

# POSSIBLE CONTRIBUTIONS OF CINEMA IN NATURAL SCIENCE EDUCATION TO UNDERSTAND HOW SCIENTISTS AND SCIENCE WORKS

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## Abstract

*It is presented some considerations related to the role of cinema to introduce and contextualize issues as the image of science and scientists and how science works. Cinema can be used as an important tool in science teacher training or education because it lets to establish connections between two relevant aspects in natural science classrooms: the emotional component that allows the audience to establish a relation with the characters of scientific stories (Arroio, 2010) and the historical-philosophical-sociological component which contributes to show a more real image of science in school. Cinema can help to show the presence of different influences in science as the importance of contexts, and to discuss about the presence of some stereotypes, and an idealized image of individual-male scientific work, a neutral science, the meaning of discovery among others. Some movies were analyzed to establish this possible contribution. In further, according to these results it is possible to compare some important elements of scientific discourse presented in cinema and this one in science school textbooks.*

**Key words:** *cinema, natural science education, science and scientist image, scientific speech.*

## Introduction

According to the literature it is well known that many science teachers have some misunderstandings related to the nature of science (Abd-El-Khalick and BouJaoude, 1997; Akerson and Abd-El-Khalick, 2003; Bell, Blair, Crawford and Lederman, 2003; Blanco and Niaz 1998; Clough, 2006; Lederman, 1992; Mellado, Ruíz, Bermejo and Jiménez, 2006; Pomeroy, 1993; Yip, 2006) and these views of nature of science are quite similar to the student's views (Blanco and Niaz, 1998; Murcia and Schibeci, 1999), as it was showed by Niaz (2009) who explain it considering some features such the empiricism and the positivism perspective presented in natural science textbooks and school curricula for science courses.

Yip (2006) pointed that these misconceptions lead science teachers to teach focused on scientific concepts and scientific facts, perpetuating these misunderstandings related to nature of science, methods of scientific research, power of science and the limitations of science. These are important reasons for one of the scientific research fields in nature of science to focus on assessment of, and attempts to improve teachers' conceptions of the nature of science. And

establish some parameters that allow these teachers to have a better understand of nature of science and how the science works when attending teacher's educational programs.

A strategy which has been used to improve the understanding of nature of science is the usage of videos, comics and other mass media in general. Between these media the cinema has been so popular as an educational tool to teach this issue.

Cinema can be an important tool since as Tanis and Seroglou (2011) suggest most of the bad image that teachers and the general public have concerning the nature of science comes from the image conveyed by the mass media, by what is interesting to use these resources to reflect in the classroom or in teacher education programs about the different elements of the nature of science.

Depending on the films that have been used it could be associated with the use of some elements of history and philosophy of science (Abd-El-Khalick and Lederman, 2000) and historical-case events as a vehicle to illustrate the process of development of scientific ideas (Dawkins and Glatthorn, 1998; Koulaidis and Ogborn, 1995; Niaz, 2009).

Previous experiences in this area have been developed by various researchers and with different objectives, not just in the science classroom but also in teacher educational programs: to motivate the science learning, to identify elements of science and pseudo-science, strengthen the images of how science works and how they have been proved best known theories by using scientific methodologies, to discuss the scientific events that have been influenced the culture, etc. Discuss about myths, legends, scientific interpretations and about the relationships between the science and art, to help students thinking differently concerning the relationship between the science and culture. Also to acquire a better understanding of the nature of science and to acknowledge the potential role of science in the management of the society (Tanis and Seroglou, 2011), covering some key ideas on the nature of science: scientific methodology, theory change, scientific inference and explanation, values, gender issue, the meaning of discovering and inventing or scientific models, critically revise the images of science and scientists that are constructed in society, in scientific, historical, and popular literature, in mass media, and at school (Adúriz and Izquierdo, 2009).

However, although the use of films is taking advantage of a historical episode which is articulated about the meta-analytical framework with a strong epistemological nature in order to analyze the nature of science, it is also possible to use film to connect teachers and students with the emotional component of the nature of science, one relevant aspect when taking into account as stated by Tanis and Seroglou (2011) that the learning of sciences can be improved upon when they are added senses and emotions to the phenomena being studied.

Arroio (2010) has pointed that the audience can interact with the characters and share their emotions and actions showed in an audiovisual setting thus evidence the potential of audiovisual, scientific and common languages to be used as a tool to mediating science teaching and learning. In this work, we intend to introduce an additional component to the above mentioned: historical, epistemological, emotional and subjective by showing how the use of the cinema may contribute from a sociological perspective to understanding the nature of science.

It is intended the sociological approach since it has been largely absent from science education research even to be considered risky for science education by some researchers that has been associated with the post-modernism, relativism and radical socioconstructivist (Cobern, 1995 and 2000; Irzik and Irzik, 2002, Izquierdo 1996, Izquierdo and Aduriz-Bravo, 2003; Kragh, 1998, Nola, 2000; Phillips, 1997; Slezak, 1994b; Solbes and Traver, 2003). Additionally, the interest in the sociology of science falls upon the fact that given the apparent overvaluation of epistemology in science, often juxtaposed to alienate the sociological aspects, vision of science policy in the descriptive perspective, the "how should work science " from " how the science actually works "(Zemplén 2009), so that the sociology of science, and the dissemination of scientific activities by the mass media are to place themselves within the same field of which it may be regarded as from outside science concepts.

## Methodology of Research

The conceptual framework used in this work was designed by Farías and Castelló (2011) in the analysis of sixty chemistry textbooks published in Spain since the mid-nineteenth century until 2010. This framework is based on the science circulation model of science proposed by Bruno Latour (2001). This French sociologist points out that scientific activity can be understood as a complex network which connects different nodes, representing the relationship between five categories of elements:

1. Mobilization of the world regards the participation of the instruments, laboratories, equipment, experiments and places for the production of science.
2. Autonomization: it refers to the participation of associations, institutions, and other disciplinary groups that account for how scientists are connected scientists around common themes.
3. Alliances: the relationship of any kind of scientific funding, sponsors, scientific support, political support and so on, to facilitate the conduct of scientific activities.
4. Public Representation, which refers to how scientists leave academic circles and become involved with the public in order to publicize their work.
5. Latour finally gives the most important role a fifth category called “nodes or links,” the concepts, theories, laws, hypotheses, constants, formulas, principles, equations and models that are set by the scientists to articulate their explanation of natural world and about which move the four categories above.

In this work it is considered that human and non human are part of such complex network also, and we assume non-humans are entities in the material world, which emerge as product of science and whose identity is referred to the practice and the relationships which are able to establish.

In this sense three films were analyzed according to Arroio (2011) (the respective data sheets are presented in Annex 1) which refers to the scientific activity:

1. Fat man and little boy (1989)
2. A beautiful mind (2001)
3. Contact (1997)

In each film was analyzed considering the categories of the framework based on the attributes listed in Table 1.

**Table 1. Categories and attributes to determine how science circulates.**

Category	Attributes
Mobilization	Instruments, laboratories, equipment, instruments, places
Autonomization	Associations, institutions, disciplinary groups
Alliances	Funding, sponsors, scientific support, political support, other support
Public representation	Relations with the lay public
Links	Concepts, theories, laws, hypotheses, constants, formulas, principles, models
Non-humans	Bodies of the material world defined by the practice of science and its relations with other nodes
Humans	Scientists, philosophers, poets, politicians ...

## Results of Research

Table 2 presents the general observations about the presence of each of the seven categories of this framework in the three films analyzed.

**Table 2. Overall results of the analysis of the three films, grouped by categories.**

	<b>Fat man and little boy</b>	<b>A beautiful mind</b>	<b>Contact</b>
Mobilization	There is a strong presence of equipment and laboratory instruments. Science is shown displaced from a central location and it is possible to see how it moves between universities, laboratories and an isolated place in Los Alamos, New Mexico where the facilities are to develop the bomb.	Constant reference is made to the places where scientific knowledge originates: eg Harvard, Princeton. It appears the Pentagon as a place associated with the scientific activity.	Equipment and laboratories appear and decentralized science major research universities in remote places like New Mexico.
Autonomization	Universities appear and play a central role, it is relevant also the image of working groups and scientific discussion.	Universities also appear it is relevant the role of groups of scientists to recognize the work and careers of their colleagues.	A state agency is mentioned continuously as responsible for the study of intelligent life beyond Earth.
Alliances	It is mentioned repeatedly how the U.S. government has invested in the project and how the scientist's has to end it according to a strict schedule established by the sponsor.	It shows how the support of colleagues and teachers can promote the movement of scientists between different levels of academic organization.	It is essential the presence of a corporation which begin to finance the project when the government stopped funding it. It is showed the process of how Dr. Arroway should seek this funding.
Public representation	Do not displayed	Do not displayed	It shows the presence of scientists in the public sphere through the media, appearing at press conferences.
Links	Referred of concepts around which rotates one of the axes of the plot, gain control of the implosion conditions ensure the success of the project.	Referred to the concepts that take the intellectual work of John Nash and how they relate to fields that have been applied.	Referred to some concepts but do not play a major role in the story.
Non-humans	The bomb, a non-human, built by the scientific work is central to the plot of the film.	Not mentioned.	Vega the planet discovered by the scientists' work is one of the central elements of the story.

	<b>Fat man and little boy</b>	<b>A beautiful mind</b>	<b>Contact</b>
Humans	Physicists working collectively appear, highlights the importance of this work and highlights the image of characters like geniuses. Appear different from other humans, scientists show their relationships with military, family, friends.	Appear central figure is John Nash as a genius, which could even understand that it has a kind of "super powers", although to a lesser extent appreciates the importance of collective work. Different characters are some mathematicians, but is central to the role of Nash's wife.	It shows the importance of scientific work in small groups (the research of Dr. Arroway) and the common space to develop the project. Besides giving scientists an important role to others as political or religious leaders that are related to scientific work.

There are different aspects to be highlighted from the results of our analysis. Initially it is important to see how at Fat man and little boy and Contact made a wide array of laboratories, equipment and instruments with which science takes place, are common close-ups of the equipments and it is clear how in the three films can be seen three different types of science: a manual job (Fat Man and Little Boy), a computer systems that receive information from large equipment and other more theoretical. So through the elements of the first category is possible to evidence, when it comes, to show how science is associate with a type of activity focused on the laboratory and experimental work, we do an oversimplification of the wide variety of ways involving the scientific work.

So also is important to notice with regard to the category of science mobilization of these three films is developed in the U.S., widely recognized universities, but also in New Mexico (two of the movies), which may be an interesting issue to analyzing post-colonial perspectives and transmitting a simplified image of science is done in one place (USA), with considerable potential for the work of these topics with teachers and students.

In reviewing the category 2, it is important to notice how scientific associations do not appear and it is delegated the entire role of communication and the establishment of consolidated knowledge to universities and especially those expertise workgroups and small. In Contact is essential to appreciate how scientific work can be performed in governmental institutions but also how it can be detached from them as far as the funding comes from external agents to them. In all three films is clear the role played by peers to validate one's findings thus convey ideas regarding the scientific activity of the widely far idealized with scientific genius working alone. It is also important to consider multiple perspectives from which universities can be seen not only important in teaching and training future generations of scientists but also as epicenters of discussion, engines of social dynamics related to academic or external institutions that have products for external project manager to them.

One aspect that is highly important in the films is the presence of funding, which is the axis of the three stories, the close relationship between scientists and agents "outside" that are essential to complete different projects. Governmental agencies, the U.S. military, a billionaire sponsor, are showing, especially in Fat Man and Little Boy and essential in Contact the presence of economic support in the activities that the Working Group of Oppenheimer and Dr. Arroway do. It is also possible to appreciate how these sources of support are essential not only to provide the resources for research but also to mark the agendas and objectives of the work of scientists. On the other hand in A Beautiful Mind is possible to appreciate a different type of support, scientific, exemplified in the way they move certain mechanisms for promotion and advancement within the academic communities.

In relation to the main public representation of science is best exemplified in Contact, this film is clear how after a significant scientific discovery occurs, it leaves the realm of the

public through the media communication, how scientists until recently confined to the screens of their computers in New Mexico facilities are common players in press conferences, letting know of their findings. Comparing the three films is important as a discussion of the existence of scientific activities that do not require confidentiality to be represented publicly, which is a new opportunity to show the complexity and particularities of the various scientific activities.

For Latour, the links are the most important actors of scientific activities as they bring together the other elements, this author does this emphasis to the possibility of staying in the “external” factors to science and forget about what really constitutes it (Latour, 2001). And it is possible to see how the films analyzed in these two scenarios are presented one in which the concepts are put aside to focus more on other perspectives such as in *Contact*, where the concepts appear outside the central theme and on the other cases of *Fat Man and Little Boy* and *Beautiful Mind* where the chain reaction, the implosion, the critical mass, the spatial topology, regular dynamics and other concepts of science continues to show as well as trying to deal with military patrons, colleagues, etc.. revolves around the laws, principles, theories, models, etc.

When analyzing the presence of non-humans in the three films are possible to see two different dimensions of scientific activities with respect to them. Initially one in which science is responsible for producing the atomic bomb is the end product of the work of Oppenheimer and his group, the money spent by the U.S. government, the general management aspirations and Grooves, of controlling the critical mass, the reaction of plutonium, and so on. Furthermore Vega is not a product made by science but the result of observing astronomers in New Mexico, Vega has not been built has been found thanks to the immense power of the antenna equipment, telescope, software, making it possible to know more widely.

Finally, *Beautiful mind* it is possible to see how work moves away from mathematical and scientific work is an interesting topic of discussion with teachers and students about how the search for regularities and theoretical models can contribute from a different perspective to understanding the phenomena of nature without having to rely on the experiments.

When analyzing the role of humans in the three films is important to appreciate how scientists appear not only, but in the scientific activity involving military, political, business, among many others. The role of general Grooves *Fat man* and *little boy* clearly states that the participation of these humans ‘external’ of scientific work may be crucial in the work of scientists. On the other hand the possibility of understanding the work of these three scientists: Robert Oppenheimer, John Nash and Ellie Arroway, as part of their personal lives provides an important emotional connection with the viewer. The image of an alone scientist working in his laboratory enclosed weakens the possibility of seeing human scientists as hobbies, personal and ethical conflicts, love, and so on. Even in the case of John Nash who is represented as a genius, it is possible to show his more human not only through his illness but also his obsession and the struggle for recognition.

## Discussion

When comparing the results of analysis of these elements in the film (Table 2) with science textbooks (Table 3) is possible to appreciate significant differences between the way scientific work is presented in school and in the media (in this case film) and may consider some of the relationships which can be established between these two areas.



**Table 3. Aspects that characterize the different categories which describe how science circulates in textbooks**

Category	Description
Mobilization	It appears few laboratories, instruments and equipments, their images in most cases are obsolete. Science appears delocalized usually do not appear where it usually performs.
Autonomization	The autonomy is limited to the role of scientific disciplines, are not mentioned institutions, groups or scientific disciplinary.
Alliances	Not mentioned in textbooks
Public representation	However their connection with other elements of scientific activities is very poor and scientists are widely idealized.
Links	They are the most important actors in textbooks, more than half of the elements that describe the science textbooks are in this category.
Non-humans	Are strongly linked to the links and in many cases not related to humans that produce or study. His role is very important in textbooks.
Humans	Have appeared in textbooks, there is even a tendency to be working collectively. However, appear little connect of the other elements of scientific activities and are widely idealized.

Farías and Castelló (2011) states that school science, as reflected in textbooks is still attached to schemes derived from empiricism and positivism, so that focuses on the concepts, the other elements of science are broadly ignored, school science transmits images of what is science and what scientists do, which were established since the nineteenth century and which remain unaffected. Scientists in the textbooks, as well as experiments and discoveries are idealized. The science that appears in textbooks was “sanitized” of any hint of “influences” and “external factors” to science and built around the theories, laws, models, etc., Leaving out everything else, unfortunately in some cases may include instruments, laboratories, institutions and scientists themselves.

If it is compared this image of sciences with which transmitted by the mass media such as cinema, it is possible to understand that school science is far wide of science represented publicly in the media, as if we were talking about two different sciences. This conflict can be constituted in not just for students but also teachers themselves, faced with two conflicting images of science is and what scientists do. At school we learn that science is the concepts and the way they are set based on laws, theories, etc. are studied some aspects of the lives of scientists, reported as genius, single, successful, almost non-human. In the cinema students see that science is not just concepts but there are complex processes, stories that the textbook does not provide and meet with scientists in conflict, they can even identify.

Faced with this dichotomized scenario, one centered on the concepts and left out everything else and one that decentralized the account of the cognitive and contextual relevance to what provides to the contingent and the emotional, we can only go for a complementary needed between the two for school. The elements we have seen through the textbooks that are not part of school science can be brought into the classroom via the cinema. School science can no longer focus only on the concepts if we want scientific literacy and the formation of scientifically informed citizens depart the field of education, because the message is being conveyed by the school about the scientific activity not only obsolete but that does not reflect a science that can be attractive for future generations of scientists who claim today’s societies.

Also, school science can through complementarity with other perspectives, like the cinema to show the complexity and diversity of the different activities carried out by scientists today.

In this sense, cinema is a very important tool to provide examples to bring to the classroom, both for students and the teachers in educational programs, should be discussed issues such as gender, neutrality, objectivity, method and so on. While the possibility of stronger emotional connections between students and science in context and by people with emotional conflicts, ethical, professional, etc.

However, it must point out that the use of cinema in the classroom as a tool to discuss these topics and to convey a different image of science and what scientists should do from a careful selection of materials used and the orientation of the discussions and the use of these, as the stereotypical images of scientists and science may also be present in many films. However, it believes that the conceptual framework used is a good contribution to discuss the films in the light of what the sociology of science can contribute to the discussion of scientific work from the history and epistemology, making it an important contribution by this work, since until now, as noted in the introduction to the priority given to the historical use or philosophical and leaving the potential contributions from sociology of science to science education aside.

## Conclusions

An important aspect related NOS' understandings is the image of science for students, the most present stereotype is the scientific method, some researchers have shown their views about the scientific method is a sequence of steps previously organized and there is no space for imagination and creativity, the main reason is if you follow the method you will find the true scientifically correct. According to these results, we can use these films to discuss the sociological aspect of nature of science, which is not just a scientific method.

The identification process with the scenario, character, scene, dialogues is important to place the scientific content in a larger context and establish easy connections with the community outside school and to arrange the teaching situations. Learning the results and methods of scientific research will not in itself help students make better lives for themselves. We must all learn to understand *how* science and science education *can* help us help ourselves.

Cinema can provide contexts which focus on scientific issues that should engage students into some elements of nature of science. Where films catch student's attention they provide different point of view, providing the teacher with an interesting possibility to discuss the understandings of nature of science. This environment provides a kind way of talking about the social context and the scientific knowledge related. These films show that learning science involves social interactions, discussing about how science works explicitly issues supported by audiovisual context seem to be an important possibility to mediate process of making-meaning on the science classroom.

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## Annex 1

Technical specifications (IMDb -2011) IMDB - The internet movie database.

### 1. Fat Man and Little Boy (1989)

Director: Roland Joffé

Stars: Paul Newman as General Leslie R. Groves and Dwight Schultz as J. Robert Oppenheimer.

Storyline: In real life, Robert Oppenheimer was the scientific head of the Manhattan Project, the secret wartime project in New Mexico where the first atomic bombs were designed and built. General Leslie Groves was in overall command of it. This film reenacts the project with an emphasis on their relationship.

A beautiful mind (2001)

Director: Ron Howard

Stars: Russell Crowe as John Nash, Ed Harris as Parcher and Jennifer Connelly as Alice Nash.

Storyline: Biopic of the famed mathematician John Nash and his lifelong struggles with his mental health. Nash enrolled as a graduate student at Princeton in 1948 and almost immediately stood out as an odd duck. He devoted himself to finding something unique, a mathematical theorem that would be completely original. He kept to himself for the most part and while he went out for drinks with other students, he spends a lot of time with his roommate, Charles, who eventually becomes his best friend. John is soon a professor at MIT where he meets and eventually married a graduate student, Alicia. Over time however John begins to lose his grip on reality, eventually being institutionalized diagnosed with schizophrenia. As the depths of his imaginary world are revealed, Nash withdraws from society and it's not until the 1970s that he makes his first foray back into the world of academics, gradually returning to research and teaching. In 1994, John Nash was awarded the Nobel Prize in Economics.

Contact (1997)

Director: Robert Zemeckis

Stars: Jodie Foster as Matthew McConaughey as Palmer Joss and Tom Skeritt as David Drumlin  
Storyline: Astronomer Dr. Ellie Arroway has long been interested in contact to faraway lands, a love fostered in her childhood by her father, Ted Arroway, who passed away when she was nine years old leaving her then orphaned. Her current work in monitoring for extraterrestrial life is based on that love and is in part an homage to her father. Ever since funding from the National Science Foundation (NSF) was pulled on her work, which is referred to some, including her NSF superior David Drumlin, as more science fiction than science, Ellie, with a few of her rogue scientist colleagues, have looked for funding from where ever they could get it to continue their work. When Ellie and her colleagues hear chatter originating from the vicinity of the star Vega, Ellie feels vindicated. But that vindication is short lived when others, including politicians, the military, religious leaders and other scientists such as Drumlin.

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