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Chapter 5

Discussing Socioscientific Controversies in Primary and Secondary Education: Potentials and Constraints in Science Lessons

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Additional information is available at the end of the chapter

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Abstract

This chapter presents the results of an investigation conducted with the objective of understanding the socioscientific controversies approach in science teaching from the perspective of curricular integration, against the background of the new social and environmental challenges currently faced by science education. The research was conducted as a case study, and the data presented here were collected using questionnaires and interviews and were analyzed using the discursive text analysis method. The approach is predominantly qualitative and descriptive. The results of these analyses indicate the potential of the socioscientific controversies approach combined with integrated projects, fostering debate between different subject areas in discussions of subjects that are considered controversial.

Keywords: socioscientific controversies, curricular integration, science education

1. Introduction

This chapter is intended to contribute to the academic debate around discussion of socioscientific controversies (SSCs) in science teaching from an integrative perspective.

This study of SSC is situated within the context of a century in which, according to Silva and Cicilini [1], we are witnessing scientific and technological achievements that have been predicted in the past, but more in a tone of science fiction than of reality. These developments have had impacts on society, communication media, and education. The traditional way that Biology is taught has undergone changes and new issues have emerged for discussion, both

within schools and in other spheres of society. Social debate is definitively attracted by problems related to the promises, challenges, and controversies of subjects related to life sciences and technology.

Within this context, Schramm [2] has claimed that we are witnessing a Biological Revolution, some examples of which are already part of citizens' lives, such as in vitro fertilization and implantation of embryos; cloning; the medicines produced by application of biotechnological knowledge; treatments for cancer, for AIDS, and for other pathologies; modification of plants and animals by manipulating and reprogramming their genes; and the fight against the major endemic diseases, hunger, and so on.

As part of this veritable revolution, new scientific capabilities have been acquired, such as, for example, treatment of the genetic information of living beings. This Biological Revolution has not only made it possible to describe and understand life but has also enabled its modification, resulting from a new form of applied knowledge that has resulted from an alliance between the technical sciences of language and the technical sciences of biology [2].

Galvão and Reis [3] argue that nowadays the objective is to integrate scientific knowledge into the students' world, in order to help them understand the objects and events which they encounter every day, attempting to increase their interest in science and scientific activities and to encourage their involvement in processes of discussion and evaluation of socioscientific issues.

These authors state that it is the responsibility of the school and, consequently, the teacher to provide opportunities for discussion of the socioscientific issues that are increasingly part of everyday life. Schools must foster a scientific education that problematizes scientific developments, because, in addition to being necessary, it is an indispensable social duty to present students with science that is more up-to-date, historical, social, critical, and human.

Galvão and Reis [3] also point out that the teacher's role includes encouraging students to research and select reliable sources of information; contrast different points of view; seek the knowledge needed to understand a given issue; familiarize themselves with the practices, techniques, and theories of scientists, so that they can be related to their daily lives; to discuss the subjects; to study the benefits they can offer and the harm they can cause; and to critically assess and express opinions on socioscientific issues.

Therefore, the classroom should become a venue for discussion, where the students can participate actively, expressing their interest in and knowledge about the widest variety of subjects, which can be dealt with not merely in relation to scientific knowledge but also in terms of their social meaning and impact. This experience can be accomplished in a variety of different ways and should involve the points of view of distinct social groups, thereby providing a platform for discussion of the constraints on and potentials of participation in socioscientific controversies.

Within the scope of science teaching, the space occupied by this debate has been growing as a result of certain issues that have already attracted the interest of teachers and their students, such as cloning and assisted reproductive techniques. There appears to be the space and

opportunity, and even a need, to design a form of science education that is able to, effectively, foster in-depth discussion of these issues. Working from the objectives of school-based education in the sciences, we should be developing scientific literacy, in other words, providing training in the sciences that "[…] provides the tools that make it possible to better understand the society in which we live" [4],[1] to enable students to take decisions consciously.

This chapter is derived from a doctoral thesis, and its overall objective is "to present the constraints on and potentials of the socioscientific controversies approach, by means of a case study of use of the integrated project teaching method in Science lessons."

2. Socioscientific controversies in science teaching

We live in a world in which new scientific discoveries and technologies are directly connected with our lives, interfering at greater or lesser intensities in our everyday society. On this basis, Delizoicov and Auler [5] refute the assumption that scientific enterprises and their agenda are neutral, pointing out that the questions that science asks, the phenomena that are selected for investigation and the problems chosen for solution, the research avenues opened and, as a consequence, the advances achieved in one or another field are all directly linked to the values of a specific spatiotemporal context and to the demands located within it.

We live in a society in which the technology clearly impacts on everyday affairs. This is why we must prepare our students to build the skills to evaluate and intervene intelligently in technological and scientific activities. In the current context, this role falls to science teachers.

The use of socioscientific controversies (SSCs) for teaching science and technology is increasingly emphasized in curricula and in research into science teaching. Certain elements of the science, technology, and society movement [6–8] refer to these subjects as socioscientific issues, which are an expression of the application of this movement's assumptions in the classroom. It is therefore more important to educate the population to take a position with relation to the scientific and technological revolution than it is to instruct and inform it.

2.1. Socioscientific controversies (SSCs)

In attempt to situate the reader, it is worthwhile to start by discussing what is meant by SSC, basing the discussion on the literature. The terms "controversial subjects," "scientific dilemmas," "socioscientific controversies," "socioscientific issues," and "contentious subjects" are all used to designate elements in common.

According to Rudduck [9], an issue is defined as controversial if it divides people and involves value-judgments that prevent it from being settled solely on the basis of analysis of evidence or by experiment. A controversy cannot be settled by an appeal to facts, empirical data, or experience alone, because it involves both facts and issues of values.

[1]This and all subsequent quotations from work published in languages other than English have been translated by the author.

According to Nelkin [10, 11], scientific controversies can be caused by: (a) the social, moral, or religious implications of a scientific theory or practice (e.g., issues related to cloning and genetic modification of living beings); (b) social tensions between individual rights and social objectives, political priorities and environmental values, economic interests, and health-related concerns that result from the application of technology; (c) by use of public financial resources for major scientific and technological projects to the detriment of other projects, such as, for example, for social ends. These controversies can also be referred to as socioscientific issues, that is, social issues provoked by scientific and technological developments.

Ramsey [12] defined three criteria for selection of controversial socioscientific subjects: (i) whether there are differences of opinion in relation to them; (ii) whether the subject has social significance; and (iii) whether the subject, to some extent, is related to science and technology.

According to Para Reis [13], controversial socioscientific issues (CSIs) are social issues with a considerable scientific and technological dimension, such as, for example, manipulation of the genomes of living beings, in vitro fertilization, and cloning; release into the atmosphere of substances with effects on public health, on the greenhouse effect, and on destruction of the ozone layer; use of hormones and antibiotics in animal production; environmental and public health issues.

Pérez and Carvalho [14] state that CSIs encompass debates, controversies, or subjects directly related to scientific and/or technological knowledge that have a major impact on society. According to Abd-El-Khalick [15], these issues are markedly different from the exercises or "problems" that appear at the ends of chapters of the text books used in the classroom. Such exercises are generally defined and cover multidisciplinary aspects that are very often loaded with ethical, esthetic, ecological, moral, educational, cultural, and religious values.

These authors argue that the characteristics generally observed in socioscientific issues are: (a) knowledge of a scientific nature; (b) formation of opinions and choosing between options; (c) frequent appearances in the news media; (d) local scope; (e) analysis in terms of cost versus benefit and of values; (f) awareness of sustainability; (g) permeation by ethical and moral rationales; (h) permeated by understanding of risks; and (i) normally, part of people's everyday lives.

We can see that even the definition of a controversy is a controversial issue. According to Velho and Velho [16], some authors consider a controversy to be a discussion between two parties about a particular subject in which their beliefs and arguments are at stake, which is a view that places controversy on a more cognitive or psychological plane. I therefore believe that controversies cannot be separated from a wider cultural context and are, therefore, social phenomena that are historically determined.

Faced with such a diversity of definitions, I have chosen to use the term "socioscientific controversies" and have adopted the following criteria for selection of the articles that make up our corpus for analysis:

(i) controversies that are provoked by the social impacts of scientific and technological innovations and divide both the scientific community and society in general;

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(ii) that which allows discussion between two or more involved parties on a given controversy, in which their beliefs and arguments are at stake;

(iii) whether, in relation to the controversy being discussed, people are divided because this reflection involves value-judgments that prevent it from being settled solely on the basis of analysis of evidence or by experiment.

2.2. Socioscientific controversies in Brazil

The proposal of working with the SSC in the classroom is relatively new and has received little publicity. For Brazil, searching with the dates 2001 to 2014, a total of 44 publications were identified in online periodicals dealing with science teaching, which suggested this type of approach [17]. Some studies list the educational potentials that discussing SSC in the classroom can leverage, not only for learning curricula content but also for learning about processes of a scientific and technological nature and for students' cognitive, social, political, moral, and ethical development [3, 13, 18–23].

Reis [13] conducted a series of studies investigating the educational impact of conflict and controversy in the classroom, finding that their use resulted in motivation, research, and interchange of information. Reassessment of individual positions, supportive relationships between the students, and appreciation of content and of the learning experience enabled development of logical and moral reasoning skills and a deeper understanding of the important aspects of the nature of science.

Reis and Galvão [19] believe that use of socioscientific issues can be important for the establishment of a link between the scientific culture (in which the scientific community participate) and science teaching.

Ramos and Silva [20] claim that discussion of controversial subjects allows students to acquire knowledge about the type of reasoning that motivates governments, scientists, and protest movements, and also a more realistic understanding of scientific and technological development, within its social and political context, and of its impact on the general public or on specific communities. They state that it is the school's and, therefore, the teacher's responsibility to create opportunities for discussion of controversial subjects, which are an ever growing part of daily life. Schools should provide science education that informs students of scientific developments since, in addition to being necessary, it is an indispensable social duty to provide them with science that is up-to-date, historical, social, critical, and human.

Galvão and Reis [3] add that it is the science teacher's job to encourage students to: research and select reliable sources of information; contrast different points of views with each other; search for necessary knowledge; familiarize themselves with scientists' practices, techniques, and theories, creating opportunities to relate this knowledge to their daily lives; debate the subjects; determine the benefits and harm that could result; and critically assess and form an opinion on controversial issues.

Vieira and Bazzo [21] state that discussing controversial socioscientific situations can offer students a more realistic image of science, whereas not including them in science teaching

contributes to transmission of distorted ideas that often describe science as non-controversial, neutral, and disinterested.

Zuin and Freitas [22] describe how socioscientific controversies are not resolved by analysis of evidence such as empirical data. They state that we must pay special attention to considerations of ethics, morals, and values with relation to social elements and to conceptual, methodological, and technological elements related to science. Within this perspective, learning opportunities provided by teaching based on discussion of socioscientific problems have shown great potential for construction of a more realistic view of scientific development and for promotion of responsible citizenship.

Forgiarini and Auler [23] claim that another of the characteristics of controversial subjects is that they are given prominence in the press, on television, and in films, which may relate them to stereotypical ideas of science and technology and of the activity of scientists. It is accepted that both schools and the media can contribute to construction of misleading conceptions with relation to scientific and technological endeavors.

Forgiarini and Auler [23] also state that controversial subjects are still studied little in the classroom and highlight the reasons that lead many teachers to avoid them. According to Reis [13], one of the factors behind this absence could be: "[…] concerns about a possible failure of control during discussions, since there may not be correct answers, rather a diversity of value judgments" [13]. He recommends that the teacher should maintain a neutral position, that of a mediator, with relation to discussion of these subjects, in order to avoid revealing personal positions that the students might assume are correct. He states that the teacher's neutrality is of fundamental importance, because the students must be given the right to form their own opinions, and, therefore, the teacher should opt for neutrality during these discussions.

In addition to contribution to demystification of misleading ideas with relation to scientific endeavor, discussion of socioscientific controversies can also motivate students to express their opinions, to learn to construct arguments, and to take well-founded decisions with respect to scientific and technological development and its implications for society.

Reis also raises the suggestion that by using socioscientific controversies in science teaching, we can cover a range of different curricular content. This process can be conducted in an interdisciplinary manner, in the form of a collaborative effort involving teachers from several different subjects (general science, history, geography, chemistry, physics, and biology, among others).

2.3. Constraints on and potentials of socioscientific controversies in Brazil

A study conducted by Duso [17] identified work that focused on socioscientific controversies published from 2001 to 2014 in Brazilian periodicals dealing with science, available on-line, and indexed with the terms "controversial subjects," "contentious subjects," "socioscientific controversies," "contemporary subjects," or "socioscientific issues" in their subtitles, titles, abstracts, or keywords. The study located 44 papers published in the journals selected.

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The authors of these articles pointed out the difficulties faced by teachers who, in general, do not have the skills to manage and direct classroom discussions nor the knowledge needed for discussion of socioscientific issues with relation to the nature of science and the sociological, political, ethical, and economic elements of the subjects being discussed. Additionally, they also deal with the difficulties involved in assessing activities involving discussion of socioscientific controversies and/or the pressure exerted by national assessment systems that do not place value on this type of discussion, creating barriers to effective adoption of this approach.

One of the major problems of teaching, highlighted by Shulman [24], Carr and Kemmis [25], and Tardif [26], has been the lack of individual and collective systematization of teachers' experiences, which has resulted in a real absence of history and practice, without which it is difficult to conduct an analysis of its principles. This is why Lee Shulman's studies are important, because they follow teachers at different levels of education and constitute a considerable number of cases, in which their reasoning and actions while in service were recorded.

Shulman's contributions with relation to teacher's knowledge of their subjects' content are of interest in teacher training, because I consider that this knowledge helps to construct teachers' autonomy. Nevertheless, it is important to point out that achieving autonomy is not limited to teachers knowing their subjects' content, which is still in the personal dimension of a teacher's professional development, since it is also necessary to cultivate the social dimension, because teachers' autonomy is an especially collective process and not only an individual process.

Content is no longer discussed, it is simply replicated and derived. In contrast, training is a concept that must be problematized and reformulated, working from the concepts and the objectives of science teaching.

According to Fourez [27], there are divergent positions on the utility of training in epistemology, history of science, and interdisciplinary approaches, because of the complex situations or the fundamental questions provoked by scientific models. The collective dimensions of scientific work should be fostered, organizing interdisciplinary working groups and facilitating interaction between different groups of teachers from different subject areas and the scientific community.

Along the same lines, Forgiarini and Auler [23] state that teacher training that is excessively fragmented and disconnected from the social context exacerbates the extent to which the true situation is different from the ideal. They point out that the great majority of teachers suffer from knowledge gaps, from a lack of information related to controversial subjects, because controversial socioscientific issues are considerably different from the types of problems that are generally dealt with in science lessons.

However, in some of the articles analyzed, while the importance of collective working is highlighted, teachers from subjects in the humanities are not considered to have so many obligations with relation to the circumstances of controversies related to scientific subjects. The most excessive criticisms are leveled at biology teachers, possibly because of the specificity of the curricula content linked with this science.

Levinson [18] considers that science and humanities teachers have complementary strengths and weaknesses. While teachers from humanities subjects are more at home with controversy, Science teachers have greater knowledge of scientific concepts. Collaboration has useful contributions to make, but, unfortunately, the teachers from these different spheres rarely work in cooperation.

If collaboration between teachers can be fostered, the classroom can become a forum for discussions in which the students participate actively, demonstrating their interests and knowledge about the most varied range of subjects, which can be dealt with not only with regard to scientific knowledge but also in relation to their social significance and impact. This will give them the opportunity to experiment in a variety of forms or from different perspectives with the points of view of different social groups, which in turn makes dialogue over the limitations to and possibilities for debates about controversial socioscientific subjects possible.

I understand that it is not feasible to work with controversial subjects by exclusively drawing on subject knowledge. Contributions are needed from multiple fields of knowledge. This is why cooperative work is extremely necessary, so that all participants can make contributions from their own area of expertise to analyze the many different dimensions involved.

It is also indispensable to conduct in-depth studies with relation to controversial subjects, in order to avoid simplification of complex issues, and it is necessary to engage in coherent epistemological reflection on science and technology, acknowledging the impossibility of obtaining answers to all questions exclusively on the basis of technical and scientific knowledge [19], choosing working methods that are appropriate to the objectives that discussion of controversial issues in the classroom is intended to achieve.

2.4. The project teaching method as an option for integrated teaching practices

The project teaching method was pioneered by John Dewey and Kilpatrick in Chicago at the start of the twentieth century with the objective of resignifying the school environment to make it more open to real life. This approach was taken up and championed by Freinet, in France, in the 1920s and 1930s.

Kilpatrick believed that the foundation of all education is guided and decided activity. In other words, all school activities could be conducted in the form of projects, with no need for special organization.

In turn, Freinet [28] did not explicitly propose using this method, but did vehemently argue in favor of the idea of work as a vital function of each and every individual. This is the school of work that becomes the school of life, and each will become the other.

Jolibert and colleagues were influenced by Freinet's ideas and constructed a proposal based on working with projects. They proposed organizing work on the basis of principles such as the collaborative life, students' appropriation of their own school lives, and organization of teaching into projects. Jolibert [29] believed that the project teaching method allows school life to be founded on the real, open to multiple relationships with the exterior, and in which the students take an active part in their own learning.

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This concept is founded on a globalizing and interdisciplinary view of organization of schools' curricular content. Within this proposal, it is possible to combine study of significant contemporary problems by groups of students and teachers with the content of school subjects, respecting their interests and their requirements and taking students' concepts, hypotheses, and knowledge as a starting point.

There are many different approaches to working with projects, following different methodological paths. The approach that is advocated in this text is the result of certain reflections on and experiments with implementation of integrated projects in a secondary school.

Working with the project teaching method proposes changes in the teacher's role, which becomes that of a guide and a researcher who both challenges and learns. The objective is to foster in the students an understanding of the problems investigated, going beyond the information provided and recognizing the different versions of a fact, proposing explanations and hypotheses and engaging in dialogue on different points of view.

Secondary education is possibly the most appropriate time to work with interdisciplinary projects, since it is a period during which young people are going through a process of transition between childhood and adulthood and is therefore a stage in which they are defining their future roles in society. As Hernández [30] puts it, "[…] the school culture takes on a function of remaking and renaming the world and of teaching students to interpret the changeable meanings with which people in different cultures and historical periods give meaning to reality."

When working with integrated projects, the activities are organized on the basis of students' experiences, motivations, expectations, and interests, and it is assumed that working groups will be formed that enrich through meaningful collaboration. The subject matter is not predetermined, because it is the result of an open process, and is explored in relation to the students' everyday lives, so that they gain a cognitive, emotional, and relational understanding of the phenomena of the world that surrounds them.

2.5. The constraints on and the potentials of the project teaching method

According to Santomé [31], certain constraints are because of a lack of adequate planning, of work in small groups, and a lack of motivation for work that is not appropriately remunerated. Compounding these elements is the prejudice against using projects because of ignorance of their meaning and lack of professional preparedness.

We should take into account the way teachers are trained by specific subject area. According to Schor [32], as a result of the specialization of scientific knowledge, certain problems emerge that demand a collaborative approach, that is, it is necessary that specialists work together collectively. We cannot expect that subject teachers will engage in integrated work if it does not fit in with their specialties. A lack of experience during training, both initial qualification and ongoing education, with an integrative curriculum approach can create constraints.

However, according to some authors, what is reported is that working with project teaching method is a challenge for teachers, since this dynamic implies that they must take on the roles

of teachers, researchers, and mediators, leaving aside their roles as transmitters of knowledge to become mediators of learning, encouraging the formation of autonomous students, capable of acting and interacting in the world in which they live. The project teaching methodology, with activities conducted within the project, leads to considerable changes in students' behavior, interest, and motivation with relation to learning the subject.

One of the potentials of using integrated projects is the students' involvement in the process of construction of knowledge and of seeking solutions to problematic situations, in addition to positive changes in relation to day-to-day attitudes and greater motivation and involvement in the learning process.

Although it is difficult for teachers to achieve a good balance between the elements of the triad "subject matter," "activities," and "assessment" in the classroom, students are able to demonstrate and re-elaborate earlier concepts, which I consider to be of great importance in the construction of knowledge.

Beane [33] sees curricular integration as a concept that is concerned with the possibilities for personal and social integration through a curriculum that is organized around significant problems and questions, identified in a collaborative manner by the teachers and students, irrespective of the demarcations that separate subjects.

However, difficulties are encountered, especially with relation to the issue of bringing the humanities closer to the sciences. In the majority of cases, integration between these different groups of subjects proves to be a practical problem that is difficult to solve. The difficulty lies in establishing a set of common repertoires that will enable dialogue.

In view of the above, the SSC approach can be considered an ideal way to achieve curricular integration in teaching, since all of the different subject areas will get the opportunity to contribute a great deal of subject matter to the discussion.

3. Methodology

In order to understand the SSC approach using the project teaching method, I observed the planning of some of these projects in real teaching situations, thereby delineating their limits and possibilities in this area.

The SSC approach used in combination with integrated projects was observed in a private school that provides both Secondary and Technical Vocational education and is located in the state of Rio Grande do Sul, Brazil.

Data were collected by administering questionnaires containing open-ended questions to the 42 teachers with the objective of obtaining information on the conception that these teachers had of SSC, and of their constraints and potentials for teaching. This questionnaire was also designed to provide an understanding of teachers' concepts with regard to organization and application of projects conducted in the school and the constraints and potentials for using them in teaching. Fourteen teachers completed the questionnaires.

After collecting the teachers' responses to the questionnaire, it was necessary to conduct unstructured interviews [34] with the objective of probing in greater depth the research participants' thoughts with relation to use of SSC and the way the projects are organized at the school.

These interviews were conducted with the school's Principal, the Vice-principal responsible for teaching and three teachers, one from each subject area (languages, humanities, and sciences), selected using the criterion of longest time teaching at the school.

The data collected were analyzed using Discursive Text Analysis [35]. This analytical resource was used to systematize information from the questionnaires and to construct an interpretation of the subject in question from the point of view of the research participants. This analysis, which is coherent with the qualitative approach chosen, facilitates comprehension of the phenomenon investigated with no intention of generalizing or explaining it.

During this analysis, the questionnaires were read and organized into units and assigned to a system of categories that provide the basis for construction of descriptive texts (metatexts) that would be used to interpret the phenomenon studied.

In order to organize these units, a labeling system was adopted in which units from questionnaires were marked with a "Q" and those from teachers with a "T." The units were numbered from 1 to 14 to represent the respondents, with no relationship between the number and the respondent. Finally, units were also labeled with the number of the questionnaire item, separated from the number of the respondent by an underscore character (_).

Next, the interviews were transcribed but were not categorized, rather they were used as a basis for in-depth discussion of the constraints and potentials identified in the data from the questionnaires. Data from the questionnaires and the interviews were combined to construct a metatext. To identify the teachers interviewed, I used the same numbers as for the questionnaires, adding the letter "I" to indicate interview data. The Principal is identified with the label "Prin," and the Vice-principal responsible for teaching is identified with the label "VPT."

4. The constraints on and potentials of projects in the school

The principal constraint, mentioned both by the Vice-principal for teaching and by the teachers, was the time allotted by the school for planning projects, as can be observed in the following extract: "[…] we should have more time for discussion" (IT14). This time could be apportioned during the school's teachers' meetings, since this is an activity that goes beyond the teachers' normal classroom activity. The same constraint was also identified by the Principal.

> *[…] the obstacles to them having more time to plan are administrative, teachers should nowadays have "teacher's time" and be paid for it, teachers do it on their own time, just like they grade tests, they do it as part of their jobs, but if we look at it properly, it would be more time for planning than, including paid time, perhaps more meetings. (IPrin)*

Another constraint, highlighted by the Vice-principal, is related to teachers who also work for other educational institutions: "[…] also considering the teachers' working hours, considering

their involvement, sometimes, with more than one institution, well this caused some difficulties" (IVPT). This constraint, compounded by the lack of time, means that the teacher also needs to make more time available outside of the school.

> *It's obvious that there are certain barriers to this approach, but it demands that the teachers make themselves available beyond their involvement with the school. It requires teachers to talk to their peers both inside and outside of the school environment. (IVPT)*

However, despite the existence of these constraints, it is clear, in what was said by the history teacher, for example, that: "[…] we integrate and I loved meeting up to plan and grade the projects and we grew together with others who have different points of view, because we also have to negotiate" (IT4). This situation of integration and discussion of the debate encourages reflection within the group that is already working with projects.

It should not be forgotten that there is turnover among the school's teaching staff, that is, new teachers are contracted who had not taken part in the discussions about the projects. Therefore, new teaching concepts should be expected and also that teachers will be contracted who do not have this understanding of what working with projects is or how it is done.

> *Obviously, some people were not disposed, obviously they could not continue to work here because they were unable to work within this system. This is perfectly understandable, without detracting from, without considering that there is any lack of merit in these teachers' professional activity. They have to be respected, within their own concepts of education. (IVPT)*

In addition to the constraints reported above, issues related to paperwork and training also stand out in the interviews, such as, for example, personal issues, as illustrated in the following excerpt from the interview with the Portuguese language teacher: "I think that today the barriers are, on my part, overly optimistic expectations with relation to the presentation of projects; I always expect much more than the students produce" (IT13).

This constraint related to the expectations of a languages teacher was not observed in the transcripts from the humanities teacher. Here it is clear that when they are working with projects, the students tend to become more involved in the teamwork dynamic, which provides openings for exchange of ideas, which are sometimes different from the teacher's ideas.

> *[…] when we do an integrated project, we automatically involve the students and the students integrate and the students get a feel for the school, they work within a different perspective in which evidently the subjects don't matter, but they do matter, you know? But there is a type of socialization, of knowledge between all of the teachers, and with the students, and it becomes clear that many things, for example, what it means to work in a team; I think that the students take this experience away with them, because they end up, respect for human beings, because they are discussed, they're not imposed, so I have to accept that, very often, it's not how I think, so it is an exercise in democracy. (IT14)*

As the Vice-principal pointed out, when the theme is based on subjects that are more significant to the students, there is an observable increase in their involvement in the project.

> *[…] the advantages are obvious, to the extent that the students were involved in executing these projects, and they became more relevant each time, as we managed to focus on subjects that were significant to the students, as well. So, to the extent that we improved or perfected these subjects, the students' involvement with this is huge, in relation to this. (IVPT)*

We can also see that the projects approach employed at the school enabled greater integration not only among the students but also between them and the teachers. This multiple integration is superior to pure memorization of curricula content with little meaning and depends upon a dialogue between different points of view. The result is an amplified view of the world and makes it possible to "[…] form a critical and creative person, at one with their times, who can collaborate in construction of a better society, you know? You see lots of all of this in the integrated projects, you see it in action, they have thousands of ideas" (IPrin). The teacher (IT13) confirms this:

> *[…] they (the students) have a much richer view of the world, […] a completely different reality, including to me, because I was also unaware, so you realize that we live in a much larger world, with those we live with. (IT13)*

We can see, in the interviews with the management team and with the teachers, that they have a number of different conceptions with relation to the nature of the projects that are run at this school, their planning, and the possible ways of implementing them. Their expectations are primarily linked to issues with the time available for planning and discussion with groups of teachers and are associated with a lack of teachers' meetings at the school.

Therefore, analyzing the interviews with my interlocutors, I was able to identify the many constraints that could make use of projects impossible, and I was also able to reflect on other spaces in the school dynamic where it would be opportune to expand this discussion.

5. The SSC approach in the school

Within this universe of reflection about integrated projects and their relationship with the school, I consider that it is opportune to discuss SSC and consider the possible contributions that this approach can make to enhance the project teaching method.

Socioscientific controversies emerge from the social impacts of scientific and technological innovations that cause controversy in both the scientific community and society in general. I talked to the management team and to the teachers, attempting to understand the concepts that underpin their points of view with respect to SSC.

During the years that the school used projects, there were times when controversial subjects were covered, but this was not explicit. Approaching and dealing with SSC in the school context can encourage discussion of different points of view on the same subject and contribute to students' and teachers' moral development and to building their argument skills and can also contribute to an improved understanding of the scientific process as a whole.

5.1. The constraints on and potentials of SSC

The responses to the questionnaire and my conversations with the interviewees brought up certain constraints that are unfavorable to adoption of the SSC approach. Among these constraints, I highlight "Curricular planning and time" and also "Insecurity with discussion of the subject." It will be noted that the time available and the space dedicated by the school to

discussion between teachers once more figure as constraints, because, as one teacher pointed out, it is important "[…] that we discuss this among the teachers, isn't it? And everyone thinks along the same lines, you know? I think it's a good idea for us to approach it as a group […]" (IT14) to plan the project. This particular excerpt underscores the concern that all the teachers should think along the same lines with relation to the controversy to be dealt with. For this reason, this constraint can be linked to insecurity with discussion, with epistemological reflection, and with the treatment needed for use in projects.

> *[…] there are people who are in favor and people who are against, but that's it, the maturity, that the teacher's nakedness to, to be able to reach closure in each of these subjects, without giving his own opinion, agreeing or disagreeing, but then it is the adult's point of view, that has to end it. (IT13)*

The same teacher (T13) refers to the issue of neutrality in the discussion process "[…] because if the teacher also more or less sits on the fence, then he doesn't know and then the student realizes this, particularly adolescents, they will realize this […]" (IT13), thereby creating an obstacle to mediation of the subject being discussed.

> *[…] the teacher has to be very adult and take this position, of an adult, he can't give an opinion that he agrees, disagrees, I accept, don't accept, that's not it, he has to play the role of someone who is mature for power, provide a compass, you know? I think that's the teacher's job. (IT13)*

Other constraints are related to "teaching materials and supporting materials," as seen in an excerpt from another teacher: "These controversies, sometimes, are not covered in the teaching materials" (I14). This element is also highlighted in articles and by researchers [13, 21, 23] who use the SSC approach.

Another of the constraints that was cited was "assessment," and there were no comments specifically related to learning during the interviews. I therefore conclude that this may be related to insecurity with dealing with the subject, since, when assessing a discussion of controversial subjects, the teacher cannot only consider one point of view to be correct.

When asked about the potentials of using the SSC approach in lessons, the teachers considered that they provide motivation for the students to seek information on current issues. Taking into consideration the concepts involved in dealing with controversies, one teacher (T1) answered a questionnaire item as follows: "I think that this approach is always motivating and provoking, because it drives me to seek more information and greater precision with relation to the concepts covered" (QT1_5).

Other teachers stated that the controversies approach promotes better understanding of reality; as follows: "[…] it helps with development of critical reasoning and position-taking, helping students to think like a citizen and see beyond appearances[…]" (QT3_5), providing "[…] awareness of the facts and changes that are a part of learning […]" (QT4_5) and, therefore, "[…] gives significance to the students' reality" (QT14_5). A different point of view on potentials is revealed in another teacher's response: "It is important since they are who will continue scientific and technological develoxpment and presenting them with these controversies is a way of making them reflect so that in the future we can achieve better solutions than the current ones" (QT10_5).

My understanding is that including SSC among the subjects of the projects run at the school is relevant, since it provides an opportunity to discuss controversial subjects in society. Nevertheless,

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this challenge should be accepted in an integrated manner across the curriculum and within organization of the subjects and not delegated to just one subject department, because of the complexity of the subjects involved and their didactic organization. The school's Vice-principal responsible for teaching argues along the same lines:

> *Nowadays, I don't think it is conceivable any longer to analyze any controversy from the point of view of just one subject. I think it would be almost impossible. Perhaps, in my view, it is almost impossible, or such an analysis would be very prejudiced, or it would not be sufficiently enriched to even merit analysis of its results because of the bias introduced by the concepts of a specific subject. (IVPT)*

This perspective is shared by teachers from the different subjects themselves.

> *[…] that is exactly what the project is for, we identify certain issues which, after the curiosity, the asking of questions, these specific issues will be discussed with each student in the classroom, so perhaps, in Sociology they will discuss (one angle), and in History another, and in Geography they'll discuss another, I think it's more or less like that. (IT14)*

These contributions from the management team and the subject teachers show that some of the constraints are related both to planning the projects and to the way that SSCs are approached. Time is one of the most important elements to be considered in this context, followed by the challenge of directing discussions when there are differing positions on a given subject. Divergent points of view can arise among the group of teachers who are planning and organizing the project as well as among the students during lessons.

Despite these constraints, we can see that implementation of this approach in a school that is already methodologically committed to a perspective that values curricular integration appear to be appropriate and could potentialize this integration even further. The school understands that current issues that cause controversies should be dealt with through projects in several different subject areas, rather than be focused on just one branch of knowledge. In this chapter, I defend the claim that the SSC approach can potentialize this integration, not only by bringing the subjects together but also by encouraging wider curricular integration.

6. Some considerations

It is our belief that it is not enough to rely on traditional subject-based teaching alone, in which information considered relevant is provided by the teacher, with content isolated from its context. Rather, it is necessary to use methodologies that enable the integration of concepts across different subjects to be perceived in a clear and objective manner, taking advantage of the experiences provided by the environment of which the students are part, combined with an approach using socioscientific controversies to provide opportunities for discussions that are not restricted to scientific knowledge.

However, I have also shown some of the limitations of this type of activity, many related to planning its use within the daily routine of the school, describing a series of factors that are impediments to its effective implementation. These factors are linked to issues from a range of different domains, including of a political, emotional, and structural nature, in addition to elements related to training and qualifications. However, these limitations could be resolved

if the teaching staff involved in a collective project were able to discuss strategies to overcome them. It is clear that some factors are not easy to resolve and, in some cases, are under the control of the school's Principal and Vice-principal, such as allocating space and time for more effective discussions to take place, in addition to more adequate remuneration for the teachers.

The analyses of questionnaires and interview transcripts enabled us to identify the principal factors that interfere with using controversial subjects in the classroom. One of these aspects is emphasis on memorization and the little attention given to aspects related to the process of construction of scientific knowledge or to the epistemological aspects of science. This is strongly linked to teachers' initial training, where the emphasis is on depositing the subject content learnt, passing it on to the students so they are instrumentalized to pass external assessment exams and university entrance exams, ignoring the context and the reality of society.

Another factor is the teachers' lack of experience and, consequently, the students' lack of experience with discussions in the classroom, which means they do not have the necessary skills for this type of activity. Of particular importance is a lack of knowledge about how to design and manage classroom discussion activities, obviously in relation to controversial subjects. Although they did use a space for, for example, simulation of a jury, the teachers had concerns with relation to mediating these activities. This insecurity, related to a lack of experience, demonstrates the extent to which theory and practice are separated in the classroom. Both initial training and ongoing education explore the importance of group activities and of discussion, but teachers do not have experience with these activities, making it less likely that they will employ them.

Other constraints are related to the large quantity of curricular content in science subjects; the teachers' concepts of science teaching and the socioscientific issues approach; and a lack of educational resources. These teachers end up opting for direct presentation as teaching strategy and concern themselves with transmission of knowledge, filling their lessons with fragmented elements from the curriculum, when they could be utilizing aspects of knowledge production and the epistemology of science, with the result that they create an idea of science as pre-established content that the students must master.

It is our understanding that using the SSC approach within the sciences alone will not achieve integration between the different subjects. Along the same lines, taking this approach to teaching the humanities or languages, in isolation, will also fail to achieve this success. The project teaching method is one means of bringing these subjects together, because it works, organizes, and teaches in a way that is collective and integrative, making the social dynamics of working groups explicit and providing opportunities for integration.

In addition to integration, which is fostered by the project teaching method, we need to go further, by planning projects with the SSC approach, since, in order to develop citizenship, we cannot limit ourselves to discussion but must provide opportunities for the students to act on their discussions, that is, enable them to go beyond the school walls and into society, motivating them to exercise their citizenship.

Analysis of the teachers' responses showed that, in general, the staff are open to new ways of working, including the strategy proposed, involving use of socioscientific controversies in an

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integrative manner. Many of them pointed out that they already include different ways of working in their practices, albeit in an isolated manner, which reveals a fresh view on their conceptualizations of teaching, students, and education. Working from the constraints on and potentials of discussion of socioscientific controversies within an integrative approach, I believe that we need to rethink the way that initial teacher training and ongoing education are constituted. It is important to help them to internalize the educational relevance of this type of educational experience and to develop the teaching knowledge necessary to implement it in the classroom setting.

I believe that the constraints and potentials raised by the teachers with relation to this type of practice in the school are potentialized by explanation of the contradictions between what is possible and what limits effective use. From this perspective, it is possible to understand what the "constraints" are and how they operate and how, sometimes, they can be overcome. Taking them as a basis, it is necessary to undertake planned actions to ensure that this type of discussion is included as part of teachers' training, going beyond identification of limiting factors, in the direction of achieving better knowledge of and interaction with reality.

When faced with difficulties, teachers should attempt to evaluate the reasons behind the success or failure of the approach adopted. It is likely that they will not be inherent to the methodology proposed but to the way it has been conceived and managed. Particular attention must be paid to the subject and structure of the task, to the composition of groups, and to the social skills that are needed to complete the activities that follow.

Another concern related to using discussion of socioscientific controversies in an integrative model is that this approach could tend to be transformed into just another teaching resource for convincing students that scientific knowledge, because it is different, has greater validity than other types, or that it is the only knowledge that should be taken into account for decision-making. I believe that this can often lead to discussion of controversies being seen as an instrument exclusively for learning scientific knowledge, reducing a debate that could be much wider-ranging, because scientific discourse is seen as an instrument for understanding human controversies.

Teaching with Integrated Projects, allied to the SSC approach, can enable an expansion of horizons and lead to perception of the implications for understanding the reality of the curricular content of each of the subjects. In addition to this advantage, the practice can help students and teachers to perceive the importance of an integrative view of knowledge, stimulating them to advance beyond education bound by the domains of the content of a single subject. This study appears to show that the project teaching strategy is a promising way to transform the student-student, student-teacher, and teacher-teacher relationships in the classroom.

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