Science Education International
Vol.21, No.3, September 2010, 131-143

International Council of Associations for Science Education

Context based learning: A role for cinema in science education

Agnaldo Arroio
University of São Paulo, Brazil

Abstract
This paper discusses the role of cinema as a tool for science education. Based on the socio-cultural approach put forward by Vygotsky, it draws attention to the fact that an audience can interact with the characters and share their emotions and actions showed in an audiovisual setting. Experiences come from an interaction with a learning environment and personal construction of knowledge occurs through the interaction between the individual´s knowledge schemes and his or her experiences with the environment. In this way, movies are analysed by considering the potential of audiovisual, scientific and common languages to be used as a tool to mediating science teaching and learning. Audiovisual language shows itself as a valuable possibility to facilitate knowledge construction. This occurs because of the integration of an individual's reality with the surrounding environment, which develops, in the student, the sensitivity and perception of the setting.

Keywords: *Audiovisual, context based, teacher's formation, ICT, interdisciplinarity, Innovation.*

Introduction

We live in a period of very rapid growth in scientific knowledge, much of which is quickly utilized in the creation of new technology. Science and technology are today the greatest factors in changing the way we live. They have also made the world very small, so that we no longer live in the confined world of our town, region, or country isolated from what is happening in the rest of the globe (Härnqvist and Burgen, 1997).

Science education plays a very important role in broadening students' world outlook. The science classes always discuss real, concrete things and phenomena, which are a part of students' reality and even everyday life (Lamanauskas, 2003). An important task of science education is making science more relevant to students, more easily learned and remembered, and more reflective of the actual practice of science. It is suggested that students need to develop and/or improve skills in dealing with controversial issues as they prepare to participate in a democratic society. In contemporary democratic societies, lay citizens need to understand the nature of scientific knowledge and practice, in order to participate effectively in policy

decisions, and to interpret the meaning of new scientific claims which affect their lives (Sandoval, 2005). Science educators thus seem to agree that relevant, real-life, contexts are important when teaching for scientific literacy (Mork and Jorde, 2004).

According to recent research in science education, teachers have conceptions, attitudes and actions related to science teaching supported by a lengthy environmental training period in which they were students (Hewson and Hewson, 1988). It means that there is a relevant influence of this incidental training that reiterates experiences acquired in a non-reflexive manner as something natural, thus escaping criticism. If some knowledge of science is accepted as part of the education of every student, there is a need to think how best to provide that education (Lemke, 1990). It is therefore important to think of education systemic term, not limiting the student's experiences to what can possibly take place in the classroom. The role of alternative learning environments becomes critical as a prelude, a complement a follow-up to the school-based learning process. Experiences come from interaction with a learning environment.

As Holbrook (2010) point out:

> *Education cannot be developed in a vacuum. It needs a context and this context, inevitably in science lessons, involves science content and science conceptual learning. Thus, although science content need not be specified and may be related to a contemporary context, science lessons utilise the acquisition of scientific ideas to aspire to playing their major role in the development of students through an appropriate context.*

The Socio-Cultural Approach

According to Lemke (2001) it is a falsification of the nature of science to teach concepts outside of their social, economic, historical, and technological context. Concepts taught in this way are relatively useless in life, however well they may seem to be understood. Science and science education are always a part of larger communities and their cultures, including the sense in which they take in social and cultural conflicts that extend far beyond the classroom. In a socio-cultural approach, learning involves being introduced to a symbolic world. Knowledge and understandings including scientific understandings are constructed when individuals engage socially in talks and activities about shared problems or tasks (Driver et all., 1994).

The socio-cultural approach takes into account, in general, that the construction of knowledge as a social process, where social transactions and discourse are considered to be the basis for any subsequent learning. Representations of knowledge are viewed as patterned by social and cultural circumstances. This view accentuates the social and cultural genesis and appropriation of knowledge (Billet, 1996). Learning is considered as an appropriation of socially derived forms of knowledge. Appropriation is not restricted to the internalization of externally derived stimuli. It consists of a

transformational and reciprocal constructive process and results to a co-construction process.

Vygotsky (1978) suggested that the language mediates the cultural transmission process of knowledge acquired by humanity. Without the language, it is almost impossible that teacher's words make sense for the students. Knowledge can only be learned through some process of social transmission (Leach and Scott, 2003). The process of internalization is how students reorganize and reconstruct talks and activities from the social plane of classroom. It seems that not involve direct transfer of the discourse from the step involving personal interpretation where the individual comes to a personal understanding of ideas encountered at the social plane (Mork and Jorde, 2004).

It seems that students are not able to learn science on their own without guidance from other persons or cultural tools. The term zone of proximal development (ZPD) was introduced by Vygotsky (1978) to explain as the distance between what a person can do by himself, without support from others, and what this person can do with support from others or more skilled one. On this way, we consider that this kind of support could be done by other cultural tools like books, ICT and in this case by a movie.

The main reason for adopting a socio-cultural perspective as a theoretical framework of analysis was our focus on understanding the relationship between communication, learning and the socio-cultural context. Because in different contexts humans learn in different ways, then individual tend to learn through communication rather than discovery.

The language in the socio-cultural approach is considered extremely relevant in socially negotiating and meaning making. The widening interest in situated learning resides in the belief that learning is more closely linked to the circumstances of its acquisition, and that these circumstances influence the transfer of knowledge to other situations. These beliefs call for a close consideration of contributions of socio-cultural approach to understand the role of social interactions in shaping meaning making and the complexities of the situated knowledge on the classroom.

It is fundamental that the teacher investigates what are the situations that could create interest and how it can be worked and articulated to the scientific topics, because it becomes a convincing act by showing to the students other ways to dialogue concerning reality. Personal construction of knowledge occurs through the interaction between the individual´s knowledge schemes and his or her experiences with the environment. Science education must encourage the development of creative thinking (Laius and Rannikmäe, 2005).

Science teaching can be conceptualized in terms of introducing learner to one form of the social language of science. A distinction can be drawn between the everyday social language and the scientific school language. The science, which is taught in school, is a simplification of real science and for example takes into consideration the age of the students. According to Leach and Scott (2000) the concept of learning demands to describe the differences between the scientific school language and the

social language, which the student brings to the classroom (Sormunen and Saari, 2006).

Knowledge is stored in various discourses, linguistic contexts and acquires meaning and significance only in these contexts. Marková (1996) describes this connection as different social realities provide different experiences. As well, it leads to different ways of seeing the world and consequently leads to different beliefs concerning our comprehension of the world. So, words and terms which are used acquire meaning in the contexts where they are used. The relevant perspective within a sector is decisive for how a question, a problem, a statement is to be interpreted, what is interesting, pertinent an objective.

According to Schoultz and Hultman (2004), learning and development become ways to learn and they have been developed in a special culture. In this perspective, science can be viewed as a specific culture or indeed a group of sub-cultures, which have developed over a long period of time. Learning science is related to participating in activities, which offer a scientific way of thinking and acting. But this is not easy and perhaps not even possible in a traditional school context because it is expected that students must cross over certain discursive and linguistic borders.

A scientific discourse contextualizes reality in a way which differs from a more everyday way of reasoning and the essential meaning of words and terms. So the distance between the everyday world and the scientific world of the traditional school is often so great that it seems impossible for student to benefit from the teaching (Jakobsson, 2001). Säljö (1996) indicates that language use and the construction of meaning are always social processes, dependent on people who interact. Meaning is always relative to options and constraints that are present in social situations. Learning science means learning to control the use of scientific language. In this way, it is important to use this specialized conceptual language in reading, writing, problem solving and guiding practical action in the laboratory and also in daily life.

The Role of Cinema

This paper discusses the role of cinema as a tool for science education. By presenting a movie, not only the content is transmitted, but experiences of all kinds: emotions, feelings, attitudes, actions, knowledge, etc., as the cultural acquisition can give to individual symbolic systems of reality´s representation (Arroio, 2007a). Movies create trends and have a broader impact on students than any other media. Besides movies are able to create interest in scientific themes (Serra and Arroio, 2008).

On several occasions the possibilities of cinema and television as teaching instruments have been overestimated. It was thought, for instance, that the teacher could be miraculously replaced by an audiovisual. The enthusiasm for the language of images led some to believe that the transmission of ideas through audiovisual perception could take the place of verbal language. Many persons with conservative outlooks on teaching have prejudicially underestimated the rational use of audiovisual means by misrepresenting their functions and, not taking advantages of the real possibilities (Brake et al, 2003).

An artistic manifestation, as audiovisual language, shows itself as another possibility or facilitating tool during knowledge construction. This occurs because of the integration of individual reality with the natural surrounding environment, which develops, in the student, the sensitivity and perception of the universe. The audiovisual language allows such integration of the individual-environment, because it deals with scientific concepts as well as showing characters living in a world that can be recognized and identified by the students (Serra and Arroio, 2009). Using the audiovisual language, it is possible to join science, teaching and learning in a way that the communication becomes more efficient and learning more effective, besides raising interest and motivation of students in science. Another important aspect is that movies are an information source, like other media, directly influencing the perceptions and conceptions of the students. It this way they help in the acquisition of information process, contributing to the development of students critical sense.

Science fiction media combine science and pseudoscience for entertainment. It allows an opportunity to compare and contrast two drastically different eras of life on this planet. It also addresses the ethics of technological advancement (Rose, 2003). We believe that with the appropriate supporting materials and science teachers trained in using this new technique. Audiovisual can help reverse the negative attitudes that many students have toward real science by moving them from familiar experiences they enjoy to unfamiliar experiences they expect to be dull and difficult like learning physics, biology and chemistry (Dubcek et al, 2003).

A movie is a multimedia narrative form, based on a physical record of sounds and motion pictures. A movie is also a performed genre in the sense that it is primarily designed to be show in a public performance. Whereas a dramatic play is realized as a live performance by actors on a stage, a movie is show in a cinema, not as a live event, and can theoretically be repeated infinitely without change. Like drama, a movie is a narrative genre because it presents a story (a sequence of action units).

It is assuming that a movie, like a play, is a mainly a genre designed to be performed, a genre that “comes to life” in a performance. Watching a movie, like watching a play, is a collective public experience and a social occasion. Movie viewers’ come in large numbers for (mostly unconscious) expectations about how the film medium presents a real or fictional story. Above all, one generally assumes that the movie creates a verisimilar or at least likely world, a world that runs on laws of nature and logics. It is compatible with what might count as a fact or a possible experience in our own world; it is the movies’ reality effect (Barthes, 1982).

Methodology

This paper report on a movie analysis (Jahn, 2003) considering a Vygotskian perspective (Vygotsky, 1978) about contextualizing the scientific content. Audiovisual sources has an undeniable influence on the quality and quantity of experiences which make up the cognitive domain of youngsters today, given that watching TV, for example, is the second activity, after sleep, to which children devote most time (Fisch at al, 1997).

In preparation for teaching, it is necessary to view a movie a number of times.

1. First, select some commercial movies, looking for ways to take educational advantage of them. In this primary viewing it is necessary to focus on the audiovisual language to realize if this movie is able to communicate with the audience (students), youngsters in particular.
2. The second viewing is to focus on the scientific content presented on scenes in the movie.
3. The third viewing focuses on the way the scientific knowledge is presented, checking for possible mistakes and to think how the science can be contextualized in the science classroom.
4. A fourth viewing is important to select and edit short sequences more suitable for use in the teaching and learning of science.
5. The next step is to use these episodes to organize classroom's activities based on selected episodes of the movie as a cultural tool to contextualize the scientific content and motivate students in science classes.

The analysis relates to the Erin Brockovich film which focuses on environmental problems. Nowadays we consider environmental problems are areas for contemporary discussion, especially about climate change. So this movie seems to be really an important tool to contextualize and engage students to this scientific content that have a strong influence in our life.

In a world where heroes are often in short supply, the story of Erin Brockovich is an inspirational reminder of the power of the human spirit. Erin Brockovich, a 2000 movie, dramatizes the story of Erin Brockovich's first fight against the West Coast energy giant, Pacific Gas & Electric Company (PG&E).

Erin Brockovich is an unemployed single mother, desperate to find a job, but having no luck. This losing streak even extends to a failed lawsuit against a doctor in a car accident she was in. With no alternative, she successfully browbeats her lawyer to give her a job as compensation for the loss. While no one takes her seriously, with her trashy clothes and earthy manners, that soon changes when she begins to investigate a suspicious real estate case involving the Pacific Gas & Electric Company. What she discovers is that the company is trying quietly to buy land that is contaminated with hexavalent chromium, a deadly toxic waste that the company is improperly and illegally dumping and, in turn, poisoning the residents in the area. As she digs deeper, Erin finds herself a leading figure in a series of events that would involve her law firm in one of the biggest class action lawsuits in American history against a multi-billion dollar corporation (IMDb, 2010).

The following is a description of a scene where it is possible to discuss scientific content, especially the problem of corrosion and chromium pollution.

> *Erin visits a professor at a nearby college to learn more about chromium and finds out that there are actually a couple kinds of chromium and that the harmful chromium (VI) can cause a wide variety of very serious health problems in the*

case of prolonged exposure. The professor also tells Erin that chromium (VI) is in the water used to cool piston engines at factories to prevent corrosion.

As suggested by the professor in the movie, Cr (VI) is added to the water used to cool the engines. This caused the contamination of the ground water of the areas surrounding the PG&E plant. Hexavalent chromium is used in the industrial setting to make dyes and pigments as well as bricks for furnaces. It is also used in the tanning of leather and to preserve wood. The Pacific Gas & Electric Company (PG&E) used it in their piston engines to prevent corrosion.

Chromium is a transition metal which can have different oxidation states that result in different properties and reactions with other chemicals. Two common forms of chromium are trivalent chromium, Cr (III)) and hexavalent chromium – Cr (VI). Trivalent chromium is more common in natural settings and commonly found in soil whereas hexavalent chromium can be found in industrial settings and is not as safe as Cr (III). The hexavalent chromium, also referred to as chromium (VI), or Cr^{+6}, described by the professor in this scene is the dangerous form of chromium.

Discussion

As we can notice, the character Erin is a normal person like everybody, and most of the people can establish a relationship like, identification process with this character. Her problems are the same as our everyday problem. The problems are real like the ones experiences in everyday life. She is human like us. One problem is presented when chromium (VI) is ingested by the residents in the area due to its presence in their water. Among problems caused by ingesting chromium (VI) are various forms of cancer, respiratory diseases, kidney failure, gastrointestinal problems, reproductive problems, as well as nosebleeds, headaches, benign (non-cancerous) tumours, and hair loss. Workers in plants where chromium (VI) is present also experience problems when inhaling and when it comes in contact with their skin. The emotions are a way to engage students in the class activities. It is possible to propose a discussion about health problem from the environmental pollution. Many phenomena in nature are complex and require explanations using multiple perspectives (Girwidz et al, 2006). The movie show different medical cases of residents and many of the side effects are indicated.

With the audience engaged in this context based audiovisual, the teaching comprises of activities associated with the movie, enabling the learner to participate effectively in the activities of a more scientific nature. In this way, learning can be considered as a process of enculturation by participation in shared activities. When students have an opportunity to discuss about socio-scientific issues (for example, the problem of chromium contamination), they can change from one socio-cultural context to another. The issue arises as to what is more important, based on the movie context - persons keeping their jobs, or to take care of their health? This context, catching student's attention also through emotions, seems to be able to promote the community aspects of the classroom and the role of peer discussion in supporting students to learn science.

Showing a movie in the classroom seems to be more relevant, instead of just memorizing the content for exams. It is considered a mature understanding of science when the learners can demonstrate in terms of their ability ways to adapt to talking and thinking about phenomena according to the context, recognising the appropriateness, power and limitations of each (Leach and Scott, 2003). The movie presents an opportunity to discuss specific content with students, but in a contextualized way. It is possible to contextualize the corrosion process showing it as a result of reactions between a material, typically a metal, and its environment.

Socio-cultural views of learning endorse the view that knowledge is socially constructed and context dependent, and that human mental processes are structured within their historical, cultural and institutional setting (Wertsch, 1991). The audiovisual context based approach can provide students with a way to come to a personal understanding of ideas and information that already exist in their culture from their interaction during the discussion with the teacher and their peers about the scenes from movie related to socio-scientific issues.

It is proposed that the learning of science is to improve our lives, not just to get success on the school exams. Through movies it is possible to find science outside the school and realize how important science is to us. Science is thus realised as a complex of specific, situated human social and cultural activities. Science as a total system of social activities is not merely research science; it includes all the use of scientific practices at workplace, at home, in the environment. It is science as science is done and used by those who are trained to use it according to the norms of our society.

These assumptions are very helpful because they can be actively exploited when students face difficult, incomprehensible, or illogical data. The most common strategy in this case is to “naturalize” the information so that it becomes interpretable according to the context. Learning results from student’s active and purposeful involvement in activities. This enables them to process and interpret the information from audiovisual context on the basis of their existing structure of knowledge and experiences. It occurs through interactive cooperation and aids individual learning, sometimes independently and sometimes collectively. It allows the students to gain through diversity of the learning environment a way to focus on understanding culture and the meanings that culture contains as well participating in social activities (Sormunen and Saari, 2006). The fact that Erin Brockovich was not a lawyer and did not have any formal education or experience as a law clerk or a paralegal, made her victory that much more impressive.

According to Lemke (1990), classroom education still has an important role to play. Especially for the youngest students, but even for those who are already full participants in adult society, the classroom can provide a time for reflection, abstraction, analysis of practice, consideration of alternatives and theory. The use of audiovisual tools allows catching student’s attention alongside the traditional approach to the same subject matter. Moreover, by means of audiovisual tools, such effects or unique equipment can be deommstrated that woudl not be possible to show otherwise. In conclusion, the use of an audiovisual tool as a didactic tool in teaching-learning science process, leads to the improvement of its quality. The tool discussed

for achieving this is the use of movies to enhance students' understanding of scientific principles. although important is the whole context related with social issues. Scientific concepts are presented in new dimensions with the potential to make issues, which often are difficult in science, more accessible to students.

The context, which the teacher creates for the student's learning process, is important because the school work is related to student's acquiring knowledge and they need to be motivated for this. The audiovisual context is connected with real life and real people. 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. So the students recognise the whole content as being meaningful. Science alone will not make the world a better place. 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. Science education still has a great potential for good, but only if we take the true path of science ourselves, rejecting what has been and exploring together new ways of thinking, teaching, and learning (Lemke, 2005).

Of course students can see movies by themselves, but in a formal scholar situation the teacher must be present as a discussion partner with students to support them in various ways in their activities and help them to understand the scientific content in real context for everyday life. Motivation, to be successful, and science education is no exception, has to rely on a rich repertoire of experiences to build conceptual learning. These experiences pave the way to the construction of meaning, which in turn supports learning. It also helps to entertain, create or re-create a sense of wonder, which becomes the true incentive for learning (Arroio, 2007a).

Conclusion

Context-based courses are emerging at an increasing rate, with the greatest interest in the genre being perhaps found in the school subject of chemistry (Bennett and Lubben, 2006). So we consider that audiovisual context-based activities could increase the likelihood that the conceptual understanding acquired can be transferred to other contexts and also increase the student´s interest in the subject. But the most important is by this audiovisual context-based is possible to connect social issues with science and technology.

Movies can provide contexts which focus on social issues that should engage students. Where movies catch student's attention they provide different point of view, providing the teacher with an interesting possibility to discuss the issues. This environment provides a kind way of talking about the social context and the scientific content related.

The movie shows that learning science involves social interactions, discussing about socio-scientific issues supported by audiovisual context seem to be an important possibility to mediate process of making-meaning on the science classroom.

It is therefore important to think of education systemic term, not limiting the student's experiences to what can possibly take place in the classroom. With appropriate supporting activities, it is suggested that science teachers, trained in using this audiovisual context-based methodology, can help reverse the negative attitudes that many students have toward real science by moving them from familiar experiences they enjoy to unfamiliar experiences they expect to be dull and difficult.

Students can develop the ability of reading this media (movie). That is why teaching this ability is a priority for teachers of all subjects since the first years at school. This requires students to undertake critical analyses of the movies by applying abstract scientific principles they have learned in the classroom. Because if they begin to do this with movies we believe they will transfer this ability to other experiences and be less likely to be taken in by claims of pseudoscience in other formats, such as supermarket tabloids, television commercials and news stories.

This movie analysis illustrates the potential of audiovisual, scientific and common languages to be used as a tool to mediating science teaching and learning. Furthermore, the audience can learn values, information and knowledge present into the movie discourse and thus, the cinema shows the science in a society. Moreover, audiovisual language may be important mediating variables that determine the effectiveness of cinema for enhancing science teaching and learning.

Science educators have argued that science classrooms ought to be active learning environments in which students construct personal meanings within the classroom community. Some constructivist approaches have emphasized the personal construction of knowledge in the individual experiences within the learning environment are paramount, whereas others have underlined the importance of social processes in mediating cognition (Arroio, 2007b).

References

Arroio, A. (2007a). *The role of cinema into science education. Problems of Education in the 21st Century (Science Education in a Changing Society), vol.1, p. 25-30.*

Arroio, A. (2007b). Discourse Analysis into the Preservice Trainning of Chemistry Teachers. In: *2nd European Variety in Chemical Education*. Nesmerák, K., Nodzynskiej, M. (edits.). Charles University, Faculty of Science, Prague.

Barthes, R. (1982). *The reality effect*. In: Todorov, T. (Ed.). *French Literacy Theory Today*. Cambridge: CUP.

Bennett, J. & Lubben, F. (2006). Context-based chemistry: The Salters approach. *International Journal of Science Education*, 28(9), 999-1016.

Billet, S. (1996). Situated learning: Bridging socio-cultural and cognitive theorizing. *Learning and Instruction*, 6, 263-280.

Brake, M. et al. (2003). Science fiction in the classroom. *Physics Education*, 38(1), 31-34.

Driver, R.; Asoko, H.; Leach, J.; Mortimer, E. & Scott, P. H. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, 23(7), 5-12.

Dubcek, L.; Moshier, S.; Boss, J. (2003). *Fantastic Voyagers: learning Science through science fiction*. 2nd edition, New York: Springer.

Fisch, S. M.; Yotive, W.; McCann, S. K.; Scott, M. & Chen, L. (1997). Science in Saturday morning: children´s perceptions of science in educational and non-educational cartoons. *Journal Educational Media*, 23, 157-167.

Girwidz, R.; Bogner, F. X.; Rubitzko, T. & Schaal, S. (2006). Media-assisted Learning in Science Education: An Interdisciplinary Approach to Hibernation and Energy Transfer. *Science Education International*, 17 (2), 95-107.

Härnqvist, K., & Burgen, A. (Eds.). (1997). *Growing up with Science: developing early understanding of Science*. London: Jessica Kingsley Publishing.

Hewson, P. W.; Hewson, M. G. (1988). On Appropriate Conception of teaching Science: a view from studies of science learning. *Science Education*, 75 (1), 529-540.

Holbrook, J. (2010). Education through science as a motivational innovation for education for all. *Science Education International*, 21(2), 80-91.

Internet Movie Database, Erin Brockovich, http://www.imdb.com/title/tt0195685/ retrieved April 2010.

Jahn, M. (2003) *A Guide to Narratological Film Analysis*. Cologne: University of Cologne.

Jakobsoon, A. (2001). Pupil´s interactive learning in problem solving in groups. Malmö: Institutionen för pedagogic. Lärarhögskolan I Malmö.

Laius, A.; Rannikmäe, M. (2005). The influence of social issue-based in science teaching on students' creative thinking. *Science Education International*, 16(4), 281-289.

Lamanauskas, V. (2003). *Natural Science education in Contemporary School*. Siauliai: Siauliai University Press, 514p.

Leach, J.; Scott, P. (2003). Individual and sociocultural views of learning in science education. *Science & Education*, 12, 91-113.

Lemke, J. L. (1990). *Talking Science: Language, learning and Values*. Norwood, NJ: Ablex Publishing.

Lemke, J. L. (2001) Articulating Communities. Sociocultural Perspectives on Science Education. *Journal of Research in Science Teaching*. 38(3), 296-316.

Lemke, J. L. (2005). *Research for the Future of Science Education: New Ways of Learning, New Ways of Living*. Retrieved April 30, 2007. from http://www-personal.umich.edu/~jaylemke/sci-ed.html

Marková, I. (1982). *Paradigms, thought and language*. Chichester: Wiley.

Mork, S. M. & Jorde, D. (2004). We Know they Love Computers, but do they Learn Science? Using Information Technology for Teaching about a Socio-scientific Controversy. *Themes in Education*, 5(1), 69-100.

Rose, C. (2003). How to teach biology using the movie science of cloning people, resurrecting the dead and combining flies and humans. *Public Understanding Science*, 12, 289-296.

Säljö, R. (1996). Mental and physical artefacts in cognitive practices. I. P. Reiman & H. Spada (Eds.), *Learning in humans and machines* (284-324). Oxford: Pergamon/Elsevier.

Sandoval, W. A. (2005). Understanding students´ practical epistemologies and their influence on learning through inquiry. *Science Education*, 89, 634-656.

Schoultz, J.; Hultman, G. (2004). Science teaching and the school – when concepts meet context. *Journal of Baltic Science Education*, 2(6), 22-33.

Serra, G. M. D.; Arroio, A. (2008). The environment portrayed in the film and the science education. XIII IOSTE Symposium Proceedings: *The use of Science and Technology Education for Peace and Sustainable Development*, 1185-1191. Kusadasi, Turkey.

Serra, G. M. D.; Arroio, A. (2009). O meio ambiente apresentado em filmes de ficção e documentarios. *Enseñanza de las Ciencias*, v. extra, 2797-2802.

Sormunen, K.; Saari, H. (2006). Moving beyond teaching methods in school science-epistemological and sociocultural viewpoints. *Journal of Baltic Science Education*, 2(10), 20-39.

Vygotsky, L. S. (1978). *Mind and Society*. Cambridge: Harvard University Press.

Wertsch, J. V. (1991). *Voices of Mind: A sociocultural Approach to Mediated Action*. Cambridge, MA: Harvard University Press.

Appendix

Technical specifications for Erin Brockovich (IMDb -20010)

Director: Steven Soderbergh

Writer: Susannah Grant

Country: USA

Language: English

Release Date: 2000

Runtime: 130 min

Sound Mix: DTS | Dolby Digital | SDDS (8 channels)

Color: Color

Aspect Ratio: 1.85 : 1

Film negative format (mm/video inches): 35 mm

Printed film format: 35 mm

Production Co: Jersey Films