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Vermicomposting: an Idea to Work Science and Mathematics in Primary Education

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Abstract

The Portuguese curricula point out the importance of interdisciplinarity when teaching in primary education, namely between Science and Mathematics [1]. In pre-service teaching, students should experience ways of promoting this kind of work. Inquiry Based Learning (IBL) is a pedagogical approach that engages students in new discoveries and allows the connections between these two sciences [2]. This investigation emerged from a joint work in two curricular units under Master's Degree in Preschool and Primary Education – Experimental Science Practices and Methodology for Teaching Mathematics. From a contemporary science issue proposed by students – what to do with the leftovers from home meals – they started an investigation towards a clean and environmentally friendly solution. The aim was to design and implement an IBL activity for 3rd grade; students themselves should also go through all IBL's stages. Mathematical knowledge should be used and integrated all along IBL work. We assumed an interpretative paradigm [3] and developed an action-research project [4]. The participants were the three students that developed this theme and the teachers from both curricular units, which acted as tutors along this work. Data were collected through documents' investigation, experimentations, observation, students' protocols and informal conversations. The procedures were developed in four phases: (1) the initial investigation performed by students allowed them to choose vermicomposting as the most suitable solution; (2) design of a proposal task to implement in the classroom, following IBL stages; (3) development of the proposal simulating what it is expected in a 3rd grade class; science and mathematical knowledge were used to collect, interpret and conclude about data obtained. In practical terms, a worm bin was built, species were selected and conditions for vermicomposting were studied; and (4) from the results and conclusions taken, a second investigation was performed (importance of compost for lettuce growth). During all the procedures, technical and scientific rigor was taken into account. The results shaped that these investigative activities promote scientific reasoning, critical sense, curiosity and introduce students to the scientific method, therefore, developing scientific and mathematical literacy. All the activities promote interdisciplinarity and stimulate student's participation, exploration, and development of abilities and competencies.

Keywords: *Science Education, Mathematics Education, Interdisciplinarity, IBL*

1. Introduction

Several studies have associated teaching approaches with the disinterest of children and young people in sciences [5, 6, 7]. In addition, relevance has been given to the unique role of the teacher in familiarizing students, from a very early age, with basic science concepts, contributing for a greater success at later levels of learning. These studies emphasize the importance of methodologies focused in the student, such as practical investigative work. Indeed, this is also a powerful way of working when we think about pre-service teacher education.

Inquiry Based Learning (IBL) is a valuable strategy for introducing students into small research activities, promoting the acquisition of scientific knowledge and scientific method [8]. It is built on students' natural curiosity, involving them in the formulation of research questions and in the conception of hypotheses that intend to answer the initial questions and which are the origin of research and activities developed under the guidance of the teacher [9, 10]. Finally, students have the opportunity to analyse the results, think of alternative explanations and have the opportunity to argue and communicate [11], developing the competencies highlighted in Portuguese curricula [1].

Although this approach has a positive influence students' learnings, Portuguese teachers have to cope with extensive curricula contents and external school evaluations, therefore not developing

this way of work in the classes. Moreover, in pre-service teacher education students also show resistance to this form of learning [12]. Accordingly, they will become teachers that will show little flexibility and will plan lessons mostly by the book or with no connection with the real, promoting no spaces for students' active participation, knowledge construction and critical thinking.

Although Mathematics is associated with lower academic performance and disinterest by students, one of the main contributions of it is the development of critical thinking and the ability to solve real-world problems. In primary education, students should begin to apply mathematical concepts to practical situations, developing the ability to analyse problems, identify patterns, make connections, and draw logical conclusion. Moreover, when students solve problems or other situations collaboratively, they develop communication competencies in order to learn to articulate their ideas clearly and effectively. But for this to be possible, teachers' practices should be different than usual and promote exploratory teaching [13]. Thus, this way of work with students should be presented for future teachers.

Thus, assuming interdisciplinarity, practices between Sciences and Mathematics could be a way to overcome these barriers once these subjects have a lot of common educational goals. The interaction between these two sciences allows students to integrate knowledge and develop abilities and competencies that are pointed out in 21st Century Skills for Students [14] and also in Portuguese curricula [1, 15, 16]. This way of work is only possible if there are two kinds of collaboration: (1) between teachers in order to align educational goals of these two subjects and to implement a joint IBL approach in their classes; and (2) between students in which they are involved in an IBL strategy both as learners and as future teachers.

This paper describes a joint work in two curricular units of the Master´s Degree in Preschool and Primary Education - Experimental Science Practices and Methodology for Teaching Mathematics – in a private Higher Education Institution in Portugal. The main goal was to develop an IBL approach, from a contemporary science issue proposed by students, in which they integrated mathematical knowledge all along the investigation.

2. Method

In this work, we assumed an interpretative paradigm [3], since it was intended to produce knowledge through the students' investigations unveiling the interpretations that they elaborated about the study theme. As for the design, we developed an action-research project [4], since it was intended to intervene by changing the ways in which students and teachers act regarding the involvement in IBL activities.

The participants were the three students and the teachers from both curricular units that acted as tutors along these classes. During whole process, teachers work collaboratively in the planning, orientation and supporting all phases of the work. Data were collected through documents' investigation, experimentations, observation, students' protocols and informal conversations.

The procedures were developed in four phases: (1) the initial investigation performed by students allowed them to choose vermicomposting as the most suitable solution; (2) design of a proposal task to implement in the classroom, following IBL stages; (3) development of the proposal simulating what it is expected in a 3rd grade class; science and mathematical knowledge were used to collect, interpret and conclude about data obtained. In practical terms, a worm bin was built, species were selected and conditions for vermicomposting were studied; and (4) from the results and conclusions taken, a second investigation was performed (importance of compost for lettuce growth).

3. Results

Several studies have associated teaching approaches with the disinterest of students as learners and as future teachers in sciences [12]. To overcome this, we have been implementing IBL as one of the teaching approaches developed in Master classes of Experimental Science Practices and Methodology for Teaching Mathematics curricular units. This fulfils a double goal - to introduce the IBL methodology to our students and to guide them into designing a proposal for their future students, also using the same methodology.

3.1 The pre-service teaching practices – College students as learners

The proposals of our classes are usually developed into five moments that include the various stages of the IBL methodology, with different goals, which are described below. In the first moment, in both classes, students are confronted with IBL methodology in a theoretical perspective. Moreover, they are asked to think about the connections between this methodology and the exploratory

mathematics teaching [13], which have a lot of points in common, namely the collaborative work, the active learning and discussion of ideas or argumentation.

The second moment is characterised by the theme choice, according to the criteria proposed by both teachers: (1) contemporary science issue; (2) suitable for the curriculum of primary education; and (3) not usually worked in primary education classes.

The following moment is related with the investigation and discussion performed by the students guided by the teachers. In this phase, which includes discussion of existing knowledge within the group, guided and autonomous research, our students manage various sources, and which allow them to obtain a wide range of information about the theme – in this case, vermicomposting – which is fundamental for establishing the most suitable experimental conditions and designing their activities. After the research activities, our students often realise that some of their ideas and knowledge are incorrect and point out the importance of acquiring/correcting/developing knowledge in their own learning process. At this stage, they show some initial difficulty in selecting reliable sources of information and the relevance of the information gathered.

The fourth moment corresponds to the design of an interdisciplinarity proposal activity to be developed in primary education in a specific grade, which is presented in the following section. All this work is developed under the guidance of both teachers in the classroom. In the fifth and last moment, students present and discuss the proposal in the classroom in the presence of both teachers, who collaboratively comment, argue and evaluate all the developed work.

3.2 The proposal activity in primary education – College students as teachers

The project was elaborated considering a 3rd graders group, enabling the developing abilities, competencies, and attitudes according to Portuguese curricula [15, 16]. As stated before, students followed an IBL approach that it will be described (Table 1).

Table 1: Developing the Vermicomposting project

Natural Sciences	IBL phases	Mathematics
Starting point: ▪ Food waste ▪ What can I do? ▪ Students and teachers started research activities	**Orientation**	Starting point: ▪ Calculate the amount of food waste produced per 3rd graders ▪ Calculate the amount of food waste produced by the 3rd graders
Discussion about: ▪ What is a vermicomposter? ▪ How do earthworms live? ▪ How does the decomposition process take place? ▪ What are the benefits of vermicomposting for the soil? ⬇ Build the vermicomposter (Fig. 1.) and define the variables (temperature, humidity, soil pH, amount of water, type and weight of residues added, and worm's weights)	**Conceptualization**	▪ Count and check the size and weight of the worms ▪ Measure the dimensions of the composter ▪ Analyse the characteristics of a parallelepiped ▪ Calculate the volume of the soil to be introduced ▪ Calculate the weight of waste to be put in per day
▪ Research using books and the internet ▪ Build the vermicomposter and observe the worms ▪ Record the evolution of the different variables in the researcher's diary (Fig. 2.) ▪ Check the evolution of the study variables	**Investigation**	▪ Record variable data in the research diary on a daily basis ▪ Check the results weekly and monthly (drawing up graphs and tables) ▪ Discuss the results using graphs and tables

	Conclusion	
▪ Some foods can lead to mosquitoes (avoid putting these foods in the classroom) ▪ Worm showed preference for some "food" ▪ Intake of organic matter is equivalent to worm's weight ▪ Different residues show different decomposition times ▪ Worm are less active with the reduction of humidity ▪ The variables change with time and type of waste ▪ Survival of worms is thermoregulated (withstand of extreme temperature limits - 0ºC and 35ºC) ▪ Humus is produced ▪ Vermicomposting allows human beings to reduce the amount of waste they dispose of		
	Investigation (part 2)	
▪ Is the humus produced important for the soil and plant growth? ▪ Deposit humus in different soils and plant similar lettuce. ▪ Compare the growth of lettuce.		▪ Compare the growth of lettuce (size and number of new leaf) ▪ Discuss the results using graphs and tables
	Conclusion (part 2)	
▪ Water must be increase in line with plant growth ▪ The soil enriched with composting (humus) alters positively lettuce growth		

The measures of the vermicomposter are illustrated in Fig. 1. The researcher's diary included several information: the worm species and its characteristics, the daily and weekly registration about the study variables, the analyses and discussion of data obtained (in tables and/or graphs), and the lettuce's growth evolution (Fig. 2).

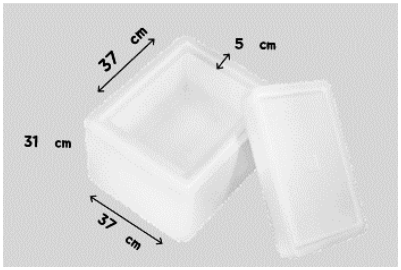

Fig. 1. Vermicomposter

Fig. 2. Researcher's diary

4. Final Remarks

Inquiry Based Learning is one of the approaches considered valuable when teaching science. However, it is not commonly used by pre-school and primary teachers in Portugal, in spite of it obvious advantages.

Several studies have associated teaching approaches with the disinterest of children and young people in sciences [5, 6, 7, 12]. In addition, relevance has been given to the unique role of the teacher in familiarizing students, from a very early age, with basic science concepts, contributing for a greater participation in society later on.

Moreover, there is a notorious difficulty for teachers to work collaboratively as they cope with strict curricula orientations and full class schedule, which does not allow them to develop

interdisciplinarity between knowledge. This is also the case for college teachers who need to organize and work between classes. Thus, the proposal presented in this paper represents an interdisciplinary approach and highlights the possibility of working all the curricular areas from a central science theme, overcoming the limits of time and rigid schedules of some institutions.

This proposal was a way to promote scientific and mathematical literacy since students were confronted to a contemporary environmental issue that they have to solve through scientific method. They were encouraged to experiment, manipulate, predict, hypothesize, register, interpret results and conclude using science and mathematics. We highlight that this task does not require any special material or equipment and can be easily performed in primary classes. This was one of our goals since most of our pre- and primary schools do not have laboratory equipment and materials.

At the end of this work, students acknowledged that this was more challenging and thought provoking than to work science and mathematics separately. To sum up, this represents a real solution for a real problem.

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