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Students at risk of dropping out: how to promote their engagement with school science?

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Abstract
The goal of this study was to understand which factors, related to school science, can interfere with engagement of students-at-risk-of-dropping-out with school science and to know what kind of activities and teaching strategies are adequate to these students. This case-study involved a chemistry-teacher and ten male students. Data was based on teacher's interview, teacher's and students' notes regarding activities implementation and students' questionnaires. Results show that linking science with society by means of practical activities – that are student centred and require agency, autonomy, and the mobilization of complex competencies – facilitated the students' engagement with school science.
Keywords: Science education; science activities; relevance; engagement

Introduction

We live in an age full of paradoxes and contradictions. On the one hand, there are major opponents to school that compete with the disciplinary and decontextualized school knowledge, making it less appealing and interesting in the eyes of the students (Resnick & Perret-Clermont, 2004; Saljo, 2004; Smyth, 2006). On the other hand, it is at school that students, future citizens, will appropriate a series of competencies to exercise their citizenship in a responsible and autonomous way (Saljo, 2004). So, not accessing a quality education or not developing essential competencies is frequently associated with social and professional exclusion (Archambault, Janosz, Morizot & Pagani, 2009; European Council, 2006). As a result, it is unacceptable that some students will not develop essential competencies or will even drop out of school. However, recent data reveal that this is still a noteworthy situation in Portugal.

Indeed, despite recent improvements, Portugal still presents significant retention and dropping out rates (GEPE, 2010). In relation to science education, international studies concerning scientific literacy highlight complex situations. For instance, PISA 2006 (OECD, 2006) revealed that Portuguese students are below average in the case of sciences, suggesting that many students have not appropriated competencies related to scientific literacy. Data comparing successful students with unsuccessful students are, particularly, outstanding. Students who have failed (i.e., who are below expected school grade), and who represent 40% of inquired students in Portugal, have performances much lower than those who are compliant, changing the overall pattern of results of the Portuguese 15 year old students. For instance, in what concerns scientific literacy, the results of PISA 2006 show that when we exclude from the overall sample unsuccessful students the results improve significantly, becoming well above OECD average (average of Portuguese general sample: mean=474.00, SD=3.00, n=5013; average of Portuguese sample without unsuccessful students: mean=517.29, SD=2.94, n=3031). The same study reveals that Portuguese students are amongst those students who are more interested in science (mean=571.00, SD=1.80, n=5013) and that even unsuccessful students find science interesting (mean=570.58; SD=1.76, n=1982).

Having in mind that both school achievement and dropping out are associated to students' engagement (Greenwood, Horton & Urley, 2002; Thijs & Verkuyten, 2009; You & Sharkey, 2009) and considering the scenario just described, it is extremely important to understand which factors may affect disengagement from school and from school knowledge. With the present study, we aim at understanding which factors related to school science can interfere with the engagement of students-at-risk-of-dropping-out with school science and, particularly, at knowing what kind of activities and teaching strategies might be adequate to these students, promoting their engagement with school science and learning.

This focus is extremely important given the prominence that science education assumes in the educational curriculum nowadays. We live in a world embedded in science and technology that demands from its citizens an understanding of science and of its specificities and how scientific knowledge is constructed (Osborne & Dillon, 2008). Appropriating scientific knowledge is fundamental to act on our complex society. Besides, science education can also facilitate the development of other transversal competencies that might further enable students' responsible participation in society (Galvão, Reis, Freire & Oliveira, 2006).

However, despite the clear advantages associated to science education, general data reveals that the number of students who choose science studies and careers is decreasing and it also confirms low levels of general scientific literacy (European Commission, 2004). So, it is important to identify which strategies might be more adequate to unsuccessful and disengaged students. According to Lin, Hong and Huang (2011), "continued suitable studies in curriculum development and instructional strategies are needed to develop positive and sustainable science education practices for students with low interest, enjoyment, or engagement in science" (p.16).

Engagement and teacher practices

Engagement with school has been gaining strength in scientific literature (Fredericks, Blumenfeld & Paris, 2004). Indeed, it is not only positively associated to school achievement as it is negatively associated with dropping out (Greenwood et al., 2002; Fredericks et al., 2004; You & Sharkey, 2009). Both situations make it an important theoretical construct for studying students who are at risk of dropping out or those students who do not develop essential competencies due to their alienation and disinterest in school knowledge (Smith, 2006).

Fredericks et al. (2004) define engagement as a multidimensional construct that involves three components (behavioral, emotional and cognitive) interacting in a complex and dynamic way. This construct reveals itself suitable for explaining students' involvement, commitment and investment in school as well as their school trajectories (You & Sharkey, 2009).The behavioral dimension has to do with participation in academic work and in social or extracurricular activities, and with conformity to the school and class rules; the emotional dimension refers to the affective experiences lived inside classroom and in school and to experiences related with the creation of affective bonds with teachers and peers. Finally, the cognitive dimension is based on the idea of intellectual investment and effort to understand academic themes and to develop complex competencies (Archambault et al., 2009; Fredericks et al., 2004).

Engagement is a psychological experience (Archambault et al., 2009) that results from the satisfaction of some basic needs, such as belonging and psychological safety, feeling autonomous and competent (Thijs & Verkuyten, 2009). And as such it grows from the complex interaction of a set of contextual factors (such as individual, familiar, social and related to school and class) and it can be changed (Archambault et al., 2009; Fredericks et al., 2004; You & Sharkey, 2009).

Several studies suggest that both the way that the teachers structure the classes and the type of involvement with students are associated to engagement. According to Thijs and Verkuyen (2009), when teachers define rules and clarify their expectations and demands, they generate a sense of competence in the students which will facilitate students' engagement with classes. In addition, when teachers support students learning, they generate a sense of belonging in students, making them more engaged with class (Thijs & Verkuyen, 2009). Similar results were obtained by You and Sharkey (2009). These authors reveal that when students perceive support from the teachers (for instance when they clarify expectations and provide clear guidelines) in what concerns homework, students display more signs of engagement. Laukenmann and col. (2003) state that when teachers support the students, they create opportunities for them to have successful experiences and to develop a sense of competence, which are essential for students' cognitive engagement with class, even more if those students are low achieving. According to Schussler's (2009), the creation of opportunities for being well succeeded with learning involves raising students' interest and a sense of authenticity in what they are doing inside the class.

So, defining clear objectives, communicating expectations, giving guidelines and monitoring work development, respecting students' rhythm are important issues to create secure environments, where students can develop a sense of belonging and interpersonal meaningful relationships, but also a sense of competence, which will affect theirs engagement (Thijs & Verkuyen, 2009). However, as Assor, Kaplan, Kanat-Maymon and Roth (2005) highlight, teachers' over controlling behaviors, for instance interfering with students learning rhythm, constantly giving guidelines and not promoting overt classroom discussion, are associated to students' less engagement with class.

In what concerns science education, Basu and Barton (2007) stress the importance of connecting science to a personal, meaningful experience, in order to create sustained interest and students' engagement. According to these authors, it is essential to create authentic opportunities for students to refine their personal and professional, future perspectives, and to develop significant social relationships in harmony with their values and believes. Besides, it is essential that students perceive science themes as useful for their lives, enabling them to develop a sense of agency over the surrounding world. Furthermore, Laukenmann and col. (2003) point to the importance of creating situations of psychological well-being and of enjoyment as these situations are associated to "experiences of cognitive engagement and competence" (p. 503).

Methodology

This is a case-study of the process of implementation of a set of selected science modules and its impacts on students who are at risk of dropping out from school. The goal of this study is to know which characteristics of these modules facilitate engagement of students' at-risk-of-dropping-out with science classes. Specific aims were: to understand the relationship between the characteristics of the activities developed, teacher's strategies, and students' appreciation of those activities and strategies; and to make an overall appraisal of the type of science activities and teachers' strategies that are more aligned with these students' needs, facilitating their engagement with science classes.

Context of the study

The modules analysed in this work were developed within a European project, PARSEL (www.PARSEL.eu). This project emerged from the need of the educational systems to respond to the increased disinterest of students in science subjects and its main purpose was to create innovative science modules that would make science subjects more relevant and popular in the eyes of students (Holbrook, 2008).

Having in mind this purpose, PARSEL modules present some common features. They are student centred, requiring their active participation and involvement. They have a practical dimension, in the sense of Abrahams and Millar (2008), i.e., activities in which students manipulate and observe real objects and materials, that might involve or not experiments. The activities involve problem solving, decision making and argumentation, for which students have to use substantive and procedural knowledge as well as, frequently, epistemological knowledge. Furthermore, the activities proposed entail collaboration and group work, requiring students to share and communicate their ideas, knowledge and information, and to explain their positions to others. Finally, the modules propose a specific model for developing the activities, in which contextualization plays a central role.

According to the model, the modules develop along three stages, in all of which there is a concern with relating the activity with students' interests and questioning about the world. So, the first stage (scenario construction), starts with a social problem and with the activation of relevant scientific concepts for understanding it. During the second phase (Inquiry-based problem solving), students develop and implement an inquiry activity in order to solve the initial problem. Finally, during stage three (Socio-scientific decision making) students are encouraged to re-appraise the initial problem, using the new acquired knowledge and, in some cases, to make a decision (Galvão, Reis & Freire, 2008; Holbrook, 2008).

Modules were implemented by different teachers in their classes, who were encouraged to gain ownership over the modules, i.e., to introduce any changes in order to integrate it into the curriculum and to adapt it to the characteristics and circumstances of their school and class. As different teachers were involved with the Portuguese team, modules were implemented with different students, in different school grades, in different school subjects and also in distinct schools and type of educational programs.

The Portuguese team implemented and tested thirteen different modules (some of which were built by the Portuguese team, but other were built by the European partners). In this paper, we will describe the four modules that were implemented and tested by the teacher involved in the case under analysis.

Modules characterization

How can we avoid energy losses in our school? (Energy Losses)

With this module, students are expected to investigate how school manages energy use, in order to remain warm during the winter and cold during summer time and to propose improvements. For that, students have to develop a plan for resolving the initial problem

(How can we avoid energy losses in school?), identify places from where energy losses or gains might occur, search for information and, based on that, they have to develop a model about ways to render school energetically efficient and present it to the school community.

Analysis of a journal and/or magazine news (Analysis of News)
The objective of this module is to facilitate comprehension of the tensions that surround scientific enterprise, technology and society. For that, students have to collect newspaper or magazine news about controversial issues related to Science, Technology, Society and Environment, analyse it by taking into consideration some critical points, present his/ her analyses to the class, and discuss their main ideas with peers.

Planning a Space Trip to Mars (Trip to Mars)
This module involves a role play activity, which goal is to facilitate reflection on environmental issues, namely on the need to adequately manage environmental resources in order to survive. For that, students are expected to search for information on the website, analyse information concerning their initial questions, write an individual report where they present their decisions and their arguments, work in groups to make an overall plan of the trip to Mars, present their proposed plan to the class and defend their ideas and discuss other's ideas and arguments.

What is worse, cigarettes or narghile? (Cigarettes)
This module describes a laboratory activity that examines the chemical components of smoke, of both cigarettes and water-pipes (narghile). The aim of this activity is to expose adolescents to the scientific aspects related with smoking and to present the relevance of chemistry in everyday life situation. This module was adapted for the Portuguese culture and so water-pipes were not considered.

Participants
This study involved a science teacher, Margaret, and a 12th grade class from a program of education and training, which was formed with the intention to provide these students with a new chance to continue studies. In Portugal, compulsory education is nine years (students aged 15). After this period, there are more three years (secondary school), in which students choose a field of study that they want to study, after which they may pursuit university studies. However, due to the high number of young people who give up studying at the end of compulsory schooling (and even before) (GEPE, 2010), on 2004 a new law was published with the goal to create education and training programs directed to those students who already dropped out school or are at-risk of dropping out (Law nº. 453/2004, from 27th July). This program aims at providing a general education and also a professional training to students, facilitating their transition to professional life. Considering the particular students that participated on the study, after 12th grade they will have a professional degree and will be able to work as electricians. The class were composed by ten students, all males, aged 17 to 20.

Margaret has been teaching science for seven years. She has a graduation in physics and chemistry, a master on science education and was working on her PhD on the same area. She became fully involved with inquiry activities during her master course. When she was allocated with this class, and facing students' academic difficulties and disengagement, she decided to implement that strategy. When Margaret joined the study, she had been teaching these students since the previous year (11th grade).

Data Collection and Analysis

This study is part of a larger study which aimed to collect evidence about the implementation of science modules from the perspectives of both teachers and students. Concerning this study, the methods used for gaining insight about teacher's perspective were: interview and teacher notes regarding modules' implementation. The interview, which was conducted by one of the researchers, aimed at collecting teacher's biographical data and information concerning modules implementation (introduced changes, perceived difficulties, students' reactions, recommendations) as well as and teacher's general appraisal of the modules. Teacher notes also focused on collecting data concerning difficulties and recommendations, introduced changes and students' receptivity as well as teacher's appraisal.

Data were analysed using an interpretative method (Erikson, 1986). Based on the previous defined categories (reasons for engaging with the project; conception concerning science education goals; appraisal of modules characteristics; modules implementation – expectancy, difficulties, changes, recommendations; students reactions), we read and re-read data so as to identify meaningful units on the text that would match those categories. Two of the researchers were involved in this process of content analysis. At first, each one analysed the data independently, considering previous defined categories, and then crossed and discussed the interpretations made until reaching a consensus. After this reduction process, we re-constructed the global perspective of the teacher, acknowledging the complexity of her perceptions in what concerns the characteristics of the modules and her perceptions about students' reactions to the modules.

For analysing students' perceptions of modules we used mainly inquiry by questionnaire. Besides this method, we collected written documents (students' works and students' written comments about the modules). Questionnaires, developed by the PARSEL group, were composed by 30 items, to which students had to answer by selecting an option: totally agree, partially agree, partially disagree or totally disagree. The items related to: general perception about science education and its relationship with science; relevancy and popularity of modules; scientific literacy promotion by the modules; perception about some characteristics of the modules and; perception about the teacher strategies. For analysing the questionnaire, frequencies were calculated and compared between each module by a Kruskal-Wallis Analysis, followed by a Post Hoc Dunnett's Test (when equal variances are not assumed). Statistical analysis was performed using the computer program SPSS for Windows (Ver.17.0, SPSS Inc.).

The Kruskal–Wallis analysis is a non-parametric method for testing whether samples originate from the same distribution. It is used for comparing more than two samples that are independent. In this case, the four modules were compared. The factual null hypothesis is that the populations from which the samples originate, have the same median. When the Kruskal-Wallis test leads to significant results, it means that at least one of the samples is different from the other samples. As the test does not identify where the differences occur, a post hoc test was used to find which sample, or samples (which module(s) in this case) were significantly different from the others.

Results

Teacher's perspective

When Margaret was invited to participate in the project she perceived the modules as an extension of what she had been doing with her class. In addition, proposed guidelines were coherent with their own conceptions regarding science education. When appraising one of the modules, she states that,

> … I think that [science education] should also aim at making students enjoy classes, shouldn't it? And it also should explore connections between science content and daily life. These modules emphasized this connection, promoting students' scientific literacy. I could list the characteristics of planet Mars and they most probably wouldn't like the lesson at all. But with this module, they learnt something about Mars and they become able to search for relevant information whenever they need. So, I think that science education should aim at involving students with science issues. How? They have to learn to participate actively in their own learning… (Interview – July, 2008)

So, modules were perceived as a means to achieve her goals concerning science education, namely making students interested in science, and developing some competencies, such as autonomous learning. According to her, contextualizing the activities and exploring science relationships with daily issues, as well as developing inquiry problem solving activities centred on students, can work as major contributions for achieving these goals. And this was another main advantage of the modules.

Generally speaking, Margaret followed the three stage model and the proposed guidelines. From her point of view, the three stage model was very important for motivating students. Through the construction of the scenario (stage 1), she was able to contextualize the module, make a connection to students' lives, call their attention for certain topics and enact their curiosity. During the last stage – (socio)-scientific decision making, she was also able to connect students' daily interests with scientific knowledge, as at this stage students had to relate conceptual science to life issues. According to Margaret, this particular issue was extremely important, as it allowed expanding students' learning further away. In commenting about the module *Analysis of News,* where she explored issues related to radioactivity, she states that:

> (...) students could relate science, technology and society. Technology, for example, scientists working in CERN. We discussed the technological institution *versus* scientific community… And their knowledge about science and scientific activity increased … And they also became more critical [and] alerted to the media. (Interview – July, 2008)

So, by reflecting on radioactivity, students were able to understand how science, technology and society interact in complex ways and how it affects their lives. In addition, they became more critical concerning the news related to science.

In what concerns the modules implemented, Margaret chose four different modules that she thought she could easily articulate with curricular contents: *Energy Losses*, *Analysis of News*, *Trip to Mars* and *Cigarettes*. In addition, these modules proposed different activities, such as a role-play (*Trip to Mars*), a text analysis (*Analysis of News*), a research activity (*Energy Losses*) and an experimental activity (*Cigarettes*).

For assessing students, she used a record sheet concerning a number of competencies related to scientific knowledge, reasoning, communication and personal attitudes (like perseverance, respect for others opinion). This sheet was filled separately by her and by the students (self-assessment), at the end of each stage of the modules. After that, she would compare both assessments and would provide feedback to the students on the following class, regarding assessed competencies. This assessment practice was not new, as she already used it in her classes before joining the project. Feedback to and from the students is a constant concern of hers. As Margaret explains,

> I was concerned with giving them constant feedback as they were developing the activities...They also wrote individual reflections about their own learning. Although we developed group activities, reflections were written individually, so that I could understand their doubts. They also had to highlight the changes that they had undergone, the difficulties they experienced and how work group functioned. This was also important – having feedback from students. (Interview – July, 2008)

So, in her perspective feedback from the students was an important means for assessing their difficulties and promoting learning.
In what concerns the process of the implementation of the modules, Margaret first implemented *Energy Losses*. She started by analyzing energy use at home and not at school as was originally proposed by the module. According to her, students became really engaged with the problem and motivated to solve it, when they first acknowledged how much energy their family spends during one weekend, and then when they extrapolated those expenses for the entire school. As Margaret explains,

> I thought that, instead of beginning with school, I would rather focus at home. As a result, I built the activity so that students could develop it during the weekend, at home. They had to get information concerning how much energy they spend at home. Next, they had to get informed about how much a kilowatt per hour costs. And then: 'Ah! I spent all this during the weekend!!' They developed this activity at home. It was stage 1. We discussed their findings in the class and then we focused our discussion at school. 'If you spent that much energy at home and you are only four, imagine how much the school will spend? And how can school save energy?' (Interview – July, 2008)

For solving the problem, students had to develop several actions, namely, to analyse the school plant and to search for relevant information in order to propose a model for saving energy at school (stage 2) and to present it to the class (stage 3). In order to build the model for energy saving, students were supported by other teachers from the engineering area. After stage 1, students were highly motivated with the inquiry activity and they were actively involved with the problem. Furthermore, as they were enrolled in a program to be an electrician, this module was particularly relevant and related to their future professions and actual interests. It was as if they were real electricians who have to solve a problem. According to Margaret, this relation to professional life was on important motivating issue for the students and it was one of the reasons that made her chose this module. In her own words,

> Once again, this is one of the activities that I really thought that would involve not only knowledge but also technical skills which are useful for their professional future. (Interview –July 2008)

The second implemented module was *Analysis of News.* This module was implemented within the curricular context of energy, nuclear energy and radioactivity. Margaret initiated it by requesting the students to collect news about radioactivity and energy (stage 1). The news collected were then analysed in the class. During this analysis, students detected and discussed some scientific inconsistencies, like the use of incorrect units and even erroneous notions of energy. After this discussion, Margaret selected two of the news, which main topic were about the negative effects of radioactivity (stage 2) and she promoted a discussion around the topic. After this discussion, Margaret asked students to go further away by exploring radioactivity according to a different angle. As she explained,

> And then, how did I develop the third stage? I wrote down: 'Go further away'. The texts that we had just analysed were centred on negative effects of radioactivity. During stage 3, we focused on its positive effects. It was the discovery of radioactivity: scientific research, technology [CERN – European organization for nuclear research], radioactivity for treating cancer... (Interview –July 2008)

According to Margaret, at the end of this module, students were able to relate science, technology and society and they also became more interested regarding news related to science. In her words,

> I remember that one day, one student approached me and showed me a newspaper article about a group of scientists who had developed some work related to radioactivity. 'Do you see teacher? It's in the paper what we've been talking about'. For me, this was a significant move. It means that they become more aware and more interested about what is happening around them. (Interview –July 2008)

During the socio-scientific decision stage (stage 3), students discussed the positive effects of radioactivity and watched a documentary about CERN's activity. According to Margaret, this module had a major impact on students'. First of all, they changed their ideas about possible future professional and academic paths. Some students admitted for the first time the possibility of following further studies and some of them could even envisage themselves as scientists. As Margaret explains,

> It was a movie about the research developed at CERN's, about physics and people who work at CERN. They kept on asking: 'And what about us? Will we be able to work there one day?' 'I like this a lot'(…) (Interview – July, 2008)

Secondly, this activity had a main impact on the students' relationship with school. In the context of the module, Margaret suggested that her students would be involved in the school project 'Environment and radioactivity'. During the implementation of the module, students developed skills for using an instrument to measure radioactivity. So they were very useful to the project, as they were able to carry on the measurement task and to present the results to the school. As Margaret states,

> (…) So, the module ended up motivating for the 'environment and radioactivity' school project, in which originally they weren't supposed to participate. (…) So they loved this module. (Interview – July, 2008)

The module also ended up challenging students' perceptions about themselves as students, as someone who has relevant knowledge concerning radioactivity and who can develop important actions concerning it.

The module *Planning a Space Trip to Mars* started with the analysis of a news concerning an oil spill accident at the sea. This worked as a framework for exploring issues related to renewable and non-renewable energies on planet Earth (stage 1). After analysing the natural resources of Earth, students changed their focus to a trip to the planet Mars based on a problem raised by the teacher: What are the conditions that will ensure our survival and preservation of food inside the ship and what perspectives do of the physician, scientist, responsible of the mission and the engineer hold about these conditions? Students worked in groups. After that, there was a debate concerning each student's perspective that was moderated by the teacher (stage 2). At the end, they compared the survival conditions of the ship with the Earth conditions and they discussed about the energy resources of planet Mars and Earth. Then, at the third stage, they presented these comparisons in a poster format. According to Margaret this module was important not only for facilitating science content learning but also, students' knowledge about scientific activity and science as they had to analyse scientific enterprise in the light of different perspectives.

> I think that comparing survival on the ship and the conditions on the planet Earth and exploring the reasons why we cannot survive in Mars was very important for the students. And I think that this discussion was useful for their learning about science, but it was not limited to this specific dimension. If we make a deeper analysis, the discussion also involved ideas related to the construction of science, didn't it? The view of the scientist, the scientific research… the doctor's perspective, which relates to society…and the perspective of each one… (Interview – July, 2008)

The last module to be implemented (*What is worse, cigarettes or narghile?*) started by requiring the students to analyse some materials, like olive oil, soap, lemon, in order to identify their acid-base nature (stage 1). After that, students analysed the components of the cigarette ash, following the suggested experimental activity (stage 2). Finally, they established a relation concerning the effect of smoking on their lungs (stage 3).
Margaret appraisal of this module differed from her appreciation of the other modules. According to her, students didn't enjoy the module, mainly due to some of its characteristics. First of all, the module was too much prescriptive and rigid, not giving enough room for the students to plan, to decide, and to deal with unexpected difficulties. Another aspect that she highlighted was the greater difficulty of this module because it involved a larger amount of previous chemical knowledge. According to her, these aspects, associated with the fact that this module was developed after the other three modules, affected students differently. As she explains,

> This module was too much oriented. They are not used to it anymore. Despite requiring the students' active involvement in the experiments and in making the conclusions, the activity was too much oriented. Students were not provided with the opportunity to propose and to explore possible solutions for the problem. Students enjoyed the content but they didn't appreciate how the activity was implemented. I would change the activity. I find it a nice activity, it has nice reflexion questions. But the way it was presented... It could be a little more open. (Interview –July, 2008)

Despite these negative aspects, Margaret found the module relevant for students, as it allowed them to make connections between the new acquired knowledge with their daily lives.

> Most of these students, (...) smoke. In a class of ten students, nine students smoke. So, when they saw the black filter, they got elucidated. 'Ah! This can happen to my lungs, teacher'. The activity and the connection they made with their lungs… to their daily life, was very important. (Interview –July, 2008)

In general, Margaret made very good appreciation of the modules, regarding its impacts on students' learning and engagement with the activities. The points most stressed were: a) its authenticity (in the sense that students had to solve real problems, for which there was no previous answer), b) its connection to students' daily life, 3) the possibility to explore the relations between science, technology and society and 4) the fact that modules involved problem solving activities centred on students. These were major aspects that, according to the teacher, promoted students' interest and enjoyment. In Margaret words,

> They [the students] reacted very well. They liked very much this kind of activities because they were able to search, to reflect, and to make self-assessment for themselves... They reacted very well to the modules. (Interview – July, 2008)

Besides, in her point of view, her students also learnt a lot about several scientific contents and they developed some relevant competencies, namely critical reasoning, and positive attitudes towards science. Finally, one important issue made salient by Margaret was the suitability of the modules to students' characteristics and expectations. According to her, being student centred and involving practical activities were two important characteristic of the modules.

> They [the students] are motivated by practical approaches. An approach that involves theory, without a practical component or any connection to their lives, makes students disengaged. They get bored … They lose interest in the activity. They get disaffected with the lesson (Interview – July, 2008).

In what concerns their expectations, Margaret explains that these students had no academic success, presented low self-esteem and were disengaged with school, and that they perceived this program as one more possibility to continue studies. So, for most of them, the decision to join this program was affected by their perception that curriculum would be based on practical activities and, as such, would be easier, increasing their chances of success. According to Margaret, these expectations were met in her sciences classes and also with the modules implementation.

Students' perspective

On overall, students' made a very positive appreciation of the modules implemented, as expressed in their responses to the questionnaire. Indeed, most students mention that they would like to do more activities of this kind (74% of concordance) and consider the tasks interesting (77%), and most of them fully or partially agree with the statements "Studying more modules like this one would make science learning more useful for my life" (90%), and "This module showed me the importance of science for decision making about social issues"(90%). These answers suggest that students felt involved with the activities, stressing its joyfulness, the promotion of a scientific knowledge, and the connection with their daily life. This last dimension was much stressed by the students and reflected on several statements.

Indeed, at the end of the activities, almost all students agreed with the following statements: "Science learning is useful and important when it involves a discussion of a social issue that includes a science component" (100%), "Knowing why I was studying science in this module made me understand the importance of learning science for my daily life" (97%) and "The social issue helped me to know why I needed to study science in this module"(100%). So, the connection between science and society, reflected in the social-scientific problem that students had to debate or to solve, and students' recognition of the important role that scientific knowledge can play in their daily issues, were important characteristics of the modules. The connection of school science to students' lives was an issue further mentioned on some students' written documents. For instance, one of the students wrote:

> I learned many things with this activity. I learned about the nuclear reactor at Chernobyl. I really liked the case of the family who heard the radiation alarm rang. This case made me think about what could happen if the nuclear reactor of Spain explodes. The film I watched about CERN was spectacular. I would like to work there. (Written Documents, 2008)

In addition to this connection to their lives, another important dimension pointed by the students was the possibility to learn things that are useful and also to become critical regarding the surrounding world. Indeed, most students agreed that developing this type of modules facilitated the construction of useful scientific knowledge (97% agreed with the statement "The tasks given to me during the studying of this module allowed me to learn scientific knowledge that is useful for my daily life") and of a critical attitude concerning news about science and socio-scientific topics (95% agreed with the statement "This module helped me being critical about scientific news in the media").

Finally, the nature of the proposed activities was also important for their overall appreciation of the modules, as suggested by their agreement with the following statements: "Solving practical scientific problems, coming for everyday issues, can be important and useful for my life", "Having to think a lot makes science more interesting", "I like to devise experiments" and "Planning my own experiments made me appreciate the importance and usefulness of science for my everyday life" (all with 100% of agreement). Besides, most of the students stated that they particularly appreciated the discussion task leading to a socio-scientific decision (stage 3) (98%). So these data suggests that by being required to actively participate in planning the activities, in solving problems and in making decisions, students were able to appreciate the role of science in their lives and felt involved with the modules.

Two additional important characteristics highlighted by the students' answers to the questionnaire were: an interpersonal dimension and a personal meaning making dimension. First, students felt that the activities allowed them to interact with peers and to share ideas with others, as illuminated by the items: "This module provided me with opportunities to participate in group work" (98%) and "This module encouraged me to share ideas with my friends" (90%). Secondly, with the modules they were able to pose their own questions and to search for answers, as exemplified in the next items: "This module encouraged me to ask questions" (90%) and "This module provided me with opportunities to get answers to my questions" (87%).

Concerning teacher strategies, all students agreed that the way the teacher developed the modules was essential for their success, namely 1) introducing the activities highlighting the importance of science for understanding daily issues; 2) using a scenario to contextualize the module; 3) the rhythm, giving time to students work over their difficulties and to explore deeply the studied themes; and 4) feedback. Results showed 100% of agreement on the item: "The teacher introduced the module in a manner which I came to understand the importance and usefulness of science for my daily life", 97% of agreement on the item "Introducing the module using a scenario made the module interesting"; 95% of disagreement on the item "The pace of teaching this module was so fast that it made my learning difficult"; 92% of disagreement on the item: "The pace of lessons in studying this module did not make the topic interesting" and full agreement on the two items concerning feedback: "Feedback from the teacher in class made me understand the importance of learning science for my daily life" and "Feedback from the teacher made the module more interesting".

By comparing students' perceptions concerning the different modules (Tables 1 and 2), we were able to uncover differences in the type of appreciations. First of all, it was evident that the module *Cigarettes*, was less popular than the others, i.e., was the module less associated with a positive affective experience. Indeed, almost all students didn't agree with the statements: "I wish I could study more modules like this one" (Kruskal-Wallis Analysis: χ^2=30.71, df=3, p<0.001; Dunnett's Test: p<0.001 for the comparison between *Cigarettes* and each one of all the other modules), "The tasks given to me through studying this module were interesting" (Kruskal-Wallis Analysis: χ^2=31.51, df=3, p<0.001; Dunnett's Test: p<0.001 for the comparison between *Cigarettes* and each one of all the other modules) (Table 2).
Secondly, students were not able to perceive the relevance of this module as much as they did with the other modules. Indeed, they didn't agree with the statements: "Studying more modules like this one would make science learning more useful for my life" (Kruskal-Wallis Analysis: χ^2=21.00, df=3, p<0.001; Dunnett's Test: p<0.05 for the comparison between *Cigarettes* and each one of all the other modules) and "This module showed me the importance of science for decision making about social issues" (Kruskal-Wallis Analysis: χ^2=29.08, df=3, p<0.001; Dunnett's Test: p<0.01 for the comparison between *Cigarettes* and each one of all the other modules) (Table 2).

Table 1. Students' general evaluation of each module. (FA) fully agree; (PA) partially agree; (PD) partially disagree; (FD) fully disagree.

		Energy Losses	Analysis of News	Trip to Mars	Cigarettes
Joyfulness					
I wish I could study more modules like this one	FA	7	9	9	0
	PA	3	1	0	0
	PD	0	0	0	5
	FD	0	0	0	5
The tasks given to me through studying this module were interesting	FA	6	10	9	0
	PA	4	0	0	1
	PD	0	0	0	7
	FD	0	0	0	2
I liked the discussion leading to making a socio-scientific decision	FA	8	10	8	2
	PA	2	0	1	7
	PD	0	0	0	0
	FD	0	0	0	0
Relevance					
Studying more modules like this one would make science learning more useful for my life	PA	7	10	9	2
	FA	3	0	0	4
	PD	0	0	0	3
	FD	0	0	0	1
The social issue helped me to know why I needed to study science in this module	FA	7	10	9	4
	PA	3	0	0	6
	PD	0	0	0	0
	FD	0	0	0	0
This module showed me the importance of science for decision making about social issues	FA	10	10	8	1
	PA	0	0	1	5
	PD	0	0	0	4
	FD	0	0	0	0
Science learning is useful and important when it involves a discussion of a social issue that includes a science component	FA	10	10	9	8
	PA	0	0	0	2
	PD	0	0	0	0
	FD	0	0	0	0
Knowing why I was studying science in this module made me understand the importance of learning science for my daily life	FA	10	10	8	6
	PA	0	0	1	3
	PD	0	0	0	1
	FD	0	0	0	0

Nature of the activities					
Having to think a lot makes science more interesting	FA	5	7	9	4
	PA	5	3	0	6
	PD	0	0	0	0
	FD	0	0	0	0
Solving practical scientific problems, coming for everyday issues, can be important and useful for my life	FA	8	10	9	8
	PA	2	0	0	1
	PD	0	0	0	1
	FD	0	0	0	0
I solved practical scientific problems, coming for everyday issues	FA	8	9	10	4
	PA	2	1	0	5
	PD	0	0	0	1
	FD	0	0	0	0
Planning my own experiments made me appreciate the importance and usefulness of the science for my everyday life ([1])	FA	-	-	-	6
	PA	-	-	-	4
	PD	-	-	-	0
	FD	-	-	-	0
I like to devise experiments ([1])	FA	-	-	-	7
	PA	-	-	-	3
	PD	-	-	-	0
	FD	-	-	-	0
With this module I was able to plan and develop my own experiments ([1])	FA	-	-	-	0
	PA	-	-	-	2
	PD	-	-	-	3
	FD	-	-	-	5
Scientific literacy promotion					
The tasks given to me during the studying of this module allowed me to learn scientific knowledge that is useful for my daily life	FA	8	10	10	4
	PA	2	0	0	5
	PD	0	0	0	1
	FD	0	0	0	0
This module helped me being critical about scientific news in the media	FA	10	10	7	3
	PA	0	0	2	5
	PD	0	0	0	1
	FD	0	0	0	0
I believe the discussions in this module were relevant for improving my reasoning skills	FA	8	10	8	3
	PA	2	0	1	3
	PD	0	0	0	4
	FD	0	0	0	0
This module made me think a lot	FA	10	7	9	0
	PA	0	3	0	0
	PD	0	0	0	8
	FD	0	0	0	1
This module encouraged me to ask questions	FA	10	10	7	2
	PA	0	0	2	4
	PD	0	0	0	3
	FD	0	0	0	1
This module provided me with opportunities to get answers to my questions	FA	10	10	7	2
	PA	0	0	2	3
	PD	0	0	0	5
	FD	0	0	0	0
Teacher strategy					
The pace of teaching this module was so fast that it made my learning difficult	FA	0	0	0	0
	PA	1	0	1	0
	PD	5	2	5	2
	FD	4	8	3	8
The pace of lessons in studying this module did not make the topic interesting	FA	1	0	0	0
	PA	0	0	1	1
	PD	6	3	7	0

	FD	3	7	1	9
The teacher introduced the module in a manner which I came to understand the importance and usefulness of science for my daily life	FA	10	10	8	8
	PA	0	0	1	2
	PD	0	0	0	0
	FD	0	0	0	0
Introducing the module using a scenario made the module interesting	FA	9	9	8	4
	PA	1	1	1	5
	PD	0	0	0	1
	FD	0	0	0	0
Feedback from the teacher in class made me understand the importance of learning science for my daily life	FA	9	10	8	8
	PA	1	0	1	2
	PD	0	0	0	0
	FD	0	0	0	0
Feedback from the teacher made the module more interesting	FA	9	10	8	8
	PA	1	0	1	2
	PD	0	0	0	0
	FD	0	0	0	0
Student involvement					
This module provided me with opportunities to participate in activities	FA	10	10	8	0
	PA	0	0	1	0
	PD	0	0	0	7
	FD	0	0	0	3
This module encouraged me to share ideas with my friends.	FA	10	9	8	1
	PA	0	1	1	5
	PD	0	0	0	2
	FD	0	0	0	1
This module provided me with opportunities to participate in group work	FA	10	10	8	2
	PA	0	0	1	7
	PD	0	0	0	1
	FD	0	0	0	0
This module was easy to understand	FA	9	7	7	0
	PA	1	2	2	2
	PD	0	1	0	7
	FD	0	0	0	1

([1]) These statements were only answered after the module with experimental activities (cigarettes)
Note: The module Trip to Mars was only developed with 9 students.

Finally, other dimensions that were appreciated differently concerning the module *Cigarettes* were: the greater difficulty of this module, and its more rigid format, creating in students less sense of autonomy. Indeed, most of the students considered that the module *Cigarettes* was not easy to understand (Kruskal-Wallis Analysis: χ^2=24,66, df=3, p<0.001; Dunnett's Test: p<0.001 for the comparison between *Cigarettes* and each one of all the other modules), it didn't made them think (Kruskal-Wallis Analysis: χ^2=31,45, df=3, p<0.001; Dunnett's Test: p<0.001 for the comparison between *Cigarettes* and each one of all the other modules) and it didn't let them to participate (Kruskal-Wallis Analysis: χ^2=35,05, df=3, p<0.001; Dunnett's Test: p<0.001 for the comparison between *Cigarettes* and each one of all the other modules) (Table 2).

Discussion

The described case reveals modules' potentiality in making students – who are at risk of dropping out school and for whom school knowledge and activities are meaninglessness – more engaged with science classes and activities. Issues commonly associated with engagement are personalization of learning and personal relevance of learnt content (Basu &

Barton, 2007; Schussler, 2009) as well as positive affective experiences (Laukenmann et al., 2003).

Table 2. Comparison of the students' answers between the four modules implemented (Kruskal-Wallis Analysis).

	χ^2(df=3)
Joyfulness	
I wish I could study more modules like this one	30.71(***)
The tasks given to me through studying this module were interesting	31.51(***)
I liked the discussion leading to making a socio-scientific decision	18.63(***)
Relevance	
Studying more modules like this one would make science learning more useful for my life	21.20(***)
The social issue helped me to know why I needed to study science in this module	13.30 (**)
This module showed me the importance of science for decision making about social issues	29.08(***)
Science learning is useful and important when it involves a discussion of a social issue that includes a science component	5.96 (ns)
Knowing why I was studying science in this module made me understand the importance of learning science for my daily life	9.43 (*)
Nature of the activities	
Having to think a lot makes science more interesting	7.49 (ns)
Solving practical scientific problems, coming for everyday issues, can be important and useful for my life	4.12 (ns)
I solved practical scientific problems, coming for everyday issues	11.40 (*)
Planning my own experiments made me appreciate the importance and usefulness of the science for my everyday life ([1])	---
I like to devise experiments ([1])	---
With this module I was able to plan and develop my own experiments ([1])	---
Scientific literacy promotion	
The tasks given to me during the studying of this module allowed me to learn scientific knowledge that is useful for my daily life	14.26 (**)
This module helped me being critical about scientific news in the media	18.26(***)
I believe the discussions in this module were relevant for improving my reasoning skills	15.95 (**)
This module made me think a lot	31.45(***)
This module encouraged me to ask questions	22.63(***)
This module provided me with opportunities to get answers to my questions	22.95(***)
Teacher strategy	
The pace of teaching this module was so fast that it made my learning difficult	7.81 (ns)
The pace of lessons in studying this module did not make the topic interesting	12.64 (**)
The teacher introduced the module in a manner which I came to understand the importance and usefulness of science for my daily life	3.85 (ns)
Introducing the module using a scenario made the module interesting	10.42 (*)
Feedback from the teacher in class made me understand the importance of learning science for my daily life	2.13 ns)
Feedback from the teacher made the module more interesting	2.13 (ns)
Student involvement	
This module provided me with opportunities to participate in activities	35.05(***)
This module encouraged me to share ideas with my friends.	24.32(***)
This module provided me with opportunities to participate in group work	24.37(***)
This module was easy to understand	24.66(***)

([1]) These statements were only answered after the module with experimental activities (cigarettes)
(***) p<0.001; (**) p<0-01; (*) p<0.05; (ns)=non significant.

The present study suggests that the nature of the activities and the teaching-learning approach, the role played by the students as well as the role played by the teacher were essential issues facilitating the personal construction of meaning and the enactment of positive emotional experiences. Students felt that they were doing meaningful things and learning important things for their lives, and as such they become involved with the activities, in order to learn more. In addition, the perception that they could complete the assigned activities successfully further affected their engagement with the modules, as they developed a sense of competency, which is an important aspect for promoting engagement as pointed by Laukenmann et col (2003) and by Thijs and Verkuyen (2009).

In what concerns the teaching-learning approach, data reveals that exploring the relation of science and society by means of practical activities, facilitated the development of a deeper understanding of the importance and usefulness of learning science. Indeed, students acknowledged that performing activities related to science topics could be a means of illuminating issues related to their lives. This sense of purpose has been pointed as extremely important for engaging students with academic topics and for predisposing students to learn more about that topic (Basu & Barton, 2007; Schussler, 2009).

Nevertheless, mention should be made that it was not only a question of linking science with society, but also the role played by students in establishing and exploring this connection. The sense of agency and autonomy in developing the modules, in overcoming difficulties, in deciding which way to go in order to develop the activity and to solve the initial problem, as well as the mobilization of complex competencies, are important aspects for explaining the positive affective experience and the construction of personal meaning.

This issue is clearly reflected in their different appreciation of the module *Cigarettes* versus the other three modules, which is based on a more closed activity where students play a more passive role. Teacher perception was already that the modules *Energy losses, Analysis of news*, and *Trip to mars* were quite different, concerning the nature of the practical work proposed and the role expected of the students. These modules were based on open activities, where students played a central role in questioning, planning, solving problems, and making decisions. On the contrary, the module *Cigarettes* was based on a much more prescriptive activity, presenting concrete guidelines that the students had to follow in order to perform the activity, and it was also grounded on more complex substantive knowledge. Relying on more previous complex chemical knowledge, students felt more difficulties with accomplishing the activity. Furthermore, due to its prescriptive character students were not as much actively involved in planning the activities and in solving the problems. So despite the teacher appreciation that the studied theme had personal relevance for the students (the chemical components of the cigarette ash and its effects on lungs and related diseases), the relevance of this module might have not been fully understood by students, due to its degree of difficulty, to their more passive role and as a result of the reduced possibility to derive a personal meaning from the module.

Other issue that might have had a particular impact on these students' appreciation of the modules was their experience of success. According to several authors, experiencing success is extremely important for developing a sense of competence, which in turn facilitates engagement with school and classes (Schussler, 2009; Thijs & Verkuyen, 2009). In the present study, students were not only able to perform science activities positively, but also, they recognized that by performing those activities successfully they could answer questions that were personally relevant. Particularly important in favouring this experience was the teacher role. According to engagement literature, teacher support and the quality of that support are key factors that affect students' engagement with class (Assor et al., 2005; Thijs & Verkuyen, 2009).

In this study, the role played by the teacher seemed to be crucial for ensuring that these students felt competent, established secure relationships, and felt autonomous, which are important factors favouring engagement (Thijs & Verkuyten, 2009). Indeed, the teacher created a safe environment by guiding and helping students overcoming their difficulties, giving them time to explore, triggering their curiosity, encouraging their questioning. Within this context, teacher feedback was also another important dimension in creating such a classroom ethos as reflected on the students' answers. Enacting formative assessment, based on feedback to the students about their competencies and learning outcomes, is an important dimension of PARSEL, which is closely related to Margaret's idea of assessment. She perceives assessment as one more dimension of the teaching process aiming at further developing students' knowledge and competencies and, also based on respect and psychological safety. This positive affective dimension might have also favoured the constructive ethos that predisposed students to engage in challenging activities and was certainly important for improving students' performance and understanding (as illuminated by other authors, e.g. Hattie & Timperlay, 2007).

Conclusion

This study highlights the importance of developing curriculum resources for improving students' engagement in school science, which are students' centred and based on personal appealing and challenging themes and activities. This study reveals that facilitating students' autonomy for deciding what to do in order to solve a problem is an important aspect for explaining the positive affective experience and the construction of personal meaning, which is reflected on students' engagement with science classes. In addition, this study highlights the important role that teachers play in increasing students' engagement. Indeed, teacher created real possibilities of success, by supporting students in overcoming their own difficulties, by helping them deriving personal meaning from the activities and by establishing positive relationships, that not only generated a sense of belonging but also challenged students to go further away in their learning, which, as already pointed, affects students' engagement.

Considering these two issues, this study shows that it was the combination of the type of activities and teaching strategies that was successful in promoting students-at-risk-of-dropping-out engagement with school science and learning. And as such, it confirms the importance of teachers appropriating curricular resources in order to facilitate students' engagement. Teachers have to acknowledge that this type of resources do promote students learning and improve their engagement with school science, and so they should be encouraged to integrate this kind of resources in their practices.

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References

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education*, 30(14), 1945-1969.

Archambault, I., Janosz, M., Morizot, J., & Pagani, L. (2009). Adolescent Behavioral, Affective, andCognitive Engagement in School: Relationship to Dropout. *Journal of School Health, 79*(9), 408-415.

Assor, A., Kaplan, H., Kanat-Maymon, Y, & Roth, G. (2005). Directly controlling teacher behaviors as predictors of poor motivation and engagement in girls and boys: The role of anger and anxiety. *Learning and Instruction, 15*, 397-413.

Basu, S.J., & Barton, A.C. (2007). Developing a Sustained Interest in Science among Urban Minority Youth. *Journal of Research in Science Teaching*, *44*(3), 466-489.

Erickson, F. (1986). *Qualitative methods in research on teaching*. Michigan: Institute for Research on Teaching.

European Commission (Eds.) (2004). *Europe needs more scientists. Report by the High Level Group on Increasing Human Resources for Science and Technology in Europe*. Brussels: author.

European Council (2006). *Progress towards the Lisbon objectives in education and training.* Brussels: European Council.

Fredericks, J., Blumenfeld, P., & Paris, A. (2004). School engagement: Potential of the concept, state of evidence. *Review of Educational Research*, 74(1), 59-105.

Galvão, C., Reis. P., Freire, A., & Oliveira, T. (2006). Avaliação de competências em Ciências. Sugestões para professores do ensino básico e do ensino secundário. Lisboa: ASA.

Galvão, C., Reis, P., & Freire, S. (2008). A big problem for Magellan: Food preservation. Science Education International, 19(3), 267-274.GEPE (2010). *Educação em números - Portugal. 2010***.** Lisboa: author.

Greenwood, C.R., Horton, B.T., & Utley, C.A. (2002). Academic Engagement: Current perspectives on research and practice. *School Psychology Review, 31*(3), 328-349.

Hattie, J., & Tiplerlay, H. (2007). The power of feedback. *Review of Educational Research,* 77(1), 81-112.

Holbrook, J. (2008). Introduction to the special issue of science education international. *Science Education International*, 19(3), 257-266.

Laukenmann, M., Bleicher, M., Fuß, S., Gläser-Zikuda, M., Mayring, P., & von Rhöneck, C. (2003). An investigation of the influence of emotional factors on learning in physics Instruction. *International Journal of Science Education, 25(*4), 489-507.

Lin, H., Hong, Z., & Huang, T. (2011). The Role of Emotional Factors in Building Public Scientific Literacy and Engagement with Science. *International Journal of Science Education*, 1–18, iFirst Article

OECD (2006). *Assessment of scientific literacy in OECD/PISA project*. Available at: http://www.pisa.oecd.org/ 8th February 2008.

Osborne, J., & Dillon, J. (2008). Science Education in Europe: Critical Reflections. King's College London: The Nuffield Foundation.

Resnick, L.B, & Perret-Clermont, A.-N. (2004). Youth in postindustrial societies. In A.-N. Perret-Clermont, C. Pontecorvo, L.B. Resnick, T. Zittounn, & B. Burge (Eds), *Joining society. Social interaction and learning in adolescence and youth* (p. 11-25). Cambridge: Cambridge University Press.

Saljo, R. (2004). From learning lessons to living knowledge. In A.-N. Perret-Clermont, C. Pontecorvo, L.B. Resnick, T. Zittounn, & B. Burge (Eds), *Joining society. Social interaction and learning in adolescence and youth* (p. 177-191). Cambridge: Cambridge University Press.

Schussler, D.L. (2009). Beyond Content: How Teachers Manage Classrooms to Facilitate Intellectual Engagement for Disengaged Students. *Theory Into Practice, 48,* 114–121.

Smyth, J. (2006). 'When students have power': student engagement, student voice and the possibilities for school reform around 'dropping out' of school. *International Journal of Leadership in Education*, 9(4), 285-298.

Thijs, M., & Verkuyten, J. (2009). Students' anticipated situational engagement: The roles of teacher behavior, personal engagement, and gender. *The Journal of Genetic Psychology,* 170(3), 268–286.

You, S., & Sharkey, J. (2009).Testing a developmental-ecological model of student engagement: a multilevel latent growth curve analysis. *Educational Psychology*, *29*(6), 659-684.