

Transversal: International Journal for the Historiography of Science 2018 (5): 146-156
ISSN 2526-2270
www.historiographyofscience.org
Belo Horizonte – MG / Brazil
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Article

Writing, Acting and Engaging in Socioscientific Controversies as a Way to Learn about the Nature of Sciences

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Abstract:

This article presents a methodology to teach about the nature of sciences and their histories through the construction of controversial dialogs in order to promote reflective and engaging practices among undergraduate and graduate students. This proposal seeks to establish the study's guidelines and organize the distribution of tasks in groups to draft scripts of dialogs that bring relevant information and that produce antagonistic positions on controversial socioscientific issues. This information will later be recorded in short home videos of 5 to 10 minutes each, which will then be shown and discussed in the classroom. Finally, this article highlights some limitations of this methodology, primarily in the way it has been used in this study. By contrast, the advantages of its use are pinpointed as a didactic strategy that serves to stimulate historical research and critical thinking regarding the nature of science and its sociotechnical relations.

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Keywords:

Historical Controversies; Video Production; Argumentation: History and Philosophy of Science; Teaching Sciences

Received: 25 January 2018. Reviewed 9 October 2018. Accepted: 2 November 2018.

DOI: <http://dx.doi.org/10.24117/2526-2270.2018.i5.11>



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Introduction

The importance of including history and philosophy of science and promoting reflections on the nature of science (NOS) in science education is already widely recognized. Though there

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are differences among the main issues detected by different scholars, there is a consensus that the promotion of a critical view of science would be the best means through which to confront the problems. Thus, the promotion of a critical view of science has been sought at different levels of science education, including at the level of teacher education, for better cognitive, social, moral, and political development (Abd-El-Khalick and Lederman 2000; Cachapuz et al. 2005; Martínez 2014; Karisan and Zeidler 2017).

However, the scarcity of teaching methods that promote reflective and engaging practices have also been identified: situations that allow us to experience the methodological limitations of historical reconstructions, as well as the difficulties of producing them in an interesting way, with understandable and intriguing narrative reconstructions.

Therefore, this article presents a methodology to teach about the nature of sciences and their histories through the construction of controversial dialogs. This study consists of a strategy to engage the general public, especially undergraduate and graduate students, in discussing controversial topics as a way to experience the nature of science and historical episodes related to the constitution of scientific culture.

Justifications

Controversies are nothing new, neither as teaching strategies nor in the methodology of historical or sociological investigation. Even in medieval education, the *disputatio* was adopted as a method of teaching and learning. To the contrary of *lectio*, which implied a passive attitude, the *disputatio* awakened the students' intellectual activity. But what appeared in this tradition was a formal method of debate to discover truths in philosophy and theology, with set rules that demanded dependence on the written tradition and the full understanding of each argument by both parties. Something more fluid and less strict has been taking place in recent decades in schools in many countries, with simulated juries and judgments of historical cases, used as a didactic strategy to teach history, with the division into sides and attributions created for defense and accusation, in such a way as to promote the students' study and participation in the classroom.

Controversy has also been used for decades in the history and sociology of science. Some focus on internal disputes between fields and scientific perspectives with other forms of non-scientific knowledge, while others develop social, economic, political, and cultural reactions to projects and scientific institutions or technological systems, etc. As a methodology of historical investigation, controversy has been applied to better understand the context and wide range of interests in play. Perhaps the most well-known case in the contemporary historiography of science is the dispute between Robert Boyle and Thomas Hobbes over air pump experiments, depicted by Shapin and Schaffer (1985). This history became a landmark in science historiography, as it showed how the broader political climate could shape the outcome of a controversy, while simultaneously helping to institutionalize the laboratory experiment as a new means of fact-making. However, many historians of science had already explored the concept of controversy regarding Copernicanism, the vacuum, evolutionism, and the priority of recognizing authorship/patent in inventions and theories.

Also within the sociology of science is a long history of studying different types of controversy and different approaches to analyzing them. Collins and Pinch (1998) developed an empirical method for studying the sociology of scientific knowledge, using contemporary cases as a method through which to study scientific controversies, which appears to be particularly impacting. Through scenes of selected events, they illustrated how scientific findings exhibited "interpretative flexibility", in turn revealing how facts can be interpreted in radically different ways by the parties in the controversy.

As Pinch (2015) observed, it is during such moments that the often invisible processes of science become more visible and thus more available to analysis. By studying a scientific controversy, or moments of contestation, one learns something about the underlying dynamics of science and its relations with a broader society. For instance, during a controversy, the normally hidden social dimensions of science (including its gender biases) may become more explicit. “Sites of contestation are places to facilitate the investigation of, for instance, the metaphors, assumptions, and political struggles embedded within science”. (Pinch 2015, 282)

As Dascal defends, “controversies are an excellent strategy when placed against the background of the familiar descriptivist and normativist positions that have dominated the history and philosophy of science” (Dascal 1998, 147).

In addition to the methodology of research and didactic strategy, controversies are also used by both disseminators of the science of the editorial market as a way to call the attention of the general public and, perhaps, involve them in taking a stance/position. As in the Science Wars, revolving around the Affair Sokal,⁴ or in the controversy surrounding the celebration of Pasteur,⁵ mutual allegations and accusations of scientific shams call attention and dig trenches concerning the scientific principles and assumptions.

The proposal that we present here stems from museum experiences, and can thus be found in the realm of scientific diffusion to the general public in informal educational environments, but that has been reformulated for university courses.

A recent literature review on Socioscientific Issues (SSI) and progressive scientific literacy demonstrated that the SSI provides an ideal context in which to improve the understanding of students and teachers about the nature of science (Zeidler 2014). Since they took on greater visibility in the early 2000’s, SSI has been strengthened as a curricular aspect of the teaching of science by aligning themselves with a view of scientific literacy that is more linked to contexts, more focused on students, and seeks a greater social engagement. Thus, science educators (Khishfe 2012; Khishfe and Lederman 2006; Sadler et al. 2004; Walker and Zeidler 2007; Zeidler et al. 2002) have sought to explore scientific aspects of the relationship between NOS and SSI in their research, addressing the NOS components within the context of issues with great repercussion, such as global warming, genetically modified foods, animal rights, among others. For this reason, be it in formal or informal contexts, SSI have been used as a fundamental means through which to develop functional scientific literacy and has been empirically investigated and linked to particular outcomes, including: promoting developmental changes in reflective judgment, moving students towards more informed views of the nature of science, increasing moral sensitivity and empathy, revealing and reconstructing alternative perceptions of science, facilitating moral reasoning, among others.

This strategy that we present here seeks objectives that are common to those set forth by SSI. According to that mentioned above, it was initially developed for museum exhibitions. As environments of controversial discussions, SSI appeared in two exhibitions: (1) Different characters expressing divergent perspectives are shown on different TV screens, trying to convince the audience and simulating a provocative debate. The TVs (4 to 6) are connected with raspberry-pi cards that synchronize the interventions and contention. The first debate

⁴ In his analysis of the context of Sokal Affair, Hilgartner (1997) argued that the intellectual impact of the successful Sokal hoax cannot be attributed to its quality as a “demonstration” but rather to journalistic hyperbole.

⁵ Gerald Geison’s book, *The Private Science of Louis Pasteur*, generated great controversy in journals. According to the historical re-reading, the legendary figure of the history of science lied about his research, stole ideas from a competitor, and was deceitful in ways that would now be regarded as scientific misconduct if not fraud. Thus, there was a serious reaction against this work in the political debate about the myths of science and its detractors.

was on childbirth, developed for the exhibition “Senses of Birth”⁶; (2) The second was a debate, also controversial, about knowledge needed for the exhibition of “Theater of Truth”, involving 4 characters: a philosopher, a scientist, a political activist, and a student. (https://www.youtube.com/watch?v=oCQKB_2fQTw).

As the debate about the childbirth was part of a public health campaign to reduce unnecessary C-sections and promote normal childbirth, there was a predominant stance in the discussion. Although antagonistic views were brought into the scene, with good formulations of the perspective under debate, the confrontation had a side that had to “be won”. The video attempted to bring the spectator, with counterpoints and surprises, to this conclusion.

By contrast, in the “Theater of Truth”, there is a symmetry among the characters’ views that, even with divergent and conflicting perspectives, tends to lead the spectator to the paradoxical agreement with all of the opponents. That is, each character/perspective exposes convincing reasons, making it difficult to think about the issue without recognizing its complexity and the validity of different perspectives.

In real life, public debates rarely allow one to candidly expose (without the need to defend or the concern not to offend the interlocutors) contrasting worldviews or highlight differences, as occurs in these skits. This device, through which we have developed the methodology presented here, allows for the joining of views that are rarely seen side by side. This is because the chosen characters can represent quite different universes, which would rarely act (dialog) in public disputes. But heated debates, in which those involved expose their divergences and dispute the consent of those present, make the debate even more captivating.

Thus, in the debate concerning the knowledge referred to above, when the young person questions: “what purpose does knowledge serve?”, insinuating that it has no purpose in real life, another character answers: “for the individual to stop being stupid”. Such an answer, which could cause friction in real life, generates only surprise in a theatrical representation, which can explore the tension that it causes in the spectators. Moreover, the inclusion of characters that express the view of common sense and give voice to the misunderstandings and resistance, which are not normally recognized or placed at the same level within a debate, provide the identification and transference of many spectators.

Methodological Proposal for Use in the Classroom

Inspired by those experiences done with actors, this study sought to develop a methodology of science teaching that has been used over the last two years in undergraduate and graduate courses of “History of the Popularization of Science”, “Practice of Teaching Biology”, and “Science in Museums” at the Federal University of Minas Gerais (UFMG).

The methodology begins with the presentation of videos that had already been produced and that serve as examples of controversies in theatrical skits. The class is then divided into groups of students who choose a scientific controversy from a menu presented by the teacher. In addition to the themes, the teachers also suggest research materials to further the students’ knowledge in the chosen theme, especially films that can be useful in the design of the controversies and perspectives of different actors, uses, and implications

⁶ www.sentidosdonascer.org. As the discussion in the exhibition is done in 6 screens, we made an adaptation to the computer screen conjugating the interventions of the characters, that can be seen in the link: <https://www.youtube.com/watch?v=iCNpYHg9cxw>.



of certain technologies and scientific theories, as well as platform games of sociotechnical controversies, accessible at <https://playdecide.eu/>.⁷

The students are then advised to share their individual studies on the theme with their colleagues in the group, making summaries of the films they watched, of the related texts, life experiences, impressions, and other references. They are also advised to clearly define the controversy in the form of a question for which multiple answers are possible and to define the characters that will represent the chosen divergent perspectives.

One suggestion for the initial drafting of the script is for each one to take on the role of a character to record an audio, improving the dialog that they will return to in order to improve upon it at a later moment. The audio serves as a framework of the dialog to be transcribed. The script must be developed in written form, as this will help to balance the input and arguments of the characters, marking interjections and counter-arguments.

Every other week, each group of students presents a version of the script, which is continuously re-elaborated after class discussion, paying attention to argumentative strategies and the configuration of the characters. Thus, in addition to promoting teamwork, groups of students are encouraged to select and rework arguments.

After adjustments, each group records a short 5 to 10-minute home video that expresses the arguments of their characters as naturally as possible, simulating a sequence of counter-arguments. Although the speeches are concatenated and oppose each other, they should be directed toward the spectator, as if in a debate among political candidates.

The dialog should contain relevant information and antagonistic positions on a controversial socioscientific issue, and above all be geared toward inspiring public debate. These are the criteria by which the works will be assessed in the end. The collective presentations at the end of the course make it possible to achieve a collective assessment and, most importantly, the discussion of historical aspects and scientific representation of science when addressing the theme.

Below is a summary table with the methodology presented in three distinct steps:

STEP	ACTIVITIES	DETAILS
Sensitivity and further development	<p>Present an example of the product (script or video) to the working groups or Guide with general instructions.</p> <p>Introduce the controversial themes and provide support materials (films, chapters, articles, videos, controversial games).</p> <p>Define the period within the schedule of the course for further development of the group members about the theme.</p>	<p>Present the guide with model and instructions about the format: script of 4 to 6 pages; time estimated for videos of 3 to 5 minutes; four characters discussing a previously defined controversial question. When possible, present an example of the work developed by another group.</p> <p>Full films; bibliographic materials recommended for the themes chosen by the groups; controversial games from the <i>Playdecide</i> Platform.</p>

⁷ *Playdecide* is an online platform that enables users to create, adapt and translate games. This site is supported by a European network of science centers and museums and works as an observatory of the tendencies of the public's view of science.



Drafting of Scripts	<p>Socialization of the individual studies between the group members (reports of films watched, related chapters, and other materials)</p> <p>Definition of the issue at hand of the four characters.</p> <p>Improvisation of the conversation and log in audio format.</p> <p>Drafting of the dialog script.</p>	<p>Discussions performed onsite or by platform with distance activities (documents in drive or ICT resources).</p> <p>Use of cell phones or audio recorders.</p> <p>Instruct the students, transcribe the dialogs, and analyze them in order to identify arguments presented spontaneously, and improve upon them based on research of different positions on the subject.</p>
Socialization of the dialog	<p>Staging and recording of the video. Exhibition of the video or dramatic reading in the classroom.</p> <p>Staging and recording of the video.</p> <p>Video exhibition or dramatic reading in the classroom.</p>	<p>Cell phones or video cameras. Image projection; computer; camera (if the video is recording in the classroom, with the support of the teacher and classmates).</p> <p>Use cell phones or video cameras for record. The video can be recorded in the classroom with the support of the teacher and colleagues. Editing and finalizing the final product.</p> <p>Projection of the results for the class and final discussion.</p>

The produced videos can be made available on a Youtube channel, as we did at our university.⁸ Of course, these videos require high-quality editing, such as recordings done in a studio, the direction of the actors, as well as sound and imagery editing, in order to be appreciated by the general public. But there is no doubt that this process serves as an educational process for these students, not only in terms of critical reflection, but also in the exercise of transposing and sharing of public representations and arguments.

Discussion

Although they were planned to address historical controversies, many videos ended up focusing on more current sociotechnical issues, such as the transmission of HIV, genetic diagnosis as a form of eugenics, environmental responsibility with global warming, medication for mental illnesses, using history on a secondary plane, basically to locate the origins of disputes related to current representations. In these cases, after the presentation of the videos, the problems of historiographic presentism are discussed and contrasted with the importance of raising different interpretations.

In fact, this tendency can be seen as a limitation if we observe from a historiographic perspective; therefore, the discussion about presentism and anachronisms is quite relevant in the history of science courses. Nevertheless, if we are not stuck to one of these specific disciplines, the use of history to discuss current cases will be considered positive. This is what seems to occur in more interdisciplinary environments, such as in Science Studies or in some

⁸ <https://www.youtube.com/channel/UCNJ3i4KNR73wq569jj9CApw>

research agendas, such as IHPST.⁹ In these fields, the sacrifice of some demands from historiography due to the transposing to current cases or to the realm of scientific policies are well-received.

We believe that one such contribution to the debates is the clear definition of the background issue, offering their different concrete implications as answer options. The platform games, like *Playdecide*, which we used as examples of the preparation of scripts, are headed in this direction. In all thematic cases available on that platform, there is a core question and four answers with concrete ramifications for public policies.

One key example experience of ours came from the theme “The Functioning of the Brain”. The game from *Playdecide*, entitled “Improvements of the Brain”, aroused great interest in the question of the relationship between the functioning of the brain with its interaction with drugs. Even if the game is focused on the possibility of improving one’s cognitive functions, it provokes the discussion on the question of the possibility of the use of drugs to control cognition, both to give greater potential to the functioning of the brain, as well as to resolve cognitive problems. In this manner, the groups can focus on different aspects, with more or less evident connections. In our experience, one of the groups explored current and future challenges regarding the improvement of cognitive functions, while another group focused on the use of drugs to resolve cognitive problems.

This last group was offered a suggestion to further develop the question of their own diagnosis of mental health diseases. As is well-known, this deals with a question that is commonly experienced in the current school reality, with heavy medication prescribed for children diagnosed with Attention Deficit Disorder, and which is highly controversial, especially in the field of education. So that the students can treat these themes, the films *Hysteria* (2011) and *Augustine* (2012) were suggested, as these films take distinct approaches to the context of the definition of specific social behavior, which characterizes this disease. These suggestions were given to aid in the comprehension of the context and of the definition of the disease itself as an aspect related to the social expectations and the behavioral patterns of some groups, in relation to specific subjects.

Below is a transcript of part of the dialog drafted by the group on the theme. The context is that of a dialog that takes place about the proposal of the possible medication of a student (Jorge) that the school suspects of having ADHD, whose diagnosis produced divergent opinions among doctors. The characters are a doctor, the principal, the teacher, and the student’s father.

Father: I think this diagnosis of hyperactivity is a bit strange, since the previous exams didn’t show anything.

Doctor: This disease is normally cured quickly with the use of appropriate medication.

Teacher: I think it might simply be a question of the child’s adaptation to the school environment, after all, he’s only 7 years old.

Principal: Cases of hyperactivity have become more and more common in school and the medications have shown great results.

Teacher: Medicating the child seems to be a sound decision, but it has consequences for the children’s lives that are not well disseminated, like the addiction to the medication, in addition to the risk of a wrong diagnosis. I am totally against medicating Jorge, especially since it is too early.

⁹ International History, Philosophy, and Science Teaching Group. <http://ihpst.net/>

Specialist: Forgive me, but I don't think the teacher has the competence to give her opinion on this subject. The medication will be of utmost importance, as it can benefit him, not only temporarily, but also by bringing positive results, such as a greater facility to deal with obstacles, consequently improving his school relationships and performance.

Teacher: I may not have medical competence, but I interact with Jorge, I studied and talked to specialists about the subject. Hyperactivity is a very rare disease. This diagnosis may be more linked to the fact of having to answer to a social demand, as was the case of hysteria, where the women who didn't fit into the standard of the day were diagnosed with hysteria. Much like in that society, our society is marked by behavioral standards that are seen as ideal and normal. What we should be discussing in this meeting is the manner in which we organize teaching, not about Jorge's medication!

In this case, the advantage of using the historical perspective to treat a controversial question becomes evident, since a historical distancing and the succession of events and interpretations about hysteria, considering the temporal distance, helps to denaturalize and comprehend elements of biopower present in the construction of a wide range of diseases. But the opposite also occurs: the comprehension of questions involved in contemporary sociotechnical controversies can, through the perception of the complexity of the factors, favor interests, a critical view of the classical narratives of the history of sciences in the construction of historical reconstructions about sciences.

Another dialog developed by the students in which the historical perspective informs and contributes is the case of the obligation of certain vaccines. The groups created a dialog in the context of a public health seminar in which they would be debating rumors that the vaccine against Dengue would be mandatory. The characters include two specialists, one against and one in favor, and two students, also with differing positions about the obligation of vaccines.

Student 1: I know people that have had collateral effects against various other vaccines.

Specialist 2: Isn't it better to have some collateral effects and be protected against a disease that can lead to death? I believe that sanctions are necessary to raise the awareness of the population. If we cite the case of Yellow Fever, it was only eradicated because of its obligation. Dengue has spread into an epidemic, like happened in the times of Yellow Fever, exactly in Rio de Janeiro some years ago.

Student 1: You cite the example of Yellow Fever, but the idea of obligation in that time was to take care of the image of the country and not public health. Rio de Janeiro, which was the "showcase" of Brazil, ended up being a complete disaster because of Yellow Fever. Even today, Rio continues to be the showcase of Brazil and Dengue has called the world's attention because of this.

Specialist 1: We have to discuss this affirmation that medicines and vaccines will save humanity from diseases. This war of man against virus and bacteria seemed to be near its end when the first antibiotics were introduced, for example. The same modernity that carries the scientific advances also produces an effect that is as harmful as it is well-known, which is the assault on the environment.

Specialist 2: Indeed, history reveals that the largest outbreaks of diseases always arose from a scenario of imbalance. But will we let the diseases spread, even with the conditions to control and even eradicate them?

The theme of vaccines has been raised in a number of countries and appears in many of them as anti-vaccine movements, which lead to heated debates in different segments. The controversy revolves around the obligation as opposed to possible collateral effects. The reference to the case of the Vaccine Revolt in Brazil,¹⁰ bringing the historical dimension to the current debate, favors the comprehension of the overlapping among the cultural, social and political, and scientific-technological dimensions.

One differential of the teaching methodology that we presented in relation to that of Collins is in the creative process of the types of arguments. By encouraging the exercise of forming conflicting perspectives, involving the potential artistic abilities of the students (be it in the performance of the characters, be it in the edition of the images) for the production of a video that, in the end, will be shared, the process has proven to be a fun and quite involving challenge.

One of the limitations that we identified in this methodology is the large investment in the time necessary to be developed. Since the presentation of the proposal (which needs to be understood and accepted), to the need to delve deeper into the chosen themes (be they of their scientific content or of the perceptions from different groups about the dispute), culminating in the presentation of the products (which can also raise discussions), approximately 20 class/hours are spent. Therefore, this is not about a methodology that can be immediately applied, but rather a set of actions that demand investment in onsite time spent in the discipline, especially as it is an activity that is developed in groups and that requires follow-up on the part of the teacher.

The other limitation of this methodology is the possibility of frustrating expectations of students as regards the reach of a consensual synthesis or closure of the questions. Thus, it is important to remember that this objective methodology brings about reflections, awakens one's interest in the theme, and raises debates that do not reach complete answers. This can leave a feeling of being unfinished, exactly due to the lack of a construction of consensus surrounding a controversial question. A finalization does not consist of a winning solution. Differently from proposals like the exposure of "Senses of Birth", which had the aim of influencing people's opinion against unnecessary C-sections, in this methodology, we seek the equanimity of arguments with the possibility that a spectator may be "convinced" by any of the stances. This experience, even though it may seem disappointing, is intellectually relevant, as the discussions are perceived by the participants as making some sort of cognitive or epistemic contribution: they clarify the problem, they permit one to identify conceptual or methodological divergences or difficulties, and they reorient the research effort.

Final Considerations

Educational activities that concentrate only on scientific products, ignoring the use of science in questions about the real world and disregarding how these scientific ideals are socioculturally framed, developed, and implemented, end up reinforcing distorted images of science.

¹⁰ The Vaccine Revolt was a popular revolt that occurred in Rio between November 10th and 16th, 1904. Provoked by the compulsory vaccination campaign against smallpox, lot of violent conflicts took place among the poor and the authorities.

In this sense, making controversies explicit contributes to the perception that the scientific facts are always negotiated and that this negotiation is not confined to the scientific community. Much to the contrary, this approach also includes various modes and other social actors related to the process of the public appropriation of science.

Attention to the contextual aspects of science or to their controversial nature can make the learning process more significant, yet still focus classes on information, reference to readings, that are normally unable to captivate the students. We, therefore, have the added challenge, which is no small task, to try to develop activities that are challenging, that can explore the fun and more inspiring side of studies.

Acknowledgments

This work was supported by funding from the National Council of Technological and Scientific Development (CNPq) of Brazil, and the Research Funding Agency of the State of Minas Gerais – Brazil (FAPEMIG).

References

- Abd-el-Khalick, Fouad and Lederman, Norman. 2000. Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education* 22 (7): 665-701.
- Bandelli, Andrea and Konijn, Elly. 2011. [An experimental approach to strengthen the role of science centers in the governance of science](#). In: *The Routledge Companion to Museum Ethics*. Edited by Marstine, Janet C, 164-173. London: Routledge.
- Cachapuz, António; Gil-Perez, Daniel; Carvalho, Anna Maria Pessoa De; Praia, João; Vilches, Amparo. 2005. *A necessária renovação do ensino das ciências*. São Paulo: Cortez.
- Collins, Harry and Trevor Pinch. 1998. *The Golem. What You Should Know About Science*. Cambridge; Cambridge University Press.
- Dascal, Marcelo. 1998. The Study of Controversies and the Theory and History of Science. *Science in Context* 11 (2):147-154. <https://doi.org/10.1017/S0269889700002957>
- Hilgartner, Stephen. 1997. The Sokal Affair in Context. *Science, Technology & Human Values* 22 (4): 506–522. <https://doi.org/10.1177%2F016224399702200404>
- Hochman, Gilberto. 2009. Priority, Invisibility and Eradication: The History of Smallpox and the Brazilian Public Health Agenda. *Medical History* 53 (2): 229-252. <https://doi.org/10.1017/S002572730000020X>
- Karisan, Dilek and Zeidler, Dana. 2017. Contextualization of nature of science within the socioscientific issues framework: A review of research. *International Journal of Education in Mathematics, Science and Technology* 5 (2): 139-152. <http://dx.doi.org/10.18404/ijemst.270186>
- Khishfe, Rola. 2012. Nature of science and decision-making. *International Journal of Science Education* 34 (1): 67-100.
- Khishfe, Rola and Lederman, Norman. 2006. Teaching nature of science within a controversial topic: Integrated versus nonintegrated. *Journal of Research in Science Teaching* 43 (4): 395-418.
- Levinson, Ralph. 2006. Towards a theoretical framework for teaching controversial socio-scientific issues. *International Journal of Science Education* 28(10): 1201-1224.
- Martínez, Leonardo. 2014. [Cuestiones sociocientíficas en la formación de profesores de ciencias: aportes y desafíos](#). *Tecné, Episteme y Didaxis: TED*, (36): 77-94. Retrieved October 29, 2018.
- Pinch, Trevor. 2015. Scientific Controversies. In: *International Encyclopedia of the Social & Behavioral Sciences*, edited by James Wright, 281-286. Elsevier Ltd.



<https://doi.org/10.1016/b978-0-08-097086-8.85043-6>

- Pinch, Trevor and Leuenberger, Christine. [Studying Scientific Controversy from the STS Perspective](#) [accessed Oct 01 2018].
- Sadler, Troy; Chambers, William; and Zeidler, Dana. 2004. Student conceptualizations of the nature of science in response to a socioscientific issue. *International Journal of Science Education* 26(4): 387-409.
- Shapin, Steven and Simon Schaffer. 1985. *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life*. Princeton: Princeton University Press.
- Tauber, Alfred. 1999. Is biology a political Science? *BioScience* 49 (6), 479 - 486.
- Walker, Kimberly and Zeidler, Dana. 2007. Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education* 29 (11), 1387-1410.
- Zeidler, Dana; Walker, Kimberly; Ackett, Wayne, Simmons, Michael. 2002. Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education* 86: 343-367.
- Zeidler, Dana. 2014. Socioscientific Issues as a Curriculum Emphasis: Theory, Research and Practice. In: *Handbook of Research on Science Education, Volume II*, edited by Norman Lederman and Sandra Abell, 697-726. New York: Routledge.

