

THE USE OF AUDIOVISUAL APPROACH TO TEACH NATURE OF SCIENCE FOR IN-SERVICE NATURAL SCIENCE TEACHER'S EDUCATION

Edson Rodrigues Santana, Agnaldo Arroio

University of São Paulo, São Paulo, Brazil

E-mail: edsonrodriguessantana@hotmail.com, agnaldoarroio@yahoo.com

Abstract

The nature of science is a subject recognized among researchers and curriculum proposals, however still find some problems, especially with regard to what teachers understand about the subject and the importance attributed to it. Another element in this discussion concerns the use of resource suitable for use in teaching and learning situations. Therefore we present a research outline still in progress which discusses the use of audiovisual and methodological support to discuss the nature of science, for that resource is being applied in an in-service education program in the Faculty of Education, University of São Paulo, Brazil. According to the preliminary results it can find some initial modifications, these enhanced by audiovisual feature tied to reflections that occur during the activities developed by teachers.

Key words: *cinema, nature of science, in-service teachers.*

Introduction

A significant number of studies focus on the nature of science (NOS) (Matthews, 1995; Bell, Lederman and Abd-El-Khalick, 1998; Gil-Perez and collaborators 2001; Acevedo, 2010; Santana and Arroio, 2009) provide examples of reported concerns that address ways to improve scientific knowledge by inserting the nature of science in teaching and learning situations. There are also documents such as the National Curriculum Parameters (PCNs, 1998), and projects such as Project 2061, as highlighted by Matthews (1995), that are examples that reinforce the relevance of the topic.

Vásquez-Alonso and collaborators (2008) show that there are two lines of inquiry regarding the improvement of scientific knowledge. The first believes that is not important to incorporate the nature of science into the classroom. The second recognizes the relevance of this issue. This second line of inquiry has a large number of researchers, including those cited above. The authors of the current study agree with the second group of researchers and highlight difficulties in converting the theme of the nature of science content into the classroom.

It is emphasized that it is necessary to know how these issues are understood in the context of Natural Science Education. A literature review by Harres (1998) about teachers' conceptions on the nature of science and its implications for teaching research identifies not only the views of teachers, but also the real role and importance of teachers' conceptions about the nature of science.

Furthermore, contributions from Acevedo (2009) are relevant. It is necessary that teachers know how to use knowledge of the nature of science in teaching and learning activities that address questions of scientific activity, use of historical situations, and use of philosophical

and sociological scientific work in order to give context to situations involving the nature of science.

The Appeal of Audiovisual and Visions of Science

A teaching strategy based on film language allows learning to go beyond a purely rational process. Instead it develops the sensory side of learning, including creative, imaginative, and critical views of the information contained in films (Arroio, 2010).

To illustrate the educational value of audiovisual materials, some questions about this medium need to be addressed, including *“What is the image reflects? Is the image an expression of reality or is it a representation? Is it possible to manipulate the image or is it the reality register?”* (Navarrete, 2008). Such questions are important so that students and teachers do not analyze the film material naively, as if it is a fact, devoid of intent and/or opinions.

Santana and Arroio (2012) present a proposal to use films with subjects related to the nature of science, highlighting potential uses, but warning against using them simply for graphics or just to draw the attention of students.

Morin (2002) discusses the idea of big science, in which science has developed titanic powers, often concentrated in government or large corporations. Many scientists believe it is possible to separate these powers of scientific activity, because this type of situation presents a simplistic view, or in the words of Morin, *“These scientists say the following: science is very good, it is moral”* (Morin, 2002, p.127). Thus, these and other representations of science also permeate the vision of science teachers.

Gil-Pérez and collaborators (2001) discuss the distorted views of science presented by teachers, such as empirical-inductivist, neutral and naive, linear, elitist, **ahistorical, and** cumulative.

Bell, Lederman, and Abd-El-Khalick (1998) not only highlight problems in conceptions about nature of science, but also point to another problem: the lack of importance given by teachers in teaching this subject.

With respect to materials, Santana (2009) presents a complaint of teachers, the lack of specific material and training. In this sense, it is not enough just to have access to films; training is needed to guide the work with this material in order to articulate aspects of audiovisual and epistemological understanding of the nature of science (Arroio & Farias, 2011).

Given the propensity to use the cinema, Wertsch (1999) developed the term ‘cultural tool’ to describe the importance of symbolic mediation between people in a communication process that involves cultural group relations.

So, it is trying through an in-service teacher education program to explore this issue by gathering questions from teachers in order to conceptualize how they understand the relevance of the proposal. From this, we developed the idea of using cinema as a methodological support for addressing questions of the nature of science. Furthermore, it is worth remembering, as highlighted by Rezende (2008) apud. Sutton 1997:

Generally films and videos reflect no scientific practice or controversy. Like textbooks, audiovisual materials tend, because of the language used, to present only the results of scientific practice and present hypotheses (or theories) as proven fact, omitting the procedural and political character of scientific practice (Rezende, 2008, p. 2, *apud.* Sutton, 1997).

Thus, it is justified the importance of educational processes that propose to use the resources of audiovisual considering these specific concerns. How in-service teacher can develop the autonomy to use these tools in their practices?

Methodology of Research

This project is part of an in-service program and proposes the notion of using audiovisual and methodological support to address the nature of science into natural science classes. Thus, it was developed a 60 hours in-service education program, organized into twelve fortnightly meetings on Saturdays. These meetings took place at the Faculty of Education, University of São Paulo.

different areas: nine in biology, three in chemistry, three in physics, one in geography and two in pedagogy. The films used were: Lorenzo's Oil, 2001 - A Space Odyssey, and Jurassic Park.

The strategy for data collection was made in accordance with the qualitative research approach, which may be conceptualized differently over time. For this study "we can offer a generic definition, primarily: Qualitative research is a situated activity that locates the observer in the world" (Denzin & Lincoln, 2006, p.17). Data analysis also followed the guidance of this kind of research, and relied on the contributions of Bardin (2010) for content analysis and on Foucault (2009) for the analysis of discourse.

It was sought to establish a relationship between the films, the visions of science, and the resources of film language. For this, we used the idea of core sense of withdrawal from Bardin (2010), the visions of science from Gil-Pérez and collaborators (2001), and the resources of film language from de Almeida (1994), and Martin (1990). It is also used descriptions from NOS (nature of science) conception and teaching practices highlighted by Akerson and collaborators (2012).

Results and Discussion of Research

It is presented the results in three stages: initial, intermediate, and final. The initial step, which used classifications from Santana and Arroio (2012), is summarized in Table 1.

Table 1. Categories of references to nature of science (NOS).

Kind of citation	Number of Teachers	% - answers
Just mention science	3	16.6
Mention with reference to NOS	6	33.3
Do not relate to NOS, only to other topics	9	50.0

According to Table 1, 50% of teachers make no reference to the nature of science, citing other topics, with little more than 30% referring to the nature of science. However, when we use the classification of Gil-Perez and collaborators (2001), we found distorted views of science, such as the naive type and dogmatic type.

The next step started from the third class, so some activities and discussions about the nature of science and the potential of audiovisual resources had already happened. To perform this step, we used snippets of the following films: Lorenzo's Oil, 2001 - A Space Odyssey, and Jurassic Park. Below, it is presented a discussion of the potential of audiovisual clips using excerpts from these films and we also present some considerations about the nature of science pointed out by Gil-Perez and collaborators (2001).

Below we present excerpts of films relating to core sense, visions of science, and cinematic language. Furthermore, Table 2 summarizes this discussion.



Figure 1: Image of Lorenzo' Oil film.

In this section, the discussion is enhanced by inferring the relation of science to society. This is characterized as the core of meaning that enables connection with the insights highlighted by Gil-Perez and collaborators (2001), which are named aproblematic and ahistorical, since they do not recognize the limitations of scientific knowledge.

Film language is used to highlight limitations. An example of film language is shown in the above image from Lorenzo's Oil where the general on the floor plan of the conference hall is viewed from a superior angle, also called *plongé*. This effect is often used to reduce the characters and show the environment. Thus, it creates a climate of superiority and allows a vision of science that reflects the limitations of science in certain situations. In the above image, both the scientists and the sick boy and his family are reduced, illustrating the limited possibilities of healing.

These images display those situations in which science has limitations to solve certain problems. In the case of this movie, the limitation is the impossibility of finding a cure for Lorenzo.



a



b

Figure 2: Images from 2001: A Space Odyssey.

The intended goal, when it was selected the given images, was to present a possible situation for teachers to discuss some elements of man's relationship with the natural world. Thus, the core of meaning related to the nature of science contains the human dimension in science, deepening the importance of historical processes, sociological and philosophical, that permeate science and society.

Through a narrative feature, typical of film language, that articulates images, sounds, and texts, it is possible to exemplify processes, such as the passing of time. For example, in 2001: A Space Odyssey, the image of a bone being thrown upward and then being replaced in mid flight by a floating pen, which provides the viewer with an understanding of the passing of time, space, and characters. This film language creates an understanding that millions of years have passed within this transition cut.



Figure 3: Image from Jurassic Park.

It highlights in the above figure from Jurassic Park the core meaning of Aspects of Epistemology of Science. It is possible to gather two visions of scientific work from this one image, including one which is rigid (algorithmic, accurate, infallible) and the other which is inductivist/atheoretical. These two visions drive the discussion of simply mechanically following the steps of the scientific method (Gil-Perez, and collaborators, 2001). The value of observation and experimentation are emphasized over the importance of theories in scientific development which, according to Chalmers (2001), creates an inductive procedure.

The dialogues present an overall body of work that includes scientists, scientific equipment, and technology that provide examples to support our argument.

Table 2. Connection with the audiovisual material.

Core meaning related to NOS	Movie	Timecode	References – Views of academic work	Cinematography
Science and Society	Lorenzo's Oil	30m 58s-32m 25s	Aproblematic and atheoretical (dogmatic and closed).	General view of the conference hall
Human dimension in science	2001: A Space Odyssey	a) 2m 29s -4m 22s b) 50m 53s – 54m 32s	Aproblematic and atheoretical (dogmatic e closed).	Image of the bone and the pen, followed by music
Aspects of epistemology of science	Jurassic Park	29m 55s – 30m 25s	Rigid, algorithmic, accurate, infallible and inductivist.	General view – scientists, experiment and technological equipment

After the initial survey gathering teachers' conceptions about the nature of science, which are shown in the table above, this study proceeds by addressing audiovisual resources also cited in this article. One could argue that, after the interventions with audiovisual material, it should be possible to identify some elements indicative of changes, which we called intermediate results.

It is selected only one example. At this stage, it is presented a transcript of the speech as well as the researcher's notes, which were recorded in the third class, after exposure to the three audiovisual products.

Researcher: What is science? What do we mean by 'nature of science', a term which, incidentally, is the title of our course? ((Teachers take a while to respond and get thinking. When they begin to respond, they speak very low and seem afraid to expose themselves, which is interesting because the class is outgoing and participates in all subjects)).

Wil: It's when you question something, but I think you should ask first, what is knowledge?

Janice: I think, for example, the animal perceives the world to survive and that way they have an understanding.

Doris: Science is human activity on the world.

Tom: I think, for example, science is a theory, which then produces a technology. For example, in building rockets, which is a technology, it uses the full theoretical understanding of physics prepared for many years.

Wil: Yeah I guess ... so we're different, because animals do not build culture, we cannot speak on animal knowledge, they act instinctively and we go beyond that. We question things, equals, like Tom said; we use science to produce things.

The excerpts above triggered a discussion on the idea of animal knowledge. This fact divided opinions, generating controversy and at the same time, reflections, that made indirect references to, for example, criticism of a scientific truth, as well as aspects of the non-neutrality of science in economic and social issues.

Below, was organized some aspects of dialog, making inferences that allow us to build interpretations of the movies that were watched. It must be said that we did not obtain direct evidence demonstrating the direct relationship with the statements of teachers and the movies they watched. We understand, just as Fischer (2001), who analyzed speech, it is not looking up the meaning of the words, but rather the socio-historical discourse that is related to the speech.

Thus, the use of film clips and discussions are embedded in an existing condition, i.e., a group that produces speech in a classroom situation, in which a theme is worked in with a feature using methodological movies.

Table 3. Connection with audiovisual material.

Core meaning	Audiovisual material	Example	Existence condition
Human aspects	Lorenzo's Oil and 2001: A Space Odyssey	Figure 1. and Figure 2.	Second and third classes
Knowledge	2001: A Space Odyssey	Figure 1. Image b	Second class
Animal knowledge	2001: A Space Odyssey and Jurassic Park	Figure 2. and Figure 3.	Second class
Technology	Jurassic Park	Figure 3.	Second class

We seek here to do what Bardin (2010) and Foucault (2009) call the archeology of analysis, i.e., looking at content. Bardin (2010) and Foucault (2009) treat their analysis of speech like the work of an archaeologist, and we use a procedure presented by Bardin (2010) to do our content analysis. It starts by drafting descriptions followed by making inferences and interpretations.

Thus, the elaborate descriptions allow us to infer. In light of the research cited by Bell, Lederman and Abd-el-Khalick, (1998); Gil-Perez and collaborators, (2001); Acevedo, (2010); Santana and Arroio, (2009), it is seen there are problems in teachers' conceptions of the nature of science. However, from these results, we can argue that there are evidences that teachers' conceptions are beginning to change.

We can identify these initial changes because discursive fragments stand out, like when participants acknowledged that science is human action, and that one must first ask what knowledge is. Moreover, the film material in the proposed course allowed the inclusion of a discussion prepared by the group itself about animal knowledge. Such responses have relevance because the teachers entered into a discursive interaction simply with exposure the ideas about science.

In this sense, the contributions from Schwartz and Lederman (2002) and Acevedo (2010) on the proposed Pedagogical Content Knowledge of the Nature of Science (PCK-NOS), are relevant because not only do we not have enough knowledge of the nature of science, but also other factors are important, such as knowledge of science content and level of teaching required needed to teach such a topic.

With respect to level of teaching required, this study contributes methodology to assist teachers. Namely, using film as a resource in appropriate settings provides what Acevedo (2010) called a necessary setting for students to learn about the nature of science. Film can assist students who are planning activities of scientific inquiry, and who want to understand the main characteristics of the nature of science. It can also help direct discussions on issues involving controversies surrounding science, promote dialogic argument, and contextualize the nature of science with appropriate examples and short narratives of the history and philosophy of science and techno-science.

Besides the changes mentioned regarding the nature of science, we understand that it is also necessary that teachers know how to use this theme in teaching and learning situations. Therefore we push for an inclusion of this issue in education, through preparing teaching and learning sequences (TLS).

For the preparation of TLS, we had discussions with the teachers regarding the implementation and validation of TLS. For this we use the work of Giordan and Guimarães (2011), in which there are theoretical and empirical elements that contributed to the construction of TLS that teachers then elaborated on.

Still using the concept of content analysis described by Bardin (2010), and also the contributions of Akerson and colleagues (2012) regarding NOS items and teaching practice, we analyzed a discussion with descriptive elements. Findings indicated that there was an increase in teachers' conceptions about the NOS-mediated insertion of audiovisual resources and supported using them in an in-service teacher educational program, similar to findings by Akerson and colleagues (2012).

Importantly, the items mentioned were used in the work of Akerson and colleagues (2012) jointly between quantitative and qualitative data, and two other items, Community of Practice (CoP) to support teaching and NOS concerns about teaching NOS. In this study, it will do not use these tools, but we will explore that data later.

In this paper it is used the same items, but not explicitly quantitative data. We also highlight that the work of employees and the Akerson and colleagues (2012) discussion occurs around different data than that obtained in this study, because their subjects were a group of teachers in training and with acceptable understanding of the nature of science. These aspects are not the same in our research because the teachers surveyed demonstrated not having an understanding of the nature of science, i.e., the subject still causes awkwardness.

It is presented below some parts of TLS developed by one of the groups, linking them with the items described above.

Subjects and Methodology			
Class	Specific objective	Subjects	Dynamics
1	<ul style="list-style-type: none"> - To investigate the role of the scientists in his scientific productions, questioning the factors that affect their development. - Individualistic and elitist science perception. It can only be done by geniuses. 	-Nature of Science	<ul style="list-style-type: none"> - Using a fragment of the movie "The Man from the Future" (4min to 8min/33s) as a visual resource, intending to discuss the "nature" of the scientist and his relationship with its sponsoring agency. - In the same fragment noted above, discuss the scientific method used by the scientist and his individualistic view.

Transcribed excerpt 1

The content presented in section 1 (transcribed excerpt 1) allows us to create a transcript of the change in NOS conception in the group of placement teachers, and allows us to question the stereotype of a scientist and the critical neutrality of science. A change in understanding of NOS is evident in this study, especially when compared to the data of the initial stage.

To achieve these goals, we intend to use audiovisual excerpts from The Man from the Future. It is important to make clear that the film was not produced to discuss the nature of science, but we appropriate this feature to highlight some relevant situations for teaching the nature of science. Since the goal of this TLS is to analyze the nature of science in this audiovisual product, some sections will be detailed below, highlighting the important points for teaching the nature of science.

Transcript Excerpt 2

The above (transcribed excerpt 2) shows that there is a benefit in using audiovisual teaching situations, so we grouped the items related to NOS teaching practice. The argument of non-intentionality of audiovisual to address NOS teaching practices in the U.S. requires us to find situations that give relevance and context to the NOS. Thus we outline three topics we cover in the course: discussions about the nature of science, limits of using this medium, and importance of audiovisual teaching NOS.

Fragment	Beginning	End	Objective
1	4min	5min 20s	Highlight scientist's ideas on individualistic and elitist views.
2	6min	8min 30s	(a) Highlight the ideas of empirical-inductivist conception
			(b) Highlight the individualistic and elitist view of the researcher
			(c) Highlight the stereotype of scientists.
3	8 min 30s	13min 10s	Relationship among science, technology, society, and to show the rigid view of science.



Scene 2 (a) – Science inferences by scientist



scene 2 (b) – Time context and elitist view of scientist

Figure 4: Selection developed by teachers from the film: The Man from the Future.

In category 2 (a) it is important to highlight the areas of empirical conception. Distorted views of science are directly related to the interests of the researcher and his or her research, even if it is believed that their interests do not interfere with their intentions. Instead it is evident that the interests of the scientist guide scientific research. Also, it is important to note that this falls under the role of development agency, which supports the work of scientists, and acknowledges they have specific interests to be observed and studied.

In section 2 (b), during the dialogue between the two characters, Sandra (project financing) and Zero (scientist), they describe Zero as the only one in the world who had a project related to particle accelerators that magnitude. The time this film was produced coincides with when the Large Hadrons Collider (LHC) was activated, which caused great concern, because there was a fear that such an experiment would create black holes that would destroy the world. From this similarity, it is evident that the interests of each era shape the social interest, therefore, the interest of scientists.

Transcript Excerpt 3: images and comments made by the group of teachers

The descriptions and selected images (transcribed excerpt 3) highlight a clear positioning of the group of teachers about the nature of science, specifically in the passage: *“It is evident that the interests of each time shape the social interest, therefore, the interest of scientists”*.

In this sense, was identified a questioning by teachers concerning the scientific objectivity; this aspect was probably related to the discussions around the films and also the reflections around some ideas of epistemology of science. In this case, contributions from Kuhn (2001), about the subjectivity and the historical and sociological aspects of science, may have influenced these teachers in the preparation stage of this teaching and learning sequence.

It was still found a concern while hearing the teachers reflect and infer scientific activity. It is likely these aspects are introduced in their classes, especially sentences like: *“From this analysis, we can discuss with the students, and it is important to emphasize to the students that this view is too extreme, and that science should be open.”*

In developing this material with intentions of practice, teachers could mobilize knowledge, by, for example, watching movies that were not used in the course, as *The Man from Future*, so that selected passages relevant to discussion of NOS can be used with students. Such discussions include concerns found in the works of Gil-Perez and collaborators (2001) about the distorted views of scientific activity, like those discussed in the classes.

Conclusions

It was presented a contribution to highlight the importance of integrating the nature of science into natural science education. Reinforce what they also point out that not just a good knowledge about the nature of science, because you also need an awareness of the topic and developing methodological proposals that subsidize teacher’s practices.

In this sense, it was developed the idea of methodological support for addressing the nature of science, such proposal is to use the resources of audiovisual, because as these are embedded in a cultural matrix, carry meanings that correspond to the desires of a particular group. However, teachers decode and find out potential for their use in certain contexts adjusting degrees of complexity in the matter.

Such action is not an easy task considering the various powers delegated to teachers, it is therefore elaborate training proposals that consider all these situations.

So in this analysis it is intended to demonstrate the use of films in a process of an in-service science teacher educational program, it was emphasized that the data presented are still preliminary, because the program is in progress, so other interventions are being applied. However it is possible to draw some conclusions based on some results, such as: teachers still have a stereotypical view of science, but at the same time begin to realize another aspect of science as demonstrated above.

It is understood that changes are still preliminary, because it is an early work and located, however the proposal to find potential in the film and discuss with teachers in depth can help inserting them into a dialogical action situations with reflection. This is important because while open space to raise awareness and understand what is science and what is ultimately important in the teaching and learning of science.

References

- Acevedo, J. A. (2010). Formación Del Profesorado de Ciências Y Enseñanza de La Natureza de La Ciência. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, 7 (3), 653-660.
- Acevedo, J. A. (2009). Conocimiento Didáctico Del Contenido para La Enseñanza de La Natureza de La Ciência (II) Uma Perspectiva. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, 6 (2), 164-189.
- Akerson, V. L., Donnelly, L. A., Riggs, M. L., & Eastwood, J. L. (2012). Developing a Community of Practice to Support Preservice Elementary Teachers' Nature of Science Instruction. *International Journal of Science Education*, 34 (9) 1371-1392.
- Almeida, M. J. (1994). *Imagens e Sons: a nova cultura oral*, Editora Cortez, p. 22-39.
- Arroio, A. (2010). Context based learning: a role for cinema in science education. *Science Education International*, 21 (3), 131-143.
- Arroio, A., & Farias, D. (2011). Possible contributions of Cinema in Natural Science Education to understand how scientists and Science Works. *Problems of Education in the 21st Century*, 37, 18-28.
- Bardin, L. (2010). *Análise de Conteúdo*, 5ª edição. Lisboa, Portugal: Edições 70, 281p.
- Bell, R., Lederman, N. G., & Abd-el-Khalick, F. (1998). Developing and Acting upon One's Conception of Science: The Reality of Teacher Preparation. *Journal of Research in Science Teaching*, 37, 563-581.
- Brasil, Secretaria de Educação Fundamental (1998). *Parâmetros Curriculares Nacionais*. Brasília.
- Chalmers, A. F. (2001). *O que é ciência afinal?* 5ª edição. São Paulo, Editora Brasiliense, p.62.
- Denzin, N. K., & Lincoln, Y. S. (2006). *O Planejamento da Pesquisa Qualitativa Teorias e Abordagens*, 2ª edição, Editora Artmed, Porto Alegre.
- Fischer, R. M. B. (2001). Foucault e a Análise do Discurso em Educação. *Cadernos de Pesquisa*, 11 (4), 197-223, 2001.
- Foucault, M. (2009). *A Arqueologia do Saber*. 7ª edição, Editora Forense Universitária, Rio de Janeiro.
- Gil-Pérez, D., Montoro, I. F., Alís, J. C., Cachapuz, A., & Praia, J. (2001). Para Uma Imagem Não Deformada do Trabalho Científico. *Revista Ciência & Educação*, 7 (2), 125-153.
- Guimarães, Y. A. F., & Giordan, M. (2011). Instrumento para construção e validação de sequências didáticas em um curso a distância de formação continuada de professores. In: *VIII Encontro Nacional de Pesquisa em Educação em Ciências*. Campinas.
- Harres, J. B. S. (1998). Uma Revisão de Pesquisas nas Concepções de Professores Sobre a Natureza da Ciência e Suas Implicações para o Ensino. *Investigações em Ensino de Ciências*, 4 (3), 197-211.
- Martin, M. (1990). As características fundamentais da imagem fílmica. In: *Martin, M. A linguagem cinematográfica*. São Paulo: Brasiliense, p. 21-29.
- Matthews, M. R. (1995). História, Filosofia e Ensino de Ciências: A Tendência Atual de Reaproximação, *Caderno Catarinense de Ensino de Física*, 12 (3), 164-214.
- Morin, E. (2002). *Ciência com Consciência*, 6ª edição, Rio de Janeiro, Editora: Bertrand Brasil.
- Navarrete, E. (2008). O cinema como fonte histórica: diferentes perspectivas teórico-metodológicas. *Revista Urutáguá*, 16.
- Rezende, A. L. (2008). História das Ciências no Ensino de Ciências: contribuições dos recursos audiovisuais. *Ciência em Tela*, 1 (2), 1-8.
- Santana, E. R., & Arroio, A. (2012). A abordagem da natureza da ciência no cinema na formação continuada de professores. In: *XVI Encontro Nacional de Ensino de Química/X Encontro de Educação Química da Bahia*. Salvador Bahia.
- Santana, E. R., & Arroio, A. (2012). O cinema e a natureza da Ciência: relações possíveis para o ensino de Ciências. In: *Castellar, S. M. V; Munhos, G. B.(org.), Conhecimentos escolares e caminhos metodológicos*. 1 ed. São Paulo; Xamã Editora, p.171-184.

- Santana, E. R., & Arroio, A. (2009). The History do Science in the Report of the Teachers of Sciences. *Revista de Educacion en Ciências, 10*, 171.
- Santana, E. R. (2009). Relatos dos professores de ciências sobre a natureza da ciência e sua relação com a história e a filosofia da ciência - SP, São Paulo, *Faculdade de Educação da Universidade de São Paulo – USP*. (Master dissertation).
- Schwartz, R. S., & Lederman, N. G. (2002). “It’s the nature of beast”: the influence of knowledge and intentions on learning and teaching of nature of science. *Journal of Research in Science Teaching, 39* (3), 205-236.
- Vazquez-Alonso, A., Manassero-Mas, M. A., Acevedo, J. A., & Acevedo, P. (2008). Consensos sobre a natureza da ciência: a ciência e a tecnologia na sociedade. *Química Nova na Escola, 27*, 34-49.
- Wertsch, J. V. (1999). *La mente em acción*. 1ª edição. Argentina: Aique Editora. 304p.

Advised by Vincentas Lamanauskas, University of Siauliai, Lithuania

Received: *October 20, 2012*

Accepted: *December 12, 2012*

Edson Rodrigues Santana	Doctoral student in Science Education, Faculty of Education, University of São Paulo, São Paulo, Brazil. E-mail: edsonrodriguessantana@hotmail.com
Agnaldo Arroio	PhD, Associate Professor, Faculty of Education, University of São Paulo, São Paulo, Brazil. E-mail: agnaldoarroio@yahoo.com Website: http://usp-br.academia.edu/AgnaldoArroio