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A Longitudinal Study of Students' Conceptions of the Nature of Science in Alternative Teacher Certification Programs

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Abstract

Nowadays, one of the primary purposes of science education is the formation of scientifically literate citizens [e.g., 1]. One required element to achieve scientific literacy is that students understand the nature of science (NOS) [e.g., 2]. Knowing how prospective teachers conceive this topic is essential because it influences how their students learn science [3]. This research aims to analyze the conceptions of the NOS that students of Alternative Teacher Certification Programs (ATCPs) with majors in scientific disciplines (Biology, Physics, and Chemistry) have and how they change through time. Phenomenographic interviews were carried out with first-semester students from six ATCPs at three moments: at the beginning and the end of the ATCP and during the first year of the professional practice. The results obtained from the analysis of the interviews conducted at the beginning (1st moment) and end (2nd moment) of the ATCP are presented here. At the beginning of their studies, the participants have essentialist conceptions of the NOS, in which science is seen as an entity apart from the human being. // On the other hand, at the end of their studies, the participants' conceptions move away from the essentialist views, and the conception of the NOS as a way of generating knowledge is deepened. These results provide information that can contribute to the decision-making of the ATCPs regarding the design and implementation of a curriculum that promotes the understanding of the NOS, not only during the training process of prospective teachers but also during professional practice.

Keywords: *Nature of Science, Conceptions, Alternative Teacher Certification Programs*

1. Introduction

Nowadays, one of the primary purposes of science education is the formation of scientifically literate citizens [e.g., 1]. One critical element to achieving scientific literacy is that students understand the NOS [e.g., 2]. There are different approaches to defining the NOS, including epistemic elements -focused on the construction of scientific knowledge and its characteristics- and non-epistemic elements -focused on sociocultural, political, and economic contexts- which influence the development of scientific knowledge [e.g., 4, 5, 6]. However, there is still no consensus that such elements encompass the complexity of the NOS [7]. Thus, various definitions of the concept generate different versions of what is understood as NOS [7].

One of the most researched topics regarding the NOS is the subjects' views about it, from preschoolers [e.g., 8] to scientists [e.g., 9]. In general terms, it has been found that subjects do not have an adequate understanding of the NOS regardless of age or educational level [e.g., 10]. Thus, knowing how prospective teachers conceive this topic is essential because it influences how their students learn science [3]. Students of ATCPs for scientific disciplines (Biology, Physics, and Chemistry) have a solid background in the discipline and, in many cases, have carried out research -during their undergraduate studies or professional practice-. Therefore, the preceding would allow us to infer that, by having scientific training and first-hand knowledge of how scientific knowledge is generated, these future teachers would have an advanced understanding of the NOS. Palmquist and Finley [11] are the only ones who have studied the views of NOS in students of ATCPs. Upon entering the program, only 33% of prospective teachers had informed views about the NOS, while at the end of the program, this number increased to 67% [11]. According to the authors, this result would reflect the positive effect of science teaching methods courses that the students had during their studies. However, what the participants expressed about the NOS does not necessarily reflect their ideas since the questions referred to only five aspects of the NOS (scientific knowledge, scientific method, scientific theories, scientific laws, and the role of scientists).

This research aims to know the conceptions of the NOS that students of ATCPs for scientific disciplines have -without restricting them to specific aspects of NOS- and to analyze how they change through time.

2. Method

In this research, we worked with the six accredited ATCPs with majors in scientific disciplines (Biology, Physics, and/or Chemistry). The participants were first-semester students. The research was carried out through a longitudinal design [12] using a phenomenographic approach [13]. The design comprised three moments of data collection: the beginning (1st moment) and end (2nd moment) of the ATCP and the first year of professional practice (3rd moment). The number of participants was: 1st moment, N=36; 2nd moment, N=15. At each moment, phenomenographic interviews were carried out. Phenomenography seeks to reveal the different ways in which subjects experience, conceive, or perceive a particular phenomenon or the world around them [13]. In the interviews, open questions are posed -directly referring to the phenomenon studied- soughing the subjects reflect on their conceptions -meanings that people give to the experienced phenomenon-. From the phenomenographic analysis of the interviews, a set of categories of description that make up the outcome space was obtained [13]. This procedure was carried out with the data collected at each moment. Finally, to determine the change over time, the categories of description obtained were compared to identify convergent and divergent elements [14]. This paper presents the analysis of the interviews carried out at the beginning and end of the ATCP.

3. Results

At the beginning of their studies, the participants had essentialist conceptions of the NOS. Science is conceived as an entity apart from the human being inherent to nature or as an entity in itself (categories A and B). In categories C and D, the conception of the NOS changes and is conceived as a knowledge discovery or construction process, respectively. In the last category (E), NOS is conceived as a construct that does not have a single definition. On the other hand, at the end of their studies, the participants also have essentialist conceptions of the NOS since it is conceived as knowledge or a way to approach knowledge independent of the human being (categories α, β, and γ). However, conceptions of the NOS as a way of building knowledge are deepened (categories δ, ε, and ζ) compared to the beginning of ACTP. In these three categories, the NOS is conceived as a process in which science is built, contrary to the idea that science exists in the world, and human beings only unveil it. These ideas account for a conception of the NOS associated with a human construction, which changes depending on the person, the environment, culture, society, and history. The conceptions of NOS are presented in Table 1.

Table 1. Students' conceptions of the NOS at different moments of their training.

<table>
<tr><th colspan="4">Conceptions of NOS</th></tr>
<tr><th colspan="2">At the beginning of ATCP</th><th colspan="2">At the end of ATCP</th></tr>
<tr><td>A</td><td>Science as inherent to nature: Science is conceived as inherent to nature, that exists in the world, and human beings only unveil it, not develop it.</td><td rowspan="2">α</td><td rowspan="2">A set of knowledge of nature: Science is conceived as a description of reality whose goal is to unveil knowledge.</td></tr>
<tr><td>B</td><td>Science as an entity in itself: Science is conceived as an entity with intrinsic characteristics that define it.</td></tr>
<tr><td></td><td></td><td>β</td><td>A way to approach knowledge: NOS is conceived as the way to access knowledge -the scientific method- and validate it.</td></tr>
<tr><td>C</td><td>A way of discovering knowledge: Science is conceived as one method or many methods to unveil the phenomena of nature. It is not the method -the scientific method-.</td><td>γ</td><td>Different ways to approach knowledge: NOS is conceived as the different ways to study the phenomenon. There is no single way -the scientific method- to do it.</td></tr>
<tr><td rowspan="2">D</td><td rowspan="2">A way of building knowledge: NOS is conceived as a process that depends on historical context and is being made constantly.</td><td>δ</td><td>Human perspective of the construction of knowledge: NOS is conceived as a “process to do science” carried out by human beings.</td></tr>
<tr><td>ε</td><td>Historical perspective of the construction of knowledge: NOS is conceived as knowledge built from the socio-historical characteristics of a particular moment in the history of humanity.</td></tr>
</table>

		ζ	A dynamic process: NOS is conceived as knowledge's provisional, non-static, and constantly changing character.
E	As a subject-dependent construct: NOS is conceived as a construct that depends on who describes it.		

4. Discussion and Conclusions

Of the total conceptions that emerge from the analysis, categories A and B are related to the general vision of the NOS. In contrast, categories C, D, γ, δ, ε, and ζ are related to epistemic elements of NOS, that is, with the construction process of scientific knowledge and its characteristics [e.g., 4, 5, 6]. Finally, category E is related to the idea that the NOS definition depends on the context of who describes it [7].

In comparative terms, there are similarities among participants' conceptions at the beginning and end of their studies (Table 1). However, in the latter case, conceptions of the NOS were more elaborated and specific (categories δ, ε, and ζ). The participants provided examples that they learned about the NOS in their science teaching methods courses. This result is in line with Palmquist and Finley [11].

In conclusion, this study sheds light on the positive effect of the ATCPs on the participants' conceptions of the NOS. This information can contribute to the decision-making of the ATCPs regarding the design and implementation of a curriculum that promotes the understanding of the NOS, not only during the training process of prospective teachers but also during professional practice.

Based on these results, prospective teachers are expected to apply what they learned to their professional practice and make their conceptions of the NOS more complex.

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