BOTANIC GARDENS, PEOPLE AND PLANTS FOR A SUSTAINABLE WORLD

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FOLLOWING THE 8TH EUROGARD CONGRESS
HELD IN LISBOA, MAY 7TH-11TH 2018

Edited by
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Revised by
Members of the Scientific Programme Committee
8TH EUROGARD CONGRESS SECRETARIAT

FROM BOTANIC GARDEN TO THE SCHOOL: NATURAL SCIENCES WITH THE IBSE METHODOLOGY OUTSIDE CLASSROOM

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ABSTRACT
Non-formal educative settings, such as gardens and museums, as well as the Inquiry-based Science Education (IBSE), a multifaceted and student-centered methodology, play an essential role as tools for Education. Based in the educative experiences in a Botanic Garden, our aim is to study the integration of IBSE outside classroom in a formal Portuguese school context. The goal is to understand the impact of this methodology in Natural Sciences learning, and in the opinions and educative products of 10 to 12 years old students.
Within a partnership with a School and a Science Teacher of the Portuguese 5th year level, and trained in IBSE, seven thematic classes on biodiversity and sustainability were taken from an Educational Program developed in Coimbra Botanical Garden. Fulfilling the curricular demands these lesson plans were integrated in the classes during the three school periods and adopted and adjusted to the existing conditions and resources.
The cognitive learning of the students in the Natural Sciences topics, and their opinions, were regularly monitored, validated and statistically evaluated by seventy-two pairs of pre and post-questionnaires and also analyzed in a semi structured interview with the teacher.
The results proved a cognitive improvement of the students in all curricular themes evaluated, as referred elsewhere. The emphasis is now to highlight the positive feedback from students and their teacher view on the work developed. After completing the innovative approach in class, the motivation involved 92% of the students, responses in 99% of them and new learning felt by all; 89% of the students showed satisfaction in the activities experienced and in the documents produced. Favoring questioning, both the teacher and the students want to continue this teaching and learning format at School, as an enlarged and creative alternative for Natural Sciences understanding. Moreover, lesson plans, new botanic thematic and the resources produced are replicable by other educational communities and diverse stakeholders, directly, or as ideas to new activities for schools.
Applying those educative strategies on a regular basis outside classroom, either in a museum, a botanic garden or a school garden, will improve knowledge, encouraging imagination and a stronger sensitivity for nature, plants and their importance for life.

KEYWORDS
Active Learning, Curricular Innovation, Experimental Practices, Non-Formal Educative Settings

INTRODUCTION

Conceptual framework - WHY this research

The educative processes with IBSE lessons outdoors, being or not guided by a formal curricula, are flexible and adapt to the needs and interests of the students, who can gain a human-nature connection and develop greater environmental awareness. Being an active, experimental and student-centered educative methodology, IBSE imitates the scientific research and it is characterized as a multifaceted activity. Students use the same skills as the scientists, like questioning, data collection, reasoning, proof review in the light of what is already known, drawing conclusions and discussing the results (Artigue et al., 2012).
IBSE means that students progressively develop key scientific ideas by learning how to investigate and build their knowledge and the understanding of the world around, based on the students' work and physical and mental realities and background. Put a question, find an answer, go further, and grow. If you ask, you want to know. The more I know, the more there is to learn: this is the attitude of a scientist (Tavares, Silva, & Bettencourt, 2015). IBSE is based in a constructivist

cognitive development model where the construction of knowledge implies hands-on, heart-on and minds-on stimulation, increasing the students' curiosity and creativity (Tavares, 2018).
Also, non-formal education environments, such as gardens or museums, are especially relevant in Science Education, for the construction of knowledge is enhanced when using these educative settings, typically outside classroom (Ainsworth & Eaton, 2010; ASE OSWG, 2011). It is known that these outdoor experiences are positively reflected on the academic performance of each student, increasing awareness to new options, in a transversal way: as an apprentice, for professional career, as political and socially active citizen (Beatty & Schweingruber, 2017; Matteman & Damsa, 2017).
Natural Science with IBSE outside classroom stimulates a first-hand experience, the appreciation of nature as a whole, a tighter relationship, promoting greater motivation and engagement for action and knowledge and environmental reflection (Tavares et al., 2015). Going to Nature as a starting point, and using it as a practice of daily life, combines with the main characteristics of IBSE methodology, which values pre-existing knowledge and a new perspective of open and team-social teaching, where the individualities of students and teachers must be taken into account, respecting each singularity (Malm, 2009; Pessoa, 2013). The two components - an environment outside classroom and a student-centered methodology - facilitate and improve the educative process (Tavares et al., 2015), where storytelling is an important tool to consider (Bedford, 2001; Tavares, 2017).

WHAT to investigate

A project promoted by the Centre for Studies in Human Development, Faculty of Education and Psychology of the Catholic University (Porto) to understand the impact of IBSE outside classroom in a real School context with young students (10 to 12 years old - 5th grade) and concerning three main levels: cognitive learning, opinions and attitudes and the work produced.

MATERIAL AND METHODS

HOW to implement

By a partnership with a School and a Science Teacher trained in IBSE and the students of the 5th grade (first year of the second cycle of basic education): a sample of 75 students of the 3 classes- A (25), B (26) and C (24). Fulfilling the curricular program (Caldas & Pestana, 2010), seven topics on biodiversity and sustainability (Table 1) were taken from the Educational Program developed in Coimbra Botanic Garden (Tavares, 2015) and adjusted to the school resources and conditions.

Timetable

The educative project was developed during three phases of a complete scholar calendar: 1st- partnership and arrangements of themes in school (April and May, previous to the project implementation at school); 2nd- application, monitoring, collection of results, and evaluation (September to July); 3rd- organization of the documents produced (June and July).

Assessment Tools and Procedure for Students' opinions and attitudes:

A-Students' Questionnaires

Regular evaluation of 72 valid pair of pre (1st term) and post (2nd term) questionnaires with five question, anonymous, were answered within 15 minutes. The 1st and 2nd questions were closed and the last three were open questions. The answers' contents were grouped by similar subjects in a maximum of 8 items, and assessed by simple statistical analysis.
There were five main items for students' opinions and attitudes: 1- Motivation for learning; 2- Actions generated in the students or the students 'proactivity; 3- Impacts on learning in general; we want to know if students think they learn more; 4- The degree of satisfaction with the methodology; if they liked to work in this way and why; 5- Suggestions for other improvements in the classes.

B- The work produced

During the three school terms of the project implementation, the students developed their work following the seven curricular topics, as referred in table 1.

C- Interview with the teacher

To understand the lived experience and the opinion of the teacher on the impact of the IBSE outdoors classes in the students' feelings and learning, a semi-structured interview (Amado, 2013) was implemented with her, at the end of the scholar year and the project implementation.

Seven curricular topics /nº of IBSE sessions
1st Term: 4 themes/10 sessions
1- Plant diversity. *The algae who wanted to be a flower*/2
2- The leaves. ***The Autumn color's in the garden leaves*** /3
3- The flower *is also a mother* /3
4- Stems, form and function of the plant organs. *Shall we hug the trees?* /2
December: Revisions; discussion of the students' projects on plant diversity; storytelling; exchange of books. Christmas homework: to write lyrics for a song on plants evolution.
2nd Term: 3 themes /10 sessions
5- The cells and DNA. *The beginnings of life* /5
6- Classification and taxonomy. *Plants have a family too*/ 3
7- Explorers. *Scientists in the school*/2
3rd Term
Exhibition of the students' texts and drawings on the *"Algae-flower"* story. Composition of the song "the alga's dream" with the music teacher, based on the verses written by the students. Helping 6th graders students learn the song. Competition for the best plant label made for the school gardens. Celebration of Earth day (May 22nd): the students place the labels in the garden plants. *"The algae's dream"* song performance at the end-of-the-year school ceremony (https://www.youtube.com/watch?v=SDypuKHtzRs - 27th May2016), interacting with the audience, all educative community (students, parents, friends, teachers and school staff).

Table 1: School chronogram of the 5th grade curricular topics and IBSE sessions

RESULTS

Concerning the cognitive learning there was a good level of knowledge in all curricular topics reflected in a change from 0% correct answers in the pre questionnaire to 70-90% in the post questionnaire, as referred elsewhere (Tavares, 2017).

This paper focuses students' opinions and attitudes (A) the work produced (B), expressed from Figures 1 to 11, respectively, and the reflections within the teacher interview (C).

A-Results in the questionnaires on students' opinions and attitudes are as follows

Comparing the questionnaire's results on question 1 (Fig.1), the motivation of students was already high (85%) during the launch of the project, in the 1st term, and was even greater at the end of the 2nd term, with 92% of them. All students were willing to collaborate, showing total enthusiasm, good will and motivation either for the activities developed or for the fulfillment of the questionnaires.

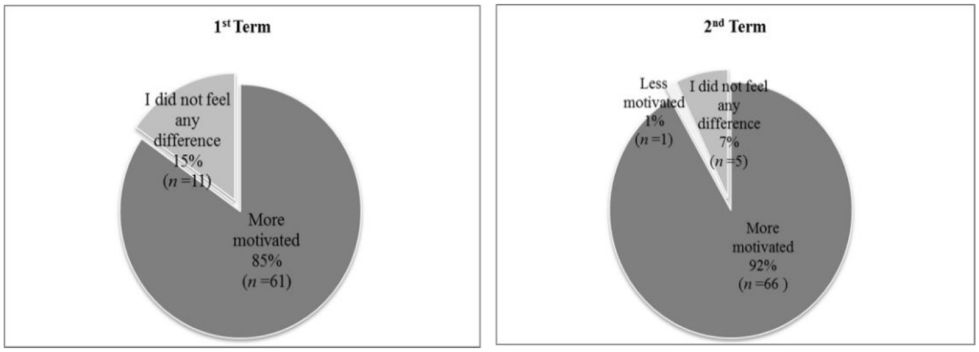


Figure 1: Results on Question 1: Motivation for learning

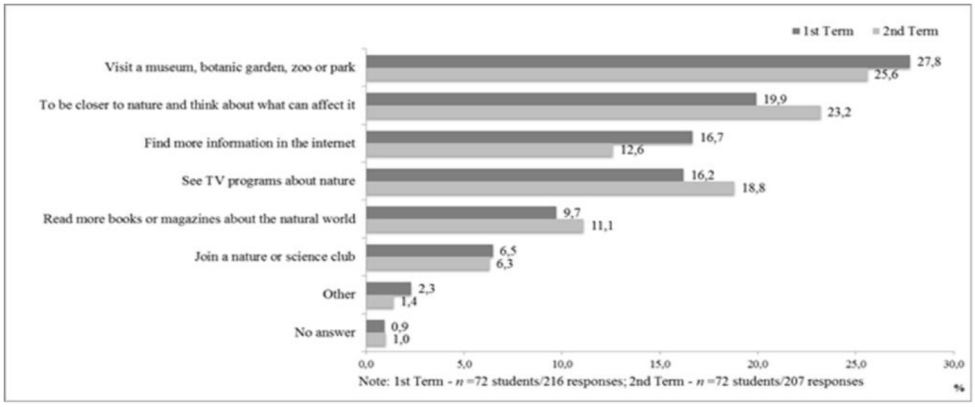


Figure 2: Results on Question 2: Impact in the students 'proactivity'

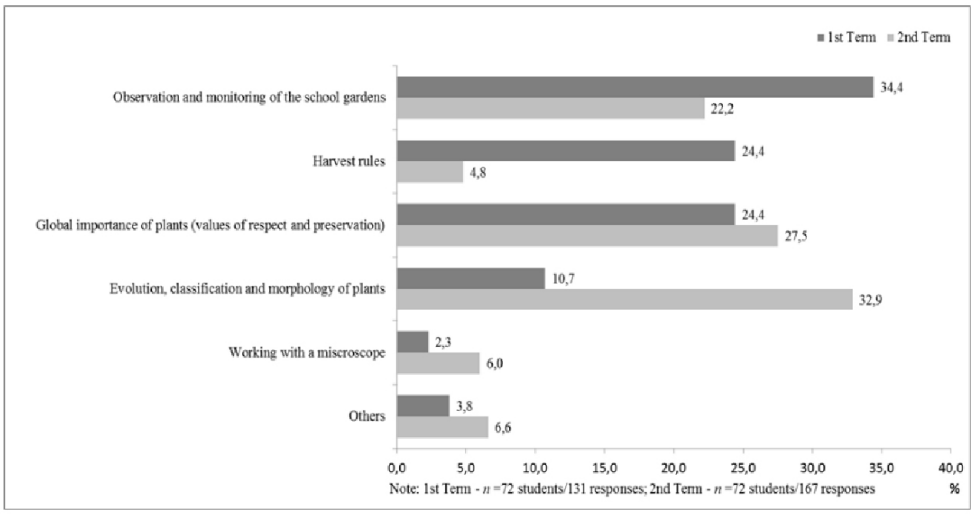
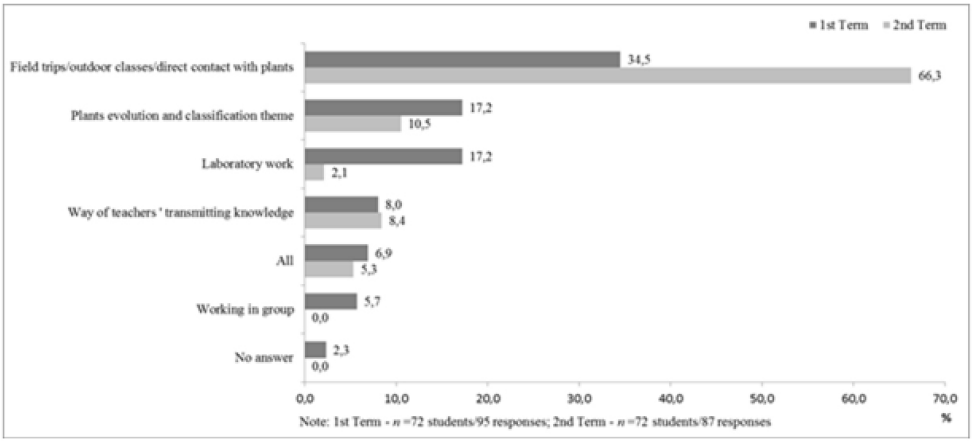


Figure 3: Results on Question 3: Impact in the student learning.



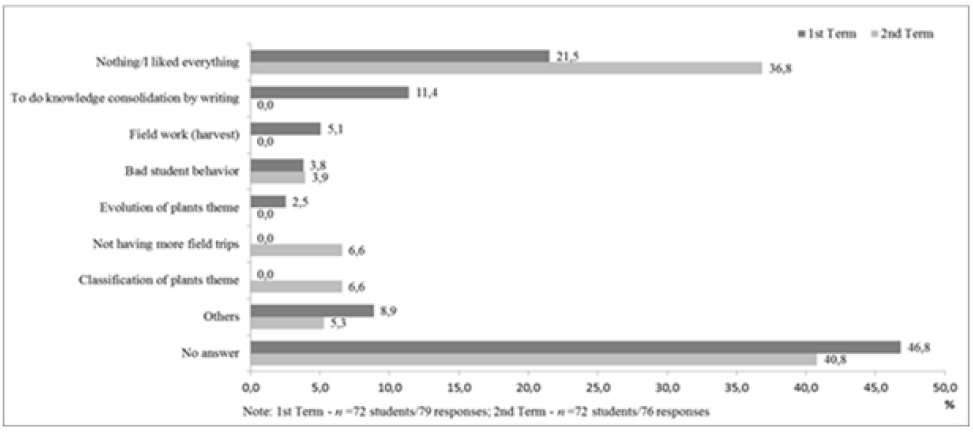


Figure 4: Results on Question 4: Satisfaction with the methodology. 4.1 - Positive points and 4.2. - Negative points

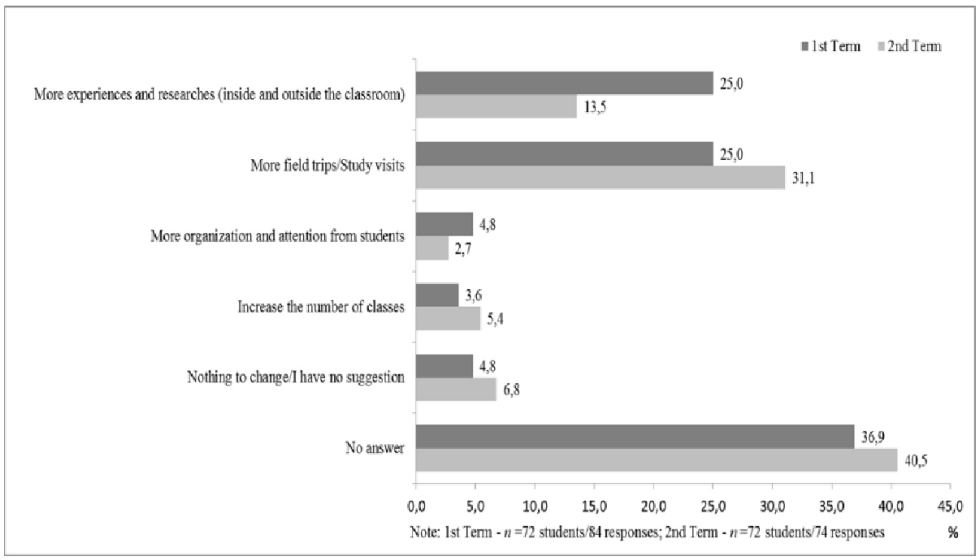


Figure 5: Results on Question 5: Improvement suggestions

The impacts and evidence of proactivity are visible with 99% of the students, as shown in Figure 2, and new learning convictions with thematic specification were revealed by 100% of them in Figure 3.

As Figure 3 reveals, the evolution of plants was an item learned represented a new approach achieved with success, and not previewed by the curricula, as is also corroborated by the answers in Figure 4.

The results of Figure 4 show complementarity of the questions in 4.1 and 4.2., showing high level of satisfaction of the students in the different items expressed and performed. As shown in Figure 5 there were 89% of students that demonstrated satisfaction in the activities experienced, in the classes' format, the products created

B- Examples of the Work produced by the 5th grade students on the seven curricular topics and IBSE sessions

Figure 6: Work produced on Topic 1: Plant diversity outside and inside classroom

Figure 7: Work produced on Topic 2 and 3: The leaves and the flowers outside and inside classroom

Figure 8: Work produced on Topic 4: Stems, form and function of the plant organs, outside classroom.



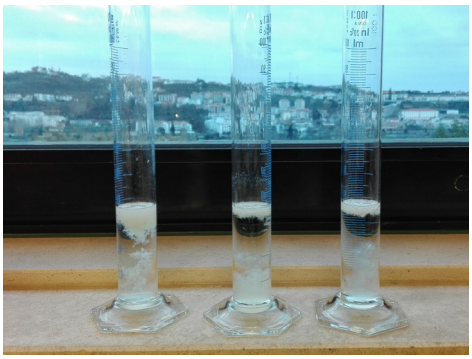



Figure 9: Work produced on Topic 5: The cells and DNA extraction, at the lab

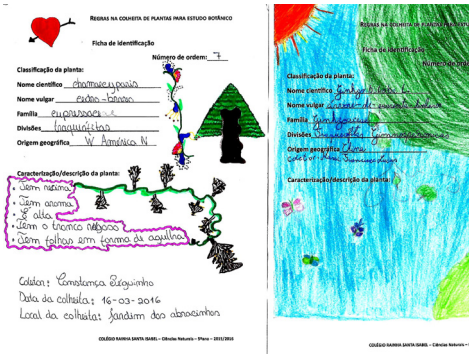
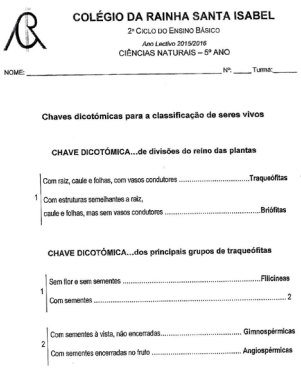


Figure 10: Work produced on Topic 6: Classification and taxonomy outside classroom.



COLÉGIO DA RAINHA SANTA ISABEL
2º Ciclo do Ensino Básico
Ano Lectivo 2015/2016
CIÊNCIAS NATURAIS – 5º ANO

NOME: _____ Nº: ____ Turma: ____

Chaves dicotómicas para a classificação de seres vivos

CHAVE DICOTÓMICA...de divisões do reino das plantas

1 Com raiz, caule e folhas, com vasos condutores ..... Traqueófitas
1 Com estruturas semelhantes a raiz, caule e folhas, mas sem vasos condutores ..... Briófitas

CHAVE DICOTÓMICA...dos principais grupos de traqueófitas

1 Sem flor e sem sementes ..... Filicíneas
1 Com sementes 2
2 Com sementes à vista, não encerradas ..... Gimnospérmicas
2 Com sementes encerradas no fruto ..... Angiospérmicas

Figure 11: Work produced on Topic 7: Explorers outside classroom and the construction of a dichotomous key for plants

and would like to have continuity in this type of classes during the next years to come. Students' perceptions were very positive in all fields, by the general high marks achieved in the answers 'percentages, and the outcomes produced, as will be supported by the next examples.

C- Teacher's Interview

The teacher's opinion on the educative experience was expressed in the final interview. Generally, the considerations related to the maintenance and obedience to the curricular programs and only a change in the usual sequence of the program items, linking to daily reality. Teacher commented that there was a better use of the school resources (e.g.- monitoring of the cycle evolution and morphology of plants in the gardens) with the great opportunity to share experience and knowledge with the other teacher partner. Also, a good and enriching collaboration in the educative process was expressed by improvement of the student's satisfaction and the learning achieved, as this format was well received by them and generated a differentiated and enthusiastic response enhancing them to learn willingly. The new educative tools and strategies constitute very positive points as there was creativity in the work produced and that is reproducible, being these considered one of the best educative attainments.

On this experience, the teacher could consider three main points: a professional improvement; a creative, complete and innovative alternative for Natural Sciences in Primary Education; and new educative products to be functional in further classes.

CONCLUSION

The novelty of this study relies on a plan integrated during one complete scholar calendar in the current Portuguese school format, not disturbing the organization of the lessons neither in terms of time nor curriculum accomplishment. It was possible to empower the students, making them the main protagonists of the education process by a day-to-day discovery of meanings, interpretation, understanding and assessment of the case-studies at school, according to the curricula targets.

By using and exploring the "nature reality" expressed in the gardens, laboratories and resources of the School, knowledge was stimulated, and also the fascination and awareness for the importance, diversity and sustainability of all living organisms. An important emphasis and an innovation for the plant's knowledge was undertaken as crucial, as sometimes this is an item under consideration by the educative community.

Reinforcing and refreshing the formal context of the

school, this research in partnership on educational practice of the Portuguese educative systems, could link the universities with school, teacher, students and all the school community, producing professional satisfaction and innovation for the teacher and the school, and a global preparation of the students. Regarding the everyday family collaboration in the home-work and cultural and social practices within the school community and the final year party (Table 1), besides amplified emotional engagement with science by new interactions with students (Aunola et al., 2013; Fleer et al., 2016), could linked wiliness and partnership to learn and to achieve tasks, empowered by a group team work efforts, a positive point refer also by students in Figure 4.

As our practices evidences reveal, the current education system allows integrating non-formal and informal elements that should be gradually incorporated by formal education, so as continually to meet the needs of student and teacher, and of the individual and society realities. Teachers did not feel reluctant to use outdoor resources as a teaching environment, as well as the students. On the contrary, they always felt very comfortable and enthusiastic any time they went out of the classroom, a particularly efficient action when students produce the labelling of the school gardens (Table 1; Figures 3, 4, 6 and 10). Similarly, this case study points to the current and real positive possibility of crossing non-formal Science classes outdoors with IBSE, respecting the formal curricular development. The teacher stated that the formalisms was relevant to organize, to plan and monitoring the state of the students' knowledge, as much as non-formal features adoption, like alteration of the order in the curricula items presentation, being all decisions made to make Science lessons more compatible with alive outside resources, that is to say, with world reality outdoors.

As futures perspectives the Science museums, botanic gardens or school gardens are paramount as outside classroom settings for Natural Science teaching and learning practices. The lesson plans and resources produced are replicable and instruments to other educational communities and the achieved outcomes even justify the proposal for a new curricular unit on botany, at first grade primary school level, on simple concepts of the differentiation and the evolution of the plants. Finally, and as both the teacher and the students referred, Science outside classroom with IBSE should be adopted on a regular basis at School.

An open system with different environment arrangements can and should be adopted to allow the "entrance" of more creativity and a diversity of thinking, opinion and points of view, dealing with IBSE methodology indications, empowering the initial interest level and motivation of students. To use the gardens of the school, for the study and understanding of plants' morphology and diversity, adapting the circumstances and educational models to the concepts to be taught, was an example to meet their expectations and needs and provide them the more adequate institutional support and resources. Relaying into the natural resources and "tools'' of the "real world" around us, changing every day, reality is a true question to follow and new Nature interpretations and meanings can achieve relevant answers to real problems.

The students are by nature curious and eager for news, ready for the curiosities around them, and for the moment. Why not use the powerful changing reality that nature permanently gives us every moment, to know, to interpret and to found knowledge? By awakening and building tastes and trends for their paths, students draw their personal tendencies early on in their careers for the future.

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