

Innovations in the Development of Critical Thinking and the Teaching of the Nature of Science and Technology: Background and Proposal for Food Engineering Course of Studies

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Abstract

This paper presents an analysis of the innovations made in scientific and technological courses of studies about STS education and it presents, as an example, the proposal of a Didactic Unit to teach Nature of Science and Technology and to develop Critical Thinking in Food Engineering students. The proposal is part of an international project on education of the technological and scientific competences and critical thinking by teaching topics related to nature of science and technology, in which different Ibero - American countries participate. The implementation methodology of the didactic units is validated, and multiple positive results have already been achieved in different courses. For this particular case, a didactic unit called "A Food Engineer at the Zoo" is proposed for the course of Food Preservation and it is intended to work with the Problem-Based Learning methodology with the aim of developing different generic engineering and critical thinking competences.

Keywords: *Innovations; Nature of Science and Technology; Critical Thinking; Food Engineering.*

1. Introduction

Natural Sciences teaching has been changing over time in order to decrease students' lack of interest to learn them (Solbes, Montserrat & Furió, 2007) and to reverse the trend towards the widespread increased rejection of scientific issues (Vázquez Alonso & Manassero Mas, 2009).

Therefore, it becomes essential, among other things, to innovate in sciences teaching and to include aspects of Nature of Science and Technology (NST) in training students from scientific and technological courses of studies. As stated by Cordero, Dumrauf, Mengascini and Sanmartino (2012), people should shift the focus of the problems to be studied, which are traditionally extracted from the same institution and not from the social context. Thus, it becomes crucial to include not only the sciences history, but also the technology history in the treatment of problems to improve the general understanding of the nature of technology (Acevedo Díaz, 2010).

The NST is a metacognition group about the functioning of science in today's world which includes multiple reflection areas of knowledge such as sociology, history, philosophy and epistemology. The main objective of the NST is the construction of scientific knowledge including issues of the aforementioned areas in order to understand relationships among Science, Technology and Society (STS). The NST is closely related to the STS movement and it is convergent with the same approaches for education in science and technology (S&T) (Spector, Strong & Laporta, 2002).

This paper mentions innovations made and describes, as an example, an approach from the National University of Quilmes to improve understanding of the NST and to develop critical thinking (CT) in students from the Food Engineering course of studies, more specifically, within the course of Food Preservation through the incorporation of a Didactic Unit (DU). The approach is part of a doctoral thesis on food education and critical thinking development within the framework of the CYTPENCRI project -Education of scientific, technological and critical thinking competences by teaching nature of science and technology themes (Project EDU2015-64642-R (AEI/FEDER, UE) funded by the Spanish State Research Agency and the European Regional Development Fund.). It is an international project shared by different Ibero-American countries.

2. Development

2.1. Background

Within the National University of Quilmes investigators have developed extensive research on the incorporation of DU on NST contents in the curricula of scientific-technological

courses of studies. The research has been carried out in the area of Chemistry (Porro, 2013; Porro & Roncaglia, 2016) and within the didactics of natural sciences area for the Bachelor in Education course of studies (Porro & Roncaglia, 2016). In all cases, positive results have been obtained by statistically assessing the intervention.

Meanwhile, from the perspective of graduates, employees and professors, a lot of research has been carried out related to the competences to be developed by graduates of the Science and Technology department from the University.

Specifically within the Food Engineering course of studies, a study has been conducted on the incorporation of animal feed contents into the food engineering curriculum (Lampert, Russo & Porro, 2017) and room interventions within the course of Food Preservation.

The development of DUs for the CT development has some background within the Food Engineering course of studies (Torrecilla, Aguado, Tijero, Ballesteros, Moral, & Lastra, 2018) based on the assumption that imaginary problem resolutions enhance students' critical thinking skills (Alharji, 2010; Shen, 2012).

2.2. Food Preservation Course

Food Preservation is a compulsory course from the last year but one belonging to the Food Engineering course of studies. Among its minimum contents are the physical, chemical and biological methods for food preservation, raw material conditioning, food storage and transportation and minimum processing. In the course, various DUs with NST contents have already been implemented, such as the work done on the history of food preservation and the production and packaging of hydroponic foods in conjunction with a dissemination project from the University (Dron, Balboa, Lampert, Verdecia & Porro, 2018). In both cases, CT was encouraged through argumentation.

At the beginning of the course and by means of the analysis of food packaging and transport, special emphasis is placed on food of plant origin and on milk. This way, students are introduced to the concept of foodborne zoonoses. In a previous course, Food Microbiology, Foodborne Diseases (FD) are developed. However, the treatment of zoonoses and parasitic diseases transmitted by food is not included within the minimum content.

Therefore, zoonoses and FD treatments are to be modified, which are currently developed in an expository manner, from the incorporation of a DU which includes NST aspects and also allows CT development.

To achieve this, this paper proposes the creation of a DU based on students' ideas about FDs and Zoonoses, students' standards on expected reactions based on research, characteristics and contents of the NST domain, epistemological assumptions, learning

perspectives, current pedagogical approaches, and characteristics of the professional competences of food engineering students. UD development is based on the application of Problem-Based Learning (PBL) methodology. In this sense, starting from an either real or fictitious problem, students must resort to various tools in order to find a solution (Branda, 2009).

2.3. DU Development

As previously stated, it is necessary to outline an unusual situation to facilitate CT development (Alharji, 2010; Shen, 2012). Therefore, an example is presented in which a Food Engineering professional has to advise on the zoo implementation and to prevent people from contracting FD and zoonoses. This way, it is intended for students to be able to relate different engineering competences (Table 1). The activity will be developed in 4-member groups, and the results will be shown at the end of the research.

Table 1. Competences to Be Developed by Students from the DU

Competence Type		Solution Example for the Proposed Problem
Technological	To identify, formulate, and solve engineering problems.	To identify that the problem is that society lacks knowledge of FD and Zoonoses prevention. On this basis, decision making begins. For instance, all visitors are subject to a prior briefing before entering the zoo.
	To comprehend, design, and develop engineering projects.	To develop a 3-sector zoo plan: one of animal contact, another of non-animal contact, and an intermediate one. The buffet and food court will be placed in the second sector so that people can enjoy a snack. In the third case, hand washing sinks with the relevant chemical substances will be installed to avoid contamination when entering into the non-animal contact area.
	To effectively use engineering techniques and implementation tools.	Likewise, since people spend several hours in direct sunshine, it is important to highlight what kind of products should be sold and how they should be packed. To prepare no-food or no-drink signs in the area of contact with animals and no-children-with-toy signs due to the risk of falling in areas where free animals are.
Social, political and attitudinal	To perform effectively in work teams and to learn in a continuous and autonomous way.	To work together with other professionals: Veterinarians, Biologists, Ecologist.
	To proceed in an ethical manner with professional responsibility and social commitment.	To avoid using fences in order to separate animals from human space, since there can often be traces of animal saliva, fecal matter or vomit. To replace fences by moats or glass enclosures to also reduce visual pollution caused by fences and to provide a view of the animal's natural habitat.
	To communicate effectively.	To present solutions with certainty and solid arguments to employers to hold the stance.

Source: Prepared by the authors based on second generation standards approach for the Engineering courses of studies accreditation in the Argentine Republic "Libro Rojo de CONFEDI".

Within the NST framework, adopting the category proposed by Vazquez Alonso (2014), working on a zoo implementation would improve the understanding of the external sociology of science and the triadic influence among Science, Technology and Society: society influence on science and technology (in this case to prevent FD and zoonoses), science and technology influence on society (engineering competences and tools to do search) and the technology social construction (considering the zoo design will be based on society knowledge). Below there is an outline as summary of the contents linked to these problems (Figure 1).

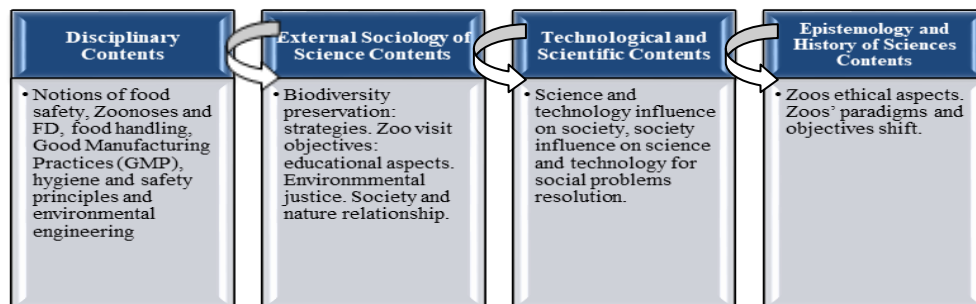


Figure 1. Summary of Disciplinary Contents and UD NST. Source: prepared by the authors.

On the one hand, the decision-making and problem solution skills will be worked in relation to CT (Halpern, 2014).

The didactic sequence will be developed in four stages, one week each.

First On-site Stage: zoonoses and its significance for food preservation is presented. The problem and critical questions that guide the research are set out.

Problem: A food engineer at the zoo.

“A food engineer is hired to help set up a zoo. However, the job was not focused on advising on the dining room, but on monitoring and advising on FD and zoonoses when people were in contact with animals and, in turn, manipulated food. It is worth mentioning that the good state of health of animals is a job already controlled by veterinarians. Nevertheless, diverse microorganisms are present in animals and are asymptomatic for them”.

Critical questions (they should not be answered, they are part of a guide to orient the search for a solution to the problem):

- a- As professional engineers, what are the aspects to consider on a zoo visit that may lead visitors to contract a disease?

- b- What engineering tools and techniques would be used to prevent FD and zoonoses when visiting the zoo?
- c- Would you work alone or in group? If you choose “in group”, what professionals would you choose for your team?
- d- What considerations should be taken into account by the Food Engineering professional when drawing up the zoo?
- e- What food engineering competences are at play when searching solutions?
- f- Make a list of the points that you would explain to your authority and their respective rationale.

Second and Third Virtual Stages: opportunities for enquiry and follow up by professors in solving the problem.

Fourth On-Site Stage: problem solutions presentation and debate among different groups will be carried out.

3. DU Application Perspectives and Conclusions

DU application on NST has achieved several positive results in the investigations carried out, improving argumentation skills and incorporating NST contents. Therefore, it is important to continue with this kind of methodology that also allows students to relate to other fields of knowledge.

The application of the proposed UD will begin to be implemented during the first quarter of 2019; however, the proposal was presented to 12 professors from the 4 educational levels in order to get their opinions, and it was found that 100% indicated that the UD is very important to acquire scientific skills, 90% that what was learned was very useful, 100% that it motivates and 90% that it allows to be more critical.

The UD application methodology, in the same way as the previous ones, is based on CYTPENCRI project. For this, two tools will be used. On the one hand, the Opinions Questionnaire on Science Technology and Society (Spanish acronym COCTS), a questionnaire consisting of 100 questions empirically designed from students' answers, in a non-technical language on a scenario to evaluate a particular feature of NST, and it suggests several sentences of judgments, where the person surveyed assesses their degree of agreement with each phrase. On the other hand, a validated test on CT development will be used. Both tools have a similar structure that ratifies the parallelism between the CT skills and the scientific thinking skills assessed by the COCTS. The experimental group receives the (DU) treatment, while the control group does not receive the treatment, but both groups

are administered the evaluation instruments before (pre-test) and after the moment of treatment (post-test).

It is important to incorporate this type of pedagogical initiatives in the dictation of subjects of scientific-technological courses of studies since, by the results obtained in the already carried out investigations, they allow to improve NST comprehension and the general competences of engineering from the CT development.

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