recommends it to be "reflective, critical, enthusiastic, who respects and transforms". The teacher starts to "contribute to awakening the search, research and development of new skills" and not only transmits information within the classroom. Currently, both are points of construction for individuals in relation to their identity, autonomy and experience.

2.3. SIGNIFICANT LEARNING

Ausubel, Novak and Hanesian (1980, p. 34) state that "the essence of the significant learning process is that the ideas expressed symbolically are related to the information previously acquired by the student" inside and outside the school and among his peers.

The authors suggest that learning can be contained in two dimensions, the significant and the receptive, and they call receptive (expositive) learning as automatic and learning by discovery as significant and link them, although both are considered significant.

Taking into consideration significant learning, the authors highlight the need to create two conditions: the student should be able to relate the information obtained by his / her existing knowledge structure and, "if the learning task itself is potentially significant" (AUSUBEL, NOVAK and HANESIAN, 1980, p. 3 and 4).

In this context, the authors emphasize that, although the students are the protagonists of their learning, the school and the teacher are not extinguished from their obligations. They must be prepared to

guide classes and provide a planned school curriculum, so that it is possible to identify the correct learning method for each moment.

3. METHODOLOGY

3.1 Methods

This academic work was carried out through the application of ABPj and DSR methodologies, leading the students in the laboratory of a "Science Fair", whose theme was Sustainability. The work was developed based on the teaching strategy of Significant Learning (AUSUBEL et al, 1980) and Interdisciplinarity (FAZENDA, 2008; TAVARES, 2008).

Students, as a group, developed tasks in order to create a solution or an idea for the problem and its product, such as: sharing responsibilities, researching, collecting and synthesizing data and information, discussing, making decisions, correcting deviations along the way, etc.

Thus, students were offered the opportunity to develop various skills and competences, for example: communication, technology, group process, planning, problem solving, critical thinking, task management and self-management (BENDER, 2014; BACICH and MORAN, 2018).

3.2 Development

The target audience was 27 students from the 5th year of elementary school at a public school in Vale do Paraíba, state of São Paulo. The interdisciplinary work was developed during 4 weeks, adapting the schedule according to the number of classes of each discipline.

Initially, the Project Map (Table 3) was created, which is an indispensable schedule to guide teachers and others involved. Then, it was made an analysis of the previous knowledge of the Sustainability theme with the 27 students, through a questionnaire with five dissertation questions and an illustrative question (Appendix A).

Table 3. Project Map: Science Fair - Sustainability.

Phases		Tasks
Project creation	Stage 1	Meeting with the coordination and direction to present the idea
	Stage 2	Elaboration of the project map
	Stage 3	Meeting with teachers, coordination and direction to present the project
Initial accompaniment	Stage 4	Survey of previous knowledge of the theme "Sustainability"
	Stage 5	Historical understanding of the context to be studied
Starting the project	Stage 6	Lecture with the Secretary of the Environment
Interdisciplinary and interventional actions	Stage 7	Search: Garbage Collection
	Stage 8	Presentation of statistics and creation of materials (tables and graphs) with data collected (garbage collection)
	Stage 9	Conversation circle: Being sustainable
	Stage 10	Textual production: Being sustainable

	Stage 11	Production of sustainable games with recyclable material
Deepening the theme	Stage 12	Formation of productive groups
	Stage 13	Research and choice of sustainable experiences to be presented at the event
	Stage 14	Conversation between teachers and groups - mediation
	Stage 15	Study and test of experience - extra-class
	Stage 16	Presentation of reports with the script of the works (experiences)
	Stage 17	Making recyclable note blocks - a souvenir of the fair
	Stage 18	Donut production - sustainable dynamics
	Stage 19	Science Fair - Sustainability
	Stage 20	Conscious disposal of materials used at the fair
	Stage 21	Evaluation in Likert scale

The students answered the questions based only on their prior knowledge, without the aid of research or any external and / or supplementary content. Subsequently, the data were treated and analyzed quanti-qualitatively, thus establishing the starting point for preparing this study.

Continuously, the work of teachers with students in promoting interdisciplinary interventional actions was contemplated, through different didactic strategies: historical understanding of the need for sustainable actions; lecture with the municipality's environment secretary addressing the topic in question; research on selective garbage collection; presentation of statistics and creation of tables and graphs with data of garbage collections by capitals of the Brazilian states and types of garbage (blue: to papers and cardboard; green: glass; red: for plastics; yellow: for metals; brown: for organic waste; black: for wood; gray: for non-recycled materials; white: for hospital waste; orange: for hazardous waste and purple: for radioactive waste), conversation circles and textual productions about the quality of “Being Sustainable”, encouraging the exercise of environmental education; elaboration of entertainment games with recyclable material “Sustainable Games”, for the whole school community to play on the day of the “Science Fair” and the elaboration of the event.

As a first step for the elaboration of the “Science Fair” event, the students were divided into productive groups and, with the help of the Informatics teacher, they researched and chose the experiences they would like to study and present during the work. The main criterion for choosing experiences was loyalty to the theme “Sustainability”.

After choosing the experience, there was a conversation between the teachers and the small groups to resolve the remaining doubts about the work. The study of the experience was carried out extra-class, the small groups had a week and a half to prepare for the presentation and, during this period, they were asked to build reports with the dissertation of the work scripts at each meeting (Appendix B).

In class, students made notepads with recyclable materials and produced donuts for the entire school community through a “Sustainable Dynamics”.

In the “Sustainable Dynamics”, the students explained to their colleagues that they could not eat all the donuts in the pot without first ensuring that everyone had acquired at least one donut to taste. As a result

of this action, we sought to arouse the interest of other children in the theme of the Science Fair, as well as to work on some of the skills of BNCC - empathy, cooperation, responsibility and citizenship (BRASIL, 2017).

The holistic presentation of the study occurred on the day the culmination of work, entitled "1st Science Fair - Sustainability". In this sense, the students presented the studied experience to colleagues in the school community, encouraged the public to play with the 15 "Sustainable Games" (handmade work with recyclable material carried out by students directly involved in the work) and distributed souvenirs: diaries with recyclable material (another artisanal work, with recyclable material, carried out by the students directly involved in the work) and cactus seedlings (donation from third parties), planted in pots adapted in egg cartons.

After the end of the event, there was a concern by the students to perform the proper disposal of all material used at the fair. A separation of the material used was carried out and a disposal was offered to the sector responsible for collecting recyclable waste in the municipality.

The project was assessed using the Likert Scale, as shown in Table 4 (an example of a result from the data in group 7).

Table 4. Group 7 evaluation on a Likert scale.

	Group 7 - Plastic made with milk				
	I totally disagree	**I disagree**	**I neither agree nor disagree**	**I agree**	**I totally agree**
The group demonstrated clarity in the concepts presented in its work					X
The group organized an appropriate presentation that made everyone understand the presentation clearly					X
Presented science, sustainability and environment concepts in a fun and engaging way with the use of new technologies					X
Did the students demonstrate teamwork?					X

Concomitantly, students also evaluated their own work and the method, according to Table 5 (an example of a result from the data in group 1).

Table 5. Group 1 evaluation on a Likert scale (Adapted from Buck Institute for Education, 2008).

	Group 1 - Soil permeability				
	I totally disagree	**I partially disagree**	**I neither agree nor disagree**	**I partially agree**	**I totally agree**
ABPj facilitated learning of the concepts of science, sustainability and environment				X	
The use of ABPj made learning more motivating				X	
All group members participated effectively in all stages of the project			X		
The success of my group depended on the union between its members				X	
Everyone in the group fulfilled the tasks established at the beginning of the project				X	
All conflicts experienced by the group were overcome in a coherent and respectful manner			X		
I consider my participation to be important and highly relevant, attending the needs of the group					X
My ability of written and oral communication was challenged in this group					X
The tasks were well defined and everyone worked on the assignments received					X
My ability to use new technologies was challenged in this project					X
The necessary knowledge for the development of the project was found in several ways					X
The presentation of the work to teachers and colleagues helped in my learning					X

4. RESULTS AND DISCUSSIONS

The questionnaire answered by the 27 students included basic questions regarding the need for sustainable actions for living and surviving on the planet.

Through the questionnaire, it became evident that, in general, the student did not know the meaning of "Environmental Sustainability" and the functionality of a "Science Fair".

It was important to note the enthusiasm and commitment students to prepare, organize and execute the first Science Fair of the institution, using only simple and reusable materials, with the function of minimizing environmental problems in nature. This activity also included practice, a fundamental element in Significant Learning (AUSUBEL, 1980), in an interdisciplinary way (FAZENDA, 2008).

Figure 1 shows the dedication of the students, preparing the donuts for “Sustainable Dynamics”.

Figure 1. Preparation of donuts for “Sustainable Dynamics”.

During the development of the dynamics, observed in Figure 1, it was noticeable the adequate and respectful attitude of the students towards the other classes of the institution. The students, directly involved in the work, did not hesitate to explain to their colleagues that the scarcity is generated from the moment when some individuals take possession, accumulate and retain resources without observing and without being responsible for the needs of the group.

These students, with behavioral maturity, explained to their colleagues that each individual is responsible for the living conditions of the group to which he belongs. They added that the individual attitude is reflected in the whole: the greater the centralization of resources, the greater the general scarcity. The greater the awareness of the whole and the importance of sharing, the greater the abundance in distribution and fostered that, using natural resources with the consciousness that all people in the community, animals, plants, the health of water, air and soil depend on personal attitude and this can be called a sustainable attitude.

Figure 2 shows the environment prepared for the execution of the “1st Science Fair” and the expectations of students from the school community.

Figure 2. Expectation of the audience for the beginning of the presentations.

Figure 2 shows the expectations of the students indirectly involved in the work and the organization of the environment, as this was an important moment for everyone.

During the presentations (Figure 3), there is a significant involvement of the students, mainly by bringing playful elements, which were given opportunities within a context more artistic. The children were able to use their creativity to represent different situations, according to the subject worked, along with the teachers' interventions, making the presentation of sustainable experiences.

Figure 3. Presentation of students at 1st Science Fair of the institution.

Using sustainable experiences: wall paint with clay, plastic of milk and potatoes, water purification, soil permeability, milk glue, deodorant and homemade filter, students were able to demonstrate the appropriation of their knowledge on the subject through suggestions designed to solve or minimize problems in the relationship between man and the environment.

This type of presentation, more freely and without strictly traditional elements, was one of the highlights of the work, in view of which allowed an expansion of the imagination of the students involved (directly and indirectly at work). The presentation of the concrete provided an analysis beyond the measurements, with which it was possible to capture the enchantment of those involved.

Still in this context, it was interesting to notice the students' ability to demonstrate to their colleagues, in a protagonist way, what they had built up from learning.

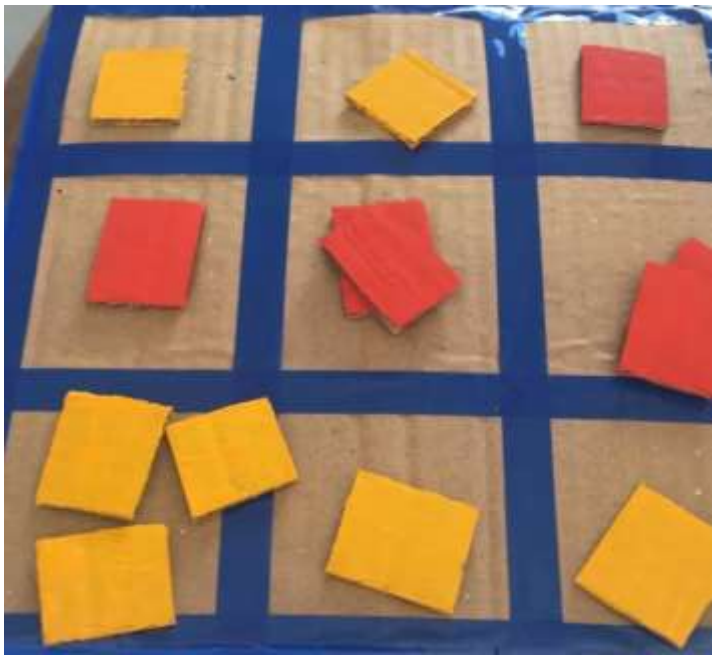
In general, observing the presentations, it was possible to verify that the class developed within the learning process, demonstrating consciousness to control the impact of environmental problems in the coming years.

Another conscious practice could be observed in offering playful activities with "Sustainable Games", such as puzzles (Figure 4) and Tic-tae-toe (Figure 5).

Figure 4. Sustainable Game: Puzzles.

The puzzle game (Figure 4), made with popsicle sticks painted with the rest of fabric paint and the Tic-tac-toe game (Figure 5), made with cardboard box painted with gouache paint and adhesive tapes, were the girls' favorites.

Figure 5. Sustainable Game: Tic-tac-toe.



Another favorable point of the event was the distribution of souvenirs (Figure 6) to students in the school community.

Figure 6. Souvenirs from the "1st Science Fair - Sustainability".

During the distribution of souvenirs at the event: diary, made with leftover fabric and shoe boxes, as well as cactus seedlings in egg cartons (Figure 6), the students had the opportunity to show a little more about the works that they developed with the help of Portuguese and Art teachers.

Considering the results of the evaluations and relating them to the applied methodology based on Significant Learning and Interdisciplinarity, it is possible to verify the effectiveness of the activities developed and the success in achieving the objectives of this work. In general, this was corroborated in the questions of the test during the work, in which the students demonstrated to have acquired greater apprehension of the knowledge when they are placed in the center of the teaching-learning process.

According to the observations made in the course of the work, it is possible to affirm that the practical activities considered non-traditional, that is, those that distanced themselves more from the usual and everyday models linked to the simple transmission of concepts by the teacher, showed greater commitment from students with regard to their participation. When the practice was more evident, for example in the presentation of experiences, there was clearly greater interest and involvement of the students.

Another factor that should be highlighted positively was the target audience, 5th grade students in elementary school, a good choice for applying the work, as this school level responded satisfactorily to the type of method chosen and to the proposal for consciousness, guidance, education and re-education environment, in a playful and didactic way, favoring the construction of knowledge by students in the protagonist guise.

5. CONCLUSION

Considering all stages of the work and the effective participation of students due to the application of a methodology that allows the centralization of students in the production of their own knowledge, student participation was significantly productive, demonstrating the importance of expanding this type of methodology in classes.

It was possible to notice that during the development of the work, specifically when school subjects are worked in a different format from traditional expository classes, students have a greater participation and involvement in daily activities, which allows them to build their own knowledge.

In this way, the results obtained in this work confirmed the effectiveness of the methodologies adopted, which consequently resulted in the success and the achievement of the proposed objectives.

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Appendix A. Questionnaire to survey previous knowledge.

Student's name: _____ Age: _____
Responsible name: _____ Age: _____
Date: __ / __ / 2019

What I know!

1. What is environmental sustainability? Explain.

2. Why should you care about the environment? Argue.

3. Tell me some of your ecologically correct attitudes.

4. What is a "Science Fair" for? Opinion.

5. Have you participated and/or attended a "Science Fair"? Comment.

6. Sustainability serves as an alternative to guarantee the survival of the planet's natural resources, while allowing human beings and societies ecological development solutions. Illustrate what you understand about the term sustainability.

Appendix B. Report of the extra-class study.

Student's name: _____ Age: _____
Responsible name: _____ Age: _____
Data: __ / __ / 2019

Work Script

1. Experiment Title: _____

2. What did the pair think of this experience? Justify.

_____
_____
_____
_____

3. How did the duo develop the proposal? (Observations that were made as the duo structured the experiment.)

_____
_____
_____
_____

3. From the experiment, what could you prove?

_____
_____
_____
_____

4. Draw the duo's experience.