Diverse notions on STS: a case-study with six kindergarten teachers in Portugal

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Abstract — This study focuses on the characterization of the notions on Science – Technology – Society held by six kindergarten teachers. During our research we have used the VOSTS tool to collect the core data before and after the participation in an appropriate in-service teacher training.

Index Terms — Science – Technology – Society – STS, Education in Science, In-service Teacher Training

1 Introduction

Science and technology are closely linked to each other [1], [2]. This union originates responsibilities in the changes of this more and more global world, the way people are part of it, interact and understand themselves.

The education in sciences should promote literacy among children and this is the reason why an investment should be made in this field of study since early age. This "should be an objective of modern societies, because it will become a source of development and creation of the necessary anilities for a responsible citizenship" [3: 5]. As such, an approach of sciences in the perspective of STS should have an integrative role in the learning process, according to the current curricular guidelines in most countries, including Portugal. This perspective "aims at the development of a responsible citizenship, at both individual and social level, thus allowing citizens to deal with scientific and technological problems" [4: 81]. Therefore and bearing in mind the improvement of life quality it is necessary to have a strong investment in education, namely in the training of educators and the education in sciences. This can become a facilitator of the process, specially through the STS approach. This idea has taken us to the development, implementation and assessment of an in-service teacher training (ITT) supported on STS with the intention of implementing practical and experimental work in the didactic and pedagogical practices of kindergarten teachers.

The main goal of this article is to disclose some of the results obtained before, during and after the ITT, in the STS conceptions of six kindergarten teachers involved in the study.

2 Objectives

Our main goals to carry out the study are: (i) to characterize the notions on STS among kindergarten teachers in the Bragança district in northern Portugal; and (ii) to assess the impact of the ITT in the rebuilding of the notions on STS among the professionals involved in the study sample.

3 Theoretical Framework

In Portugal, pre-school education follows the curricular orientations established by the Ministry of Education in 1997. These orientations are organized by well defined content areas and they foresee not only the acquisition of knowledge but also of attitudes. They also establish that knowledge grows in an articulated and integrated way.

These orientations recommend that sciences, included in the field of the world's knowledge, provide meaningful learning for the children and promote "the capacity to observe, the desire to experiment, the curiosity to know, a critical attitude" [5:85].

Harlen [6] refers to the need of a precocious scientific education, because it is fundamental for the development of scientific literacy. Moreover, as Fumagalli refers [7],

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scientific education through life is a right of all citizens.

To develop scientific concepts with children as young as those attending pre-school education, it is essential to consider which scientific concepts should be explored, as well as a suitable preparation and exploitation around these subjects.

About this, Martinez [8] and Tenreiro-vieira e Vieira [4] draw our attention to the fact that education in sciences must respect the following principles:

1. Topics must be adequate for the students' cognitive development;
2. Topic selection should be done according to its utility for the students;
3. The knowledge acquired must be transferable to life and used to act in a more autonomous way in society in order to promote democratic values.

These educational goals are coherent with the vision that promotes the STS perspective for education in sciences.

The origin of the STS movement dates back to the end of the Second World War. According to Dagnino [9] and Membleia [10], at the end of the 60s this movement emerges in several countries, although following different traditions. Back then, they tried "to understand the relationship among science, technology and society in a less naive way, highlighting the negative aspects related to scientific and technological progress in society, starting from environmental, political, economical and sociological perspectives, etc." [9: 6].

The introduction of environmental, political, economical, ethical, social and cultural questions regarding science and technology has been recommended in curricula emphasizing STS. These aim at guiding the kindergarten teachers in performing and experimenting innovative activities [11]. Besides, according to Aikenhead [12: 166], contents related to the nature of science "have received growing attention, due to the interest in teaching science following an STS approach". Therefore, this has to be considered as any other content of science, which teachers may want to teach and students may be able to learn [13].

Martins [14] argue that STS education is a movement in the teaching of science in a real life context, where connections to technology with implications in society are established. As such, education in an STS perspective intend to give an integrated vision of sciences and not a decontextualized one, according to what many people still follow.

So, the purpose of an STS education is to promote literacy in science and technology, allowing the individual to actively take part in democratic decision-making [10]. This means that teachers have to rethink their STS notions.

In this sense, with this research we aim to contribute to the continuous training of educators. Martins [14] proposes continuous and updated training courses which enable teachers for the teaching of sciences in an STS orientation. In the perspective of Cachapuz, training must be "a research process in which the production of knowledge is reinvented in the improvement of an innovation" [15:148], in this case, specifically, in the teaching of sciences. The Ministry of Education [16] recognizes the teacher's continuous training as a priority for educational change which can contribute to the increase of both knowledge and professional development [17].

But Pórlan and Rivero [18] warn us about the fact that teacher's continuous training does not promote a practical and professional knowledge that integrates he theoretical knowledge and the knowledge based on experience in a satisfactory way. As such, teachers find it difficult to make a critical separation from their activity and trainers find it difficult to assume that the alternative and innovating teaching models are not directly transferred to the teachers, especially when the work conditions remain unchanged. So, in the training programs it is necessary that the courses in itself favor a debate about the purposes of scientific education, the nature and the importance of science, as well as STS interactions. All this must be projected to facilitate the critical analysis of the current teaching of sciences and the creation or appropriation of alternative proposals [19].

To reach the previous goals we propose that kindergarten teachers do more STS practical and experimental activities suitable to kindergarten children, which we consider can contribute to the implementation of innovative didactic and pedagogical practices.

4 DEVELOPMENT

The results we report regard the characterization of the initial and final notions of STS by the six kindergarten teachers participating in the study and were collected with the VOSTS (Views on Science-Technology-Society) tool by Aikenhead, Ryan and Fleming, more precisely with an abridged Portuguese version by Canavarro [20], who

validated the 19 items for Portugal, which can be overviewed in Table 1.

TABLE 1

THE VOSTS TOOL: ITEMS, ORIGINAL CODES AND CORRESPONDING TOPICS ACCORDING TO CANAVARRO [20]

Item/Original Code	Corresponding Topic
1 (VA11)	Definition of Science
2 (VA21)	Definition of Technology
3 (VA31)	Science, Technology and Quality of Life
4 (VA41) and 5 (VA51)	Political and Government Control over Science
6 (VA61)	Science Control by the Private Sector
7 (VA71)	Influence of specific groups of interest in Science
8 (VA81)	Contribution of Science and Technology to social decision-making
9 (VA91)	Contribution of Science and Technology to the creation of social problems and investment in R&T versus social investment
10 (VA101)	Contribution of Science and Technology to the solving of social problems
11 (VA111)	Contribution of Science and Technology to economic well-being
12 (VA121)	Ideology and Religious Control of Scientists
13 (VA131)	Social life of scientists
14 (VA141)	Gender effect on scientific careers
15 (VA151)	Decision-making on scientific questions
16 (VA161)	Decision-making on technological questions
17 (VA171)	Public control of technology
18 (VA181)	Nature of scientific models

The research methodology that supports VOSTS is naturalistic, meaning that "it tries to emphasize the perspective of the participants and to accept the legitimacy of their vision." [21:487]

The VOSTS survey is very different from the conventional tools which measure the conceptions or representations of science, concretely in what concerns the ambiguity of the questions and the classification of the answers, because it expresses the ideas about STS and not the numerical results [20], [22]. Thus, it is through the guarantee that the domain of possible item answers does not vary according to a theoretical point of view or to the researcher's ideas. On the contrary, those answers show a qualitative basis centered on the patterns of answers.

The score of answers to the VOSTS survey presented by Canavarro [20], results in three different categories: (i) realistic – an option which translates an appropriate notion of science, (ii) acceptable – an option which is not completely appropriate but still reveals some merit; and (iii) naive – for the more inadequate responses.

In order to collect data about the STS conceptions of the six kindergarten teachers, we applied the Portuguese version of VOSTS at the beginning and at the end of the ITT during our entire study.

In order to better understand the notions kindergarten teachers have from STS, we conducted an interview after the analysis of the responses to the survey. This interview has allowed us to collect information regarding academic education and training, professional experience and informal access to science for each of the teachers involved in the study. This has also allowed the teachers to describe their ideas on STS and to explain the sense they gave to their answers to the VOSTS survey. The final analysis provided the researchers with a deeper and better understanding of the teachers involved, as well as with the evolution of their ideas [23]. The use of the interview has revealed itself particularly useful for the understanding of the depth of their ideas, mainly the ones of the "naive" type. [24], [25], [26].

The interviews were made one week after filling in the VOSTS surveys and they lasted approximately 50 minutes.

5 RESULTS

As previously referred to, the results have been obtained in two moments during the application of the VOSTS survey: at the beginning of the ITT and at the end.

When answering the survey at the beginning of the ITT we have obtained the responses which are collected in table 2.

TABLE 2

CATEGORIZATION OF RESPONSES GIVEN BY KINDERGARTEN TEACHERS TO THE VOSTS SURVEY AT THE BEGINNING OF THE ITT

Kindergarten teacher	Answer categorization		
	Realistic	Acceptable	Naive
A	8	10	1
B	6	10	3
C	5	12	2
D	7	11	1
E	7	7	5
F	5	12	2

By the end of the ITT the same professionals gave the following responses to the VOSTS survey, table 3.

TABLE 3

CATEGORIZATION OF RESPONSES GIVEN BY KINDERGARTEN TEACHERS TO THE VOSTS SURVEY AT THE END OF THE ITT

Kindergarten teacher	Answer categorization		
	Realistic	Acceptable	Naive
A	13	5	1
B	8	11	5
C	7	8	4
D	11	8	0
E	7	9	3
F	9	9	1

Based on the reading of tables 2 and 3 we realize that three of the teachers have decreased the number of naive responses, one has maintained them and the others have increased them. We believe that these latter cases may be related to the fact that kindergarten teachers need more time to change their notions. Moreover, along the interview they gave rather confusing and unclear answers.

The analysis of the answers to the VOSTS survey filled in at the beginning of the ITT lead us to the interviews, which after the content analysis, allowed us to define some answer categories regarding the conceptions about STS adopted by two or more kindergarten teachers. So, from the interview's analysis we highlight the conception of the following items:

1. Science as "a body of knowledge" and technology as "application of science".

Kindergarten teacher A shared her opinion: -"…to consider Science we have to follow a methodology and science also implies the evolution of Technology".

Kindergarten teacher B considered that "Science… is everything that studies natural phenomena… Technology… it's the instruments, everything that is in permanent change, for progress, television, computers".

Kindergarten teacher C pronounced herself in this way: -"I think that Science is everything around us, basically it is a science that teaches us (…) I understand Technology more as a question of instruments, of tools, everything that is needed to make the study."

Kindergarten teacher D presented the following definition: "Science is the way to solve problems and to know where we are and where we are going. Science is used to give answers to these questions… Technology is the Science serving human beings".

Kindergarten teacher E concluded: "... Science looks for the answers of everyday life problems, society, politics, everything related to life (…) Technology is what makes it work…hum...it's what makes those answers work".

Kindergarten teacher F considered that "Science is a set of phenomena, natural or not (…) and Technology is one of the means that Science also uses to know and to improve its knowledge".

2. Science and Technology as inter-connected domains with influence in society.

Kindergarten teacher A said that "[Science and Technology] are implicitly connected, because for me it is a little hard to disconnect them… for example in the case of health".

Kindergarten teacher B has the opinion that "society is dependent on Technology…so in our everyday life it means everything. People get up in the morning and turn on the TV to watch the news… I think that everything is connected".

Kindergarten teacher D said that "everything is connected, it is the human being who is in the center, it is made by human beings, it is used by human beings and it is for the human beings".

Kindergarten teacher E expressed that "for me, Technology is connected with Science and many times they even blend (…) everything is connected, for example, in our daily routine most of what we use, everything has science and technology in it, the TV's, the microwaves, the LCD, plasma TV, I don't know, it's everywhere."

Kindergarten teacher F said that "everything is connected, for example the "Computer Magalhães" (…) if there are any errors the society rejects it and there is a need to improve the technologies, where the science has a contribution, so there must be a connection between everything.

3. Science and Technology "as beneficial domains for Society"

Kindergarten teacher A stated that "the inter-relation of Science-Technology-Society is quite evident for me in the field of medicine… in the search for new ways to cure diseases…"

Kindergarten teacher D emphasized that "for example in health, there are so many things that improve people's life quality, not just health, the means of transport for example. Everything is at the service of society."

4. *Not always do institutions and the specific groups of interest have influence in Science*.

Kindergarten teacher A explained that "in Portugal there are certain groups against research projects, namely the Green Party, environmentalists… they can try but no one, neither the government pays attention to them and I think that scientists do the same".

Kindergarten teacher B questioned: "Do you really think that scientists let Institutions influence them? I think that the last word will always be theirs… the scientist, who is for example researching a certain disease; do you think that he will allow any influence?

Kindergarten teacher F shared the idea that "although they may try, these Institutions or groups are not able to influence successfully the course of certain research, thus the last word always belongs to the scientists". Then,

however, teacher F changed her answer to a "realistic" answer.

5. *Ideologies and religious beliefs of the scientist do not affect their work*.

Kindergarten teacher B presumed that "the scientists' work and knowledge are above all religion and beliefs (…) the way that he has lived (may influence) but knowledge is above all that".

Kindergarten teacher D, in her VOSTS survey, chose the option "religious beliefs do not affect the scientist's work. Scientific findings are deeply rooted in theories and in experimental methods. Religious beliefs are extrinsic to science". During the interview, she changed with confidence her answer to a "realistic" option.

Kindergarten teacher E believes that "religious beliefs, although it doesn't mean that this actually happens, should be apart from science, they shouldn't allow any influence, perhaps many times they do… I want to believe that a scientist who is searching for a solution for a problem won't let himself be influenced by any of his beliefs."

6. Aspects related to the scientists' social life

Kindergarten teacher C selected the option that states: "Scientists in a social environment behave differently from other individuals, but this doesn't mean that they don't have a family or a social life". Then she changed her answer to a "realistic" idea.

Kindergarten teacher F supposed that "sometimes there must be scientists who really give everything up because their passion for science is so great that they have to go abroad… they either devote themselves to their children or to their professional life. So, family conditions are very important for the success of the research… I think that being a scientist is a profession that has no fixed working hours, they don't have time for themselves, if the research does not turn out as they wish they always need more time. Sometimes they are almost finishing the research and they have to repeat it all over again.

7. Decision-making on scientific questions

Kindergarten teacher B said that "personal opinion is not relevant; the scientist has to base his work on concrete facts… each scientist supports himself/herself on different facts, as a matter of fact one defends more a certain fact and another defends a certain theory".

Kindergarten teacher E paid attention to the following: "I don't like to believe that the moral values, religion and things like that may influence the scientists' work, if so I'll stop believing them, I cannot believe that the scientists answers would be opposite from those that they give because they were influenced by these factors".

8. An idealistic vision of the scientist and of his work

Kindergarten teacher A bounced between two opinions: "I have a romantic idea about the scientist, but it doesn't match reality. The scientist is the one who researches to improve the society"

Kindergarten teacher B listed the scientist's work: "it is credible, difficult, it requires a lot of research, a lot of persistence… it is very meticulous"; scientists "are very intelligent people… they are very distracted … they are normal people but very intelligent, with intelligence above the average".

Kindergarten teacher C did not say much: "I think [that scientists] have an image, let say, a little different from other people, at least those who I see on television, it is either their hair, their clothes or their behavior in society, they are always a little absent-minded".

Kindergarten teacher E portrays a scientist this way: "it's a person of great integrity, responsible, worried about society and the world around us.

From the previous findings we can conclude that the six teachers revealed rather "naive" conceptions of Science, Technology in the interview and of their inter-relation with Society, although in the three corresponding items from the VOSTS survey they have presented answers categorized as "acceptable" and/or "realistic". On the other hand those results allow us to verify that Teacher E is the one who presents more ideas of the "naive type", followed by teachers B and F. We still noticed that some "naive" answers changed after the interview to "acceptable" or "realistic", for example the answer of teacher F on item 7 and the option of teacher D on item 13.

To sum up, the main naive ideas presented by the participants are related to the following aspects:

1. The notion of science appears in correlation with scientific knowledge in the responses of most of the kindergarten teachers. Meanwhile technology appears as being linked to tools which allow the actual practice of science. This shows that science and technology are seen as a sole enterprise - a kind of techno-science which aims at improving life quality.
2. The responses of the teachers are similar when referring to the fact that

science, technology and society are linked and they illustrate this by giving health and the media as examples.

3. The majority of teachers has shown an idealist and conventionalized notion of the scientist and its work, associated to the discovery of absolute truths, above factors such as religion or politics.

The data analysis of the interview has allowed us to identify isolated ideas which have not been allocated to any response category. They are about idiosyncratic naive ideas on STS which we shall present in due time.

In the second moment of data collection through the VOSTS survey filling, after the ITT ended, we saw that four kindergarten teachers show a superior number of "realistic" and "acceptable" responses and consequently an inferior number of the "naive" type. Nevertheless, two kindergarten teachers showed a superior number of answers categorized as "naive" and we must say that at this moment we have no reliable information which allows us to justify this situation.

The items which had the greatest number of "naive" responses were item 13 about "scientists' ideologies and religious beliefs" with three "naive" answers, and items 19 and 7 related to "Nature of the scientific models" and "Influence of specific groups of interest in Science" for which two Kindergarten teachers marked the answers "naive".

6 OVERALL CONCLUSIONS

The in-service teacher training has allowed the kindergarten teachers to become more aware of their own notions and values of the inter-relation of science, technology and society. On one hand the results show that the ITT may have influenced the reshaping of STS notions by the kindergarten teachers involved in the study. On the other hand the results emphasize the need to invest in the permanent training of kindergarten teachers with the goal of increasing scientific literacy of population in general, and children in particular.

As a result we must say that this study met its objectives and that the in-service teacher training showed positive results with regard to their conceptions of STS. This shows a strong, contribution to improve science education at the level of kindergarten.

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