



## Using Nature of Science Enriched-PBL in Pre-Service Science Teacher Education

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### Abstract

*Learning methods such as Inquiry-Based Learning (IBL), Project-Based Learning (PjBL) and Problem-Based Learning (PBL) are adequate for Science and NOS learning since they promote several skills, such as questioning, communication, argumentation and cooperation. In this study, with 8 Master students, in science teacher education, we used an enriched-PBL strategy with aspects of Nature of Science (NOS), since PBL is described to promote prior knowledge activation. Students, working in small-groups, were presented with Life Science's problems about timely themes included in the national curriculum of Life and Earth Sciences at the middle and high school level (grades 8 and 10 of K-12), such as the consequences of introduction of invasive plants in ecosystems. Upon reading, brainstorm and discussion in small-group, each group presented a different solution to the class and all the solutions were discussed. Students were also asked to identify the NOS items present in the problem and their ideas were discussed. All the students were actively engaged in the learning process and were able to identify the NOS items included, such as the scientific methods, interaction between scientists and the importance of publishing. The learning process was also assessed, using an anonymous questionnaire. The students considered that the problem provided was interesting and that stimulated motivation towards learning (63% of students classifying as 4 or 5 in a scale 1 to 5). All the students considered that they performed an important role in their own learning process (88% of students classifying as 4 or 5 in a scale 1 to 5). In conclusion, the applicability, and potentialities of this method in pre-service science teacher education is discussed.*

**Keywords:** *Problem-Based Learning; Nature of Science; pre-service science teacher*

### 1. Introduction

The Nature of Science (NOS) refers to the epistemology and sociology of science, science as a way of knowing, and the values and beliefs related with the scientific knowledge and its development [1]. Students' informed views of NOS is a central goal for K–12 science education given its relevance for the development of science literacy [2]. However its implementation is rather deficient [3]. The authors refer to the lack of professional skills to teach NOS as one of the factors that explain this situation. [2] describe that pre-service biology teachers held both correct conceptions and misconceptions about NOS, which highlights the need to address these issues in initial teacher training programs. Learning methods such as Inquiry-Based Learning (IBL), Project-Based Learning (PjBL) and Problem-Based Learning (PBL) are adequate to both Science and NOS learning since they promote several skills, such as questioning, communication, argumentation and cooperation. PBL also promotes prior knowledge activation [4] and has been thoroughly applied in higher education (e.g [5]). The purpose of this study was to describe how students of a pre-service science teacher education program assess a NOS enriched-PBL approach. An integrative problem, including aspects of NOS, about a socio-scientific issue - impact of invasive species in the extinction of native species - was presented to the students.

### 2. Methodology

This interpretative exploratory study was conducted in 2017 in a 120 minutes session of a Biology and Geology Didactics course of a Portuguese University Master's program in Biology and Geology Teaching (for middle and secondary science teaching certification). A qualitative and descriptive approach [6] was implemented. Both researchers were present: one taught the session and the other one took observation notes.

#### 2.1. Participants

Eight Master students (5 females and 3 males) attending the course, accepted to participate in the study, and signed the informed consent form. They were in the first year of the two-year Master's

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program (2<sup>nd</sup> cycle Bologna).

## 2.2. Intervention

According to PBL methodology an ill-structured problem-situation was presented to the students about the consequences of the introduction of invasive plants in ecosystems. After reading, brainstorming and discussing in small group (2 or 3 students) about the problem-situation, students searched for information on recommended websites. Finally, each group presented to the whole group their proposed solutions. All proposals were discussed. Students were also asked to identify aspects of NOS in the problem-situation. Students were also asked to fulfil a handout (that worked as a hard scaffolding designed for middle school students) while dealing with the problem-situation.

## 2.3. Data collection procedures

Students answered to an anonymous questionnaire assessing the learning process, adapted from [7] and [8], with a scale 1 to 5.

Students' answers identifying the NOS items present in the problem were analysed, and their comments about the handout were registered. Observation notes were also analysed.

## 3. Results

In general students considered the learning process positive as shown by their responses to the items of the questionnaire that are assembled according to the topics: teacher support (Table 1), quality of problem and resources provided (Table 2), and students' role and interaction (Table 3).

Table 1. Results about teacher support

Items	1	2	3	4	5
The teacher directed us with pertinent questions.	0	0	0	5	3
The teacher stimulated us to exploit prior knowledge.	0	0	1	2	5
The teacher gave us clues instead of the correct answer, when asked a question.	0	0	0	2	6
The teacher promoted questioning by all the students in each group.	0	0	0	4	4
The teacher encouraged us to express our ideas clearly.	0	0	2	4	2
The teacher asked us how we came to the solution and what reasoning we followed.	1	0	1	2	4

Note: n = 8 students.

Table 2. Results about quality of the problem and resources provided

Items	1	2	3	4	5
The problem presented has several solutions.	0	0	3	0	5
The problem was written in a comprehensible language.	0	0	3	3	2
The problem provided was interesting and stimulated motivation towards learning.	0	0	3	2	3
The resources made available for the research were adequate.	0	1	1	3	3
The scaffold provided promoted a structured learning.	0	0	1	5	2

Note: n = 8 students.

Table 3. Results about students' role and interaction

Items	1	2	3	4	5
I participated in the group work.	0	0	0	0	8
When I came across something I didn't understand, first I consulted with a fellow student then consulted the teacher.	0	0	0	1	7
I collected and selected relevant information for the group work.	0	0	1	4	3
I raised pertinent questions.	0	1	3	3	1
I responded the pertinent questions I have raised.	0	0	2	5	1
I discussed with colleagues in the group with respect for	0	0	1	1	6



different ideas.					
I performed an important role in my own learning process.	0	0	1	5	2
I justified my opinions using scientific arguments.	0	0	2	5	1
I was able to propose a solution to the problem.	0	2	1	4	1

Note: n = 8 students.

Each group presented a different solution to the class and all the solutions were discussed: neutralize the pH of the soil, introduce a plant-specific virus that affects the invasive plant, and manual removal of all the parts of the invasive plant.

All the students were actively engaged in the process of solving the problem-situation and were able to identify the NOS items included, such as the scientific methods, interaction between scientists, and the importance of publishing. They made comments about the handout that they considered too dense, too demanding and too long.

#### 4. Discussion and conclusions

Giving the positive way students reacted to the NOS enriched-PBL task it is pertinent to conclude that Life Science's problems about timely themes included in the national curriculum of Life and Earth Sciences at the middle and high school level (grades 8 and 10 of K-12), integrated with NOS aspects and several curriculum objectives, may constitute an applied learning method for pre-service science teacher education. This proposal is according to authors that have suggested critical and reflexive reading of cases for NOS teaching [9] and that highly contextualized NOS instruction may induce students' connection to science knowledge [10].

Integrative problems, NOS-enriched PBL, may be used for many different purposes, for instance in order to ask pre-service teachers to identify the curricular objectives addressed in each problem.

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