ACTIONS IDENTIFIED BY PRE-SERVICE TEACHERS IN A DECISION-MAKING PROCESS RELATED TO NUCLEAR WASTE MANAGEMENT

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Abstract

This study makes part of a research project that aims to introduce pre-service teachers in Nature of Science (NOS) through argumentation and decision-making processes. This proposal analyses pre-service teachers’ preliminary conceptions about the actions required in the decision-making process necessary for solving a socio-scientific issue about nuclear waste management. Socio-scientific issues are recognized as effective contexts for learning and training about decision making processes. Furthermore, they contribute to attain a functional understanding of NOS, in the sense of how science actually works and produces reliable knowledge. This is essential to prepare cultured members of society and informed citizens. In general, the results highlight prospective teachers’ difficulties for identifying key actions in the decision-making process. Data show that the categories “expose solutions to the conflict” and “evaluate possible solutions” are the less recognised actions, maybe because these are actions in which they need to create good arguments. Moreover, the participants show a tendency to adopt punitive measures, instead of looking for a consensus. These results could be associated to the student teachers’ naive conceptions about actions involved in the construction of scientific knowledge. Therefore, the results highlight the need of a deeper teacher training in Nature of Science, promoting the use of operations involved in decision making processes.

Keywords: Socioscientific Issues, Decision-Making; Nature of Science, Teacher Training, Nuclear Waste.

1 INTRODUCTION

Dealing with Nature of Science (NOS) has been an important goal in Science Education for ages and it continues to be nowadays [1], [2]. Currently, teaching and learning about NOS in science lessons is considered of special relevance to attain Scientific Literacy [3], [4], [5] since it is essential to prepare future scientists, cultured members of society and informed citizens [6]. According to Lederman and Lederman [2], understanding NOS does not make a scientifically literate person by itself. Literate individuals also have a functional understanding of science content, know how the content was developed (ability to do and know about inquiry practices) and the ability to make informed decisions about scientifically based personal and societal issues. Socio-scientific issues (SSI) are recognized as effective contexts for developing the knowledge and processes that contribute to attain scientific literacy [7], [8]. According to Ryder [9], an understanding of NOS, in the sense of how science actually works and produces reliable knowledge, is believed to be important for students to critically engage with SSI.

Despite the acknowledgement of its relevance for Science Education, NOS is not always well reflected in the curriculum perhaps due to the lack of consensus on how to best understand it and how to be taught [6]. Recent studies in literature such as Kampurakis’ [10] point out the difficulties of teachers for enacting NOS issues in science lessons. This author identifies students’ alternative conceptions as one of the aspects that hinder the learning process. Hence, there is a need for developing teaching materials that promote an adequate learning of NOS as well as training teachers in this issue.

Framing NOS interventions in SSI enables students to deal with this complex theme and to visualize the relevance of developing and adequate conception of NOS as they address scientific issues that influence their current world and therefore their future [11]. Moreover, SSI contexts make students to
consider social, economic, ethical and moral aspects of the problem in addition to the scientific content knowledge [7]. It needs to be noted that SSI contexts are frequently associated with a controversial dimension, which is motivated by differences between content knowledge and NOS, such as risk perceptions, empirical data interpretation as well as social impact of science and technology [12]. This controversial dimension requires students' engagement in argumentation in decision-making processes, practices promoted in the teaching sequence developed in this study, as a result of the analysis of students' conceptions about the actions and skills required to solve a problem about electrical energy.

The goal of this study is to analyse the actions pre-service teachers' preliminary conceptions about the actions required in the decision making process necessary for solving a socio-scientific issue about nuclear waste management.

2 METHODOLOGY

In this study, the participants were 60 pre-service teachers attaining a course about Science Education during a semester in three public Spanish Universities. Of these, 20 were students of the fourth year of the Degree in Early Childhood Education, another 20 were in the third year of the Degree in Primary Education, and the remaining 20 were students in the second year of the former grade.

For data collection, the participants complete a questionnaire at the begging of the semester. The questionnaire was designed by the authors in order to introduce students to Nature of Science aspects. The analysed data correspond to the participants' individual written responses to the last question of the questionnaire, which consisted in an open question about the actions required for making a decision in the context of a nuclear waste management.

The text of the question, illustrated with the image reproduced in Fig. 1, was:

Imagine that you are a character similar to Hommer Simpson who works in a nuclear power plant as responsible for waste management. One day you receive a call from the director of one of the nuclear cemeteries in which the central deposits the waste, informing that the workers in charge of depositing them don’t do it in the adequate conditions, so if they do not change their procedures, the cemetery will no longer store your waste. Which actions would you need to carry out for making a decision that enable you to solve the conflict? Prepare a list.

Figure 1. Image accompanying the open question in the questionnaire.
The methodology draws from qualitative content analysis [13] aimed at systematically describing the meaning of qualitative material by classifying it as of the categories of a coding frame. The coding frame used was specifically developed by the authors, in interaction with the literature, the data collected, and other results obtained in previous research within the project. The categories that compose the rubric are the following:

- Identify the causes of the conflict (observe, take data, make interviews)
- Investigate possible solutions (find information, meet with experts, meet with groups involved)
- Expose solutions to the conflict (show advantages and disadvantages, elaborate arguments based on data)
- Evaluate possible solutions (analyse the information provided, compare advantages and disadvantages)
- Make a decision on the best solution (draw a conclusion, make an informed argument, seek consensus among the groups involved)
- Examine the effectiveness of the decision made (observe, take data, analyse the information obtained, draw a conclusion).

3 RESULTS

Table 1 summarizes pre-service teachers’ conceptions about the actions required for solving the problem. In general, the most frequent action is “to identify the causes of the conflict” (OP1), identified in the participants from two of the three universities examined (UNV1 and UNV2). However, in UNV3 the most frequent action is “to make a decision on the best solution” (OP5). Furthermore, it is also noteworthy that the less frequent action is “to evaluate possible solutions” (OP4), being even absent in the results of UNV1.

<table>
<thead>
<tr>
<th>Action</th>
<th>Frequency</th>
<th>Example</th>
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<tbody>
<tr>
<td>OP1. Identify the causes of the conflict</td>
<td>12 UNV1, 19 UNV2, 12 UNV3</td>
<td>“To bring together all the workers in order to know which problem they had for not making their work appropriately” (PT.18)</td>
</tr>
<tr>
<td>OP2. Investigate possible solutions</td>
<td>3 UNV1, 2 UNV2, 5 UNV3</td>
<td>“Seeking alternatives among all to change the way of doing it” (PT.11)</td>
</tr>
<tr>
<td>OP3. Expose solutions to the conflict</td>
<td>2 UNV1, 2 UNV2, 9 UNV3</td>
<td>“To justify why the changes are necessary for solving the situation” (PT.22)</td>
</tr>
<tr>
<td>OP4. Evaluate possible solutions</td>
<td>0 UNV1, 3 UNV2, 1 UNV3</td>
<td>“In case of not being as agreed, to communicate to the director that the workers will receive the correct indications for depositing the waste and the obligation of carrying them out” (PT.46)</td>
</tr>
<tr>
<td>OP5. Make a decision on the best solution</td>
<td>10 UNV1, 2 UNV2, 1 UNV3</td>
<td>“To elaborate proposals for improvement among all the workers” (PT.35)</td>
</tr>
<tr>
<td>OP6. Examine the effectiveness of the decision made</td>
<td>4 UNV1, 15 UNV2, 6 UNV3</td>
<td>“To bring them together again to know how the changes are affecting to the work” (PT.10)</td>
</tr>
</tbody>
</table>

Analysing the data by universities, we observe that in one of the universities (UNV1) they mainly identify the problem (OP1) and make a decision without carrying out any other intermediate action (OP2 Investigate possible solutions, OP3. Expose solutions to the conflict or OP4. Evaluate possible solutions), which could provide information that enable them to make an argumented decision (OP2 and OP4) and most likely consensual among the involved parties (OP3). Moreover, the participants from this university either evaluate the adopted decision once it has been carried out.
With regard to the other two universities (UNV2 and UNV3) the pattern is not exactly the same. In this case the participants lean towards identifying the causes of the problem and evaluating the adopted decision that has been mainly imposed and without looking for consensus:

“To remember again the norms that govern the company and make clear that they cannot be broken. To inform them that if it happens again, they will take actions” (PT. 59)

In addition, as reflected in the data, only 3 out of the 40 participants from these two universities (two from UNV2 and one from UNV3) make a consensual decision. The others, apart from imposing the measures without carrying out operations that make these actions to have more support (both from information and for the involved parties), they opt for punishing workers:

“To inform the director that workers would receive the adequate procedure for depositing the waste and the obligation of carrying them out. In case of continuing making it wrong, they would be hired” (PT.47)

4 CONCLUSIONS

This proposal analyses pre-service teachers’ preliminary conceptions about the actions required in the decision making process necessary for solving a socio-scientific issue about nuclear waste management. Socio-scientific issues represent interdisciplinar learning context, since they leave the boundaries of disciplines and point to the integral education of the individuals. Analysing these problems require also ethics and values, as well as seeking solutions in the social context rather than in the individual one.

Thus, Socio-scientific issues are recognized as effective contexts for learning and training about decision making processes. Furthermore, they contribute to attain a functional understanding of NOS, in the sense of how science actually works and produces reliable knowledge. This is essential to prepare cultured members of society and informed citizens.

In general, the results highlight prospective teachers’ difficulties for identifying key actions in the decision-making process. Data show that the actions as “expose solutions to the conflict”, “investigate possible solutions and “evaluate possible solutions” are the least recognised. They are the actions most related to elaborating high-quality arguments and which support a good decision making process.

Moreover, the participants show a tendency to adopt punitive measures, instead of looking for a consensus. These results could be associated to the student teachers' naive conceptions about actions involved in the construction of scientific knowledge.

In addition, we also find that participants have little awareness about the importance of following up and of analysing the implementation of the decision made. To understand that the process of decision-making is not linear and that it requires a later analysis and reflection is fundamental within the process.

Therefore, the results highlight the need of a deeper teacher training in Nature of Science, promoting the use of operations involved in decision making processes. In particular, it is necessary to work it through argumentation, analysing what is a good argument and the actions that could be taken for developing it. Hence, we suggest that pre-service teacher courses should include the implementation of small research projects around socioscientific issues so that students can analyse and reflect about the characteristic procedures of scientific methodology that enable knowledge construction.

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