

Learning science in a STS perspective: a didactic experience with 5th grade students

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Abstract

Many schools' practices are still centred on a traditional transmission-reception model, leading students to have a deformed image of Science, not facing it as a living body of knowledge, not relating it to their day-to-day problems and not discussing the relations between Science, Technology and Society. Besides, students lose interest on science classes. This was the case of a 5th grade class which we observed. To address this problem a pedagogical action was prepared, on the theme "The Cell- the basic unit of life", that would allow students to discuss the Science, Technology and Society (STS) relations. Several didactic materials were created, developed and applied, seeking to incorporate the syllabus to real day-to-day life situations, in order to improve student's science and technology literacy and enhance skills, attitudes and values acquisition, decisive to raise informed and democratically active citizens, capable of taking decisions in regards to scientific, technological and sociological events. The aim of the study was to understand the impact of this pedagogical approach in the student learning and perceptions about STS interactions. A qualitative methodology was used. Data collection was based on observation, field notes, questionnaires, group interviews, document-analysis and video and audio- recordings. Data analysis indicates that the developed intervention strategy, with STS orientation, contributed to students learning, improving in parallel, their conceptions about STS interactions and the image they have on the subject of Natural Sciences.

Keywords: Science Education; STS relations; 5th grade students; Natural Sciences; Cell.

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Introduction

The huge advances in science and technology achieved by mankind in recent decades profoundly shape contemporary societies, affecting culture and the daily life of the world population. These advances have had a double face, revealing themselves as negative (pollution, environmental degradation, weapons of mass destruction, etc.) or positive (prevention, control and eradication of some diseases, increased life expectancy, environmental restoration, etc.). So, it is crucial that citizens have power to question and argue critically what they see, hear and read and are involved in decision making. For this they need to acquire scientific and technological knowledge, as well as to develop critical thinking, to enable them to understand the world's problems and contribute to the construction of proposals to diminish or abolish those (Vieira et al, 2011).

This requires that teachers take to the classroom current affairs, mixing them with the curriculum contents in order to make those attractive and meaningful to the students, helping them to build an array of useful knowledge with social significance, important to raise free citizens, responsible, endowed with critical spirit, able to fully participate in the collective life of society and taking rational and informed decisions (Aikenhead, 2009; Cachapuz et al, 2004; Vieira et al, 2011).

The orientation of science curricula according to a perspective Science, Technology and Society (STS), more humanistic, because linked to real and contemporary contexts, it is assumed as a current, innovative and promising model capable of forming citizens scientifically literate (Aikenhead, 2009; Vieira et al., 2011). Galvão et al. (2000) suggest that students of Basic Education should develop the following skills, correlated with a STS teaching-learning orientation: (i) recognition of the importance of Science and Technology in observation of phenomena; (ii) recognition of the role of science and technology in the processing and use of resources on earth; (iii) recognition that human intervention on Earth affects individuals, society and the environment and raises issues of social and ethical nature; (iv) understanding of the consequences that the use of resources on earth has for individuals, society and the environment; (v) understanding the importance of scientific and technological knowledge in the explanation and resolution of situations that contribute to the sustainability of life on Earth; (vi) discussion of the implications of scientific and technological progress in the profitability of resources; (vii) knowledge of the applications of music technology, telecommunications, new materials research and medical diagnosis; (viii) research on costs, benefits and risks of scientific and technological innovations for individuals, society and the environment; (ix)

recognition of the need for a critical analysis to face ethical issues of some of the scientific and technological applications; (x) understanding of how science and technology have contributed to improving the quality of life; (xi) understanding of how society can condition, and has conditioned the course of scientific and technological advances in health and global security.

Yet, in many classrooms the teaching is still mainly based on a transmission-reception model, without connections between curriculum contents and the students' daily lives, making young people turn away from science (Martins et al, 2007). This was the case of a 5th grade class where a general disinterest of students for the subject of Natural Sciences was observed. To address this problem an educational intervention based on a Science-Technology-Society (STS) perspective on the theme "Cell - Basic Unit of Life" was implemented. The implications of the implemented strategy on students learning process were analysed, as well as their perceptions about Science, Technology and Society (STS) interactions.

Methodology

Participants

The study involved 19 students, 10 boys and 9 girls, of a 5th grade class of a school in Viana do Castelo, a small city in the north of Portugal. Their ages were comprised between 9 and 11 years. It was a diverse group in terms of knowledge, skills and behaviours. In general, they show a lack of interest in Natural Science classes.

Pedagogical intervention

In order to define the intervention strategy the school context and the class were observed. In the Natural Sciences classes it was identified an absence of connections between curriculum content and the students' daily lives, resulting in a visible detachment of most students of the topics covered. To address this problem an oriented STS didactic sequence was designed and some teaching materials were created, because, as stated by Campos (2010), STS oriented teaching requires new materials that support the underlying philosophy.

The pedagogical intervention took place over four weeks. Classes were developed to encompass a social, environmental, cultural, political and economic dimension, foster the development of relevant personal and social values and attitudes, and promote connections between different program contents. Digital presentations, edited videos, laboratory activities, quizzes, tasks forms and discussions were used. Laboratory activities were introduced with a video created by the teacher-researcher, in which an idealized Syrian scientist

Said Al-Maidah, after being deprived of his laboratory due to war, calls for solidarity of the class concerned, to find solutions to the problems presented (table 1).

Table 1 – Laboratory activities implemented during the regency of Natural Sciences classes

Activities	Problem-issues
1	"Let's help <i>Said Al-Maidah</i> to find out if the well water is contaminated with microorganisms?"
2	"Let's help <i>Said Al-Maidah</i> to find out if this buccal epithelium contains bacteria?"
3	"Let's help <i>Said Al-Maidah</i> to find out if the onion skin cells contain chemicals?"

To observe microorganisms in water samples a laser pen was used for being a simple technology that can be used in areas without access to microscopes.

Data collection and analysis

Regarding the particularities of the present study, performed during the regency of the teacher-researcher in the classroom, the research relied on a qualitative paradigm, mainly based on an interpretative and descriptive methodology (Coutinho, 2014).

Data was collected through questionnaires (before and after the intervention), observation,

document analysis, audio and video recordings and group interviews.

The questionnaires intended to gauge the perceptions of students about the STS interactions. The questions and corresponding categorization of the answers were based on questionnaire Views on Science -Technology Society (VOSTS). This questionnaire seeks to aggregate students ideas about contents related to Science and Technology, in a perspective of interconnection with Society, organizing them into three categories: Realistic, Acceptable or Naive (Aikenhead and Ryan, 1992; Canavarro, 2000) (table 2).

Table 2 – Conceptual framework of the questionnaire on the STS students' conceptions

Dimension	Item
Science and Technology	Science concept
	Technology concept
	Relation Science – Technology
Influence of Science and Technology in Society	Role of Science and Technology on social problems resolution and human well being
	Responsibility to decide about scientific and technological development

Participant observation was used because the researcher was simultaneously the teacher. Yet, it was also held a non-participant observation, namely before the regency. The analysis of field notes resulting from participant observation allowed to reflect on aspects related to the context, the actions,

relationships and the interaction of the students through the activities presented.

The analysis and interpretation of documents produced by the participants were fundamental to understand the implications for student learning resulting from the intervention. The completion of

the group interviews aimed to clarify some aspects relating to the preliminary analysis of data collected. The audio and video recordings served to support the analysis of the implemented activities and the group interviews.

The data were organized making use of texts in the form of interpretative and descriptive narratives and tables presenting statistical data. To ensure the quality of the study, triangulation of data was done, crossing data from the questionnaires and document analysis with data from transcription of audio and video recordings of activities and group interviews, as well as the field notes.

Results

As can be observe in table 3, most of the students presented a realistic or acceptable conception of science and technology and their relations even before the pedagogical intervention (Q1), but it was notorious during classes an increase on the understanding and clarity students present about these concepts, especially regarding STS interactions (Q2).

Table 3 – STS perceptions: students answers on Q1 (before pedagogical intervention) e Q2 (after pedagogical intervention) by category.

	Type of answer	Q1 (%)	Q2 (%)
Science concept	Realistic	64	47
	Acceptable	18	47
	Naive	18	6
Technology concept	Realistic	29	71
	Acceptable	47	29
	Naive	24	0
Relation Science - Technology	Realistic	76	94
	Acceptable	18	6
	Naive	6	0
Role of Science and Technology on social problems resolution and human well being	Realistic	47	65
	Acceptable	41	35
	Naive	12	0
Responsibility to decide about scientific and technological development	Realistic	70	71
	Acceptable	30	23
	Naive	0	6

The pedagogical strategies used, and the associated discussions, contributed significantly to these results, because they emphasize the role of science and technology in human wellbeing and to solve social problems, as can be seen in the following examples of students' answers:

"It has everything to do with each other. The evolution of technology contributes to science and then both to the evolution of society"

"We learn that science and technology bring good things but also bad things"

"We learn more things about Syria, about their problems"

"I knew that people on Syria are going hungry and that they are at war, but did not think that way"

"We have learned that bacteria are important for life on Earth"

Most of the class was touched with a video about the Syria situation, and interested in learning more about the situation presented and willing to contribute to a solution:

"It's for us to know! After all we are not so bad, while we are here, they are at war! Teacher, tell us more about why it happened this war in Syria"

"How can we help? We don't have a microscope"

"I think it was very important what Said told us, to know what is happening on the other side of the world and compare with our lives"

The groups were very focused and committed to the implementation of laboratory activities and they were amazed with the observations using the laser pen and the microscope:

"Take it easy, take it easy, let's read carefully"

"Ahhh! My God, what is this?! I do not believe what I see!"

"How beautiful! This is a show!"

"Really cool! Hey, that's bad! If they drink it they will get sick!"

"Oh my God, that organism is really great, just by looking at it I will become infected!"

"Look out, look out, this is the best!" (They are to refer to the cells of the buccal epithelium)

During these activities, the teacher-researcher was merely a mediator of learning, trying to interfere as little as possible, revealing an ongoing concern to actively engage students in the learning process, using a constant questioning, according to Vieira et al. (2011) recommendations for Science Education with STS guidance. This means to (i) give the opportunity to students to explain and clarify their thoughts, (ii) create and sustain a learning environment that encourages students to question, explore and express their ideas and (iii) create opportunities for sharing and discussion in order to help students develop a deeper understanding of social issues.

The videos with the "Syrian scientist" as a didactic and pedagogical tool, seemed to contribute to increase motivation, enthusiasm and commitment to the proposed tasks, making them meaningful to students, taking into account that allowed them to explore and solve problem situations with global impact as stated by Vieira et al. (2011).

Even though they were not very receptive to fulfil the protocols ("Oh, teacher, you even have to write all this?"), all the groups were able to draw the observations, noting the total magnification used and the names of cell structures (Figure 1). Most of them answer correctly the questions asked, and their performance got better along classes.

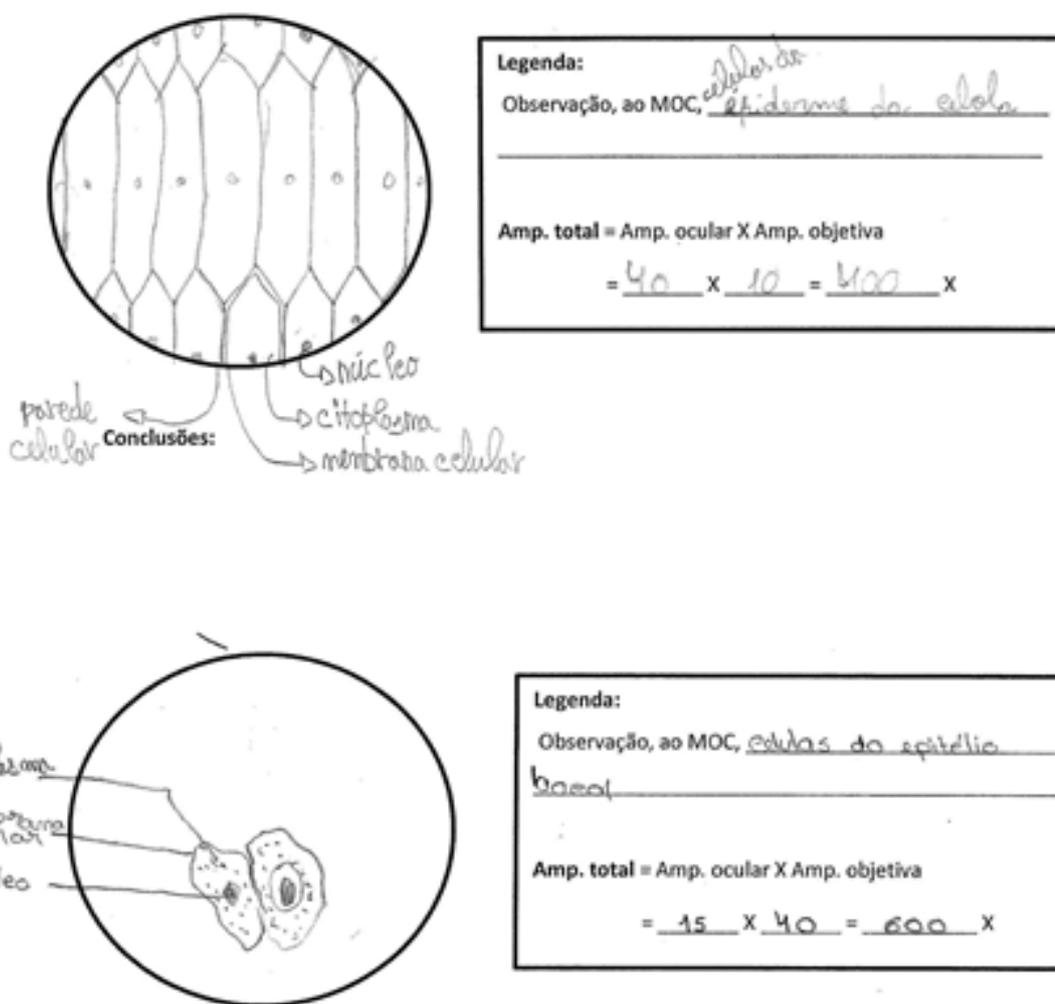


Figure 1 – Examples of drawings done by students.

As can be seen in the drawings, but also in the dialog below, besides being aware of the Syrian war and the problems arising from it, the majority learned the correct structure of the cell.

Teacher- researcher: "What kind of cells are we observing now?"

Student 1: "Plant cells."

Teacher- researcher: "So, which constituents of the cell we expect to see?"

Student 1: “Nucleus, cell wall, cytoplasm, membrane.”

Teacher- researcher: “So, we are facing the same constituents of an animal cell except what?”

Class (in chorus): “The cell wall.”

In general, along the pedagogical intervention a significant improvement was found in the student’s performance, showing they have acquired skills and expertise in handling the Optical Microscope and completion of laboratory protocols.

By the end of the intervention all students considered that the subject of Natural Sciences helps them to understand the world around them, and even students usually less participatory were interested and actively engaged in activities proposed.

Conclusions

Analysis of the responses to the questionnaires, crossed with the information from the document review and field notes, point that the strategies and materials used stimulate students’ interest and learning in topics of Natural Sciences, particularly in promoting discussions of STS character and in laboratory activities. Even students usually less participatory were motivated, engaging enthusiastically in activities proposed.

It is noteworthy that a constructivist STS oriented pedagogical action improved students’ perceptions about STS interactions and levels of scientific and technological literacy. On the other hand, it promoted the acquisition of skills and attitudes of democratically involved and informed individuals, involving them actively in their own training, presenting a more realistic image of science and technology and its implications for the Society, either positive (in terms of health, environmental recovery, creating utensils, etc.) or negative (military resources, pollution, stress, consumerism, etc.).

It should also be noted that starting from the apathy of most of the participants towards the discipline of Natural Sciences, checked over the observation period by the teacher-researcher, a considerable part showed, gradually, a greater involvement in the proposed activities and a greater interest for the presented contents, revealing elements of an increase in the value attributed to the discipline in question.

At the same time the students raise their awareness about social problems and the willing to contribute to their solution, and, departing from the Syrian humanitarian crisis, they reflect upon effects of war on peoples’ life.

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