PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 50, 2012
14

THE ROLE OF BIOGRAPHIES IN CHEMISTRY EDUCATION AND ITS CONTRIBUTION TO UNDERSTANDING HOW SCIENTISTS AND SCIENCE WORKS

Diana M. Farías
National University of Colombia, Bogota, Colombia
E-mail: dmfariasc@unal.edu.co

Agnaldo Arroio
University of São Paulo, São Paulo, Brazil
E-mail: agnaldoarroio@yahoo.com

Abstract

In this study it is presented several considerations concerning the elements that biographies could contribute to chemistry education. It is analyzed two particular cases: biographies from two high school chemistry textbooks and an audiovisual in the form of an animated fictional documentary about the life of Marie Curie. The analysis was carried out following a methodology designed to analyze textbooks in which we visualize science as a network where we identify elements that allow us to track how science circulates; we have used previously these elements in analyzing audiovisual materials for classroom (Arroio and Farías, 2011).
These results show that despite the fact that biographies have elements which justify the criticism they have received within science education they can improve the contextualization and localization of scientific activity by making new connections between those actors that are not generally part of schools' accounts of science: scientists, institutions, and places, amongst others. This fact was further substantiated after analyzing the documentary.
It is proposed that the inclusion of biographies has a vast potential for conveying a more realistic image of scientific activity - but only if the biographies are specifically designed for teaching and are understood to be narrowly related to the popularization of science, science education, and the historiography of science. Moreover, biographies can lend more weight to the role of scientists as narrative axes, where then the school discourse can recover the person, that is, the scientist as a subject and individual. Within a setting where school science is primarily centered on concepts this process can strengthen the affective links between students and teachers.
Key words: *audiovisual, image of science, narratives, scientists, textbooks.*

Introduction

One of the most pressing concerns within science education is the youth's lack of interest in getting involved with science careers or science education itself. The alternatives that seek a solution to this problem have resorted to the need to demonstrate that what is learned is meaningful, to highlighting the connections between science and society, e.g., through the STSE focus, or to highlighting the relationship between science education and citizenship education, amongst others.

An important task of science education is making science more relevant to students,

ISSN 1822-7864

more easily learned and remembered, and more reflective of the actual practice of science, at least it is expected to be done.

It is possible to provide some situations to confront the students´ views of science to challenge them to reflect about it. Experiences come from interaction with a learning environment, on this it is important to give them a chance to understand how science works.

According to Holbrook (2010):

> 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.

It is fundamental that teachers investigate which situations could make students interested in science and how that interest can be developed and connected to the understanding of the nature of science. These kind of strategies can also help establish links between the nature of science and reality. The importance of the knowledge of how science works has been acknowledged by science education researchers, policy makers and teachers (Matthews, 1994), but it is necessary to bring students closer to science, to at least learn about science, not just to able to pass school exams.

Farías and Castelló (2011) have shown how science in textbooks reflecting the priorities of school science has, to a large extent, forgotten about the scientists, who generally appear as spatiotemporally delocalized, depersonalized, decontextualized and mythologized. Scientists could actually be an emotive link to youth who might identify with or feel attracted to them through their life story.

In general sense, narrative may be defined as "telling someone else that something happened" (Herrenstein-Smith 1981, p. 228 apud Metz et al. 2007). According to Norris et al. (2005) the narrative describes "the desire created in readers and listeners to know what will happen". Stories are used every day as a way of making sense of and communicating events in the world (Avraamidou and Osborne, 2008).

Schank and Berman (2002), point out a story as " structured, coherent retelling of an experience or a fictional account of an experience... and that in some sense, all stories can be considered didactic in nature, in that they are intended to teach or convey something to the listener".

In this study, through the view of the life of scientists as captured in biographies, it was studied one of the possibilities of the need to turn the center of attention of the school science discourse to the scientists themselves.

The genre of biography has been greatly related to the popularization and teaching of science as well as to the historiography of science, which was consolidated in the 19th and 20th centuries. In this consolidation the focus shifted to the history of disciplines and ideas, leaving out the history of the life of scientists, which then became the subject of the genre of biography (Söderqvist, 2007a).

Aside from being a constitutive element of scientific culture, and having a vast utility for contextualizing the history of social science culturally and politically, at some point in history biographies have been written for pedagogic ends. They have been written to show how exciting science can be and to show the human side of those few men who were beginning to be questioned in light of the possibility of science being connected with the war. Nevertheless, biographies then lost significance not only for the history of science, but also for scientific education when they became related to a more "literary" and "anecdotal" character, one much against the rigidity of the positivist scientific discourse (Söderqvist, 2007b).

Additionally, from the perspective of the history of science biographies started turning into an undesirable element given that as a literary genre they reflected not only the values of the author and of its time, but also gave importance to certain aspects in line with certain interests depending on what was hoping to be conveyed to the readers, leaving out others deliberately (Kragh, 2007). Moreover, its programmatic function favors the repetition of stereotypical representations, conveying the narrative of the heroic history of the 19th century, dehumanized and embodied by a few selected geniuses (Lindskov, 2007).

In terms of science education biographies have been criticized at great length for being written in short phrases with idealized comments describing the scientist and a great number of facts about places and dates, but without contributing elements that reflect the social and historic contextualization of scientific activity (Jaffe, 1938; Izquierdo, 1996; Kipnis, 1996; Söderqvist, 2007a).

Despite the negative outlook of biographies, we consider that faced with the need to connect students and teachers with science they can turn out to be useful for demonstrating that science is not only a group of finished products, but the result of processes carried out by people just as human as the actors of the educative process. In this study it was set out to analyze biographies from the model of the circulation of science as proposed by Bruno Latour. This is a model in which science is understood as tangled network where we find politics, scientists, equipment, laboratories, non-humans, scientific models and institutions, amongst others, all connected.

Methodology of Research

In this study it was analyzed the biographies from two chemistry textbooks published in Spain and an animated fictional documentary about the life of Marie Curie:

Book 1: Física y Química. (1994), authors: A. L. Lasheras and Ma. P. Carretero;
Book 2: Ciencias Físico-químicas. (1935), author: A. Mingarro;
Episode 22 of the animated series "Así es la vida. Los inventores: Marie Curie" (1994) (Such is life. Inventors: Marie Curie), director: Albert Barillé.

The methodology used was designed by Farías and Castelló (2011) for the analysis of the way in which science is talked about in textbooks. This methodology is based on the model of the circulation of science as proposed by Bruno Latour (2001), a french sociologist who considers that scientific activity can be understood as a complex network in which different nodes are connected, representing the relationship between five categories of elements:

Mobilization of the world: the participation of instruments, laboratories, equipment, experiments and places in the production of science.

Autonomization: the participation of associations, institutions, disciplinary groups, and others that take into account how scientists are connected with each other around common subjects.

Alliances: the relationship between scientists and any type of funding, patronage, scientific support, political support, etc. which facilitate the realization of scientific activities.

Public representation: the way in which scientists leave their academic circles and get involved with the public with the end of making their work known.

Finally, Latour grants the most important role to a fifth category he designates as "nodes or links", these are the concepts, theories, laws, hypotheses, constants, formulas, principles, equations, and models that are established by scientists to articulate an explanation of the natural world and around which the other four categories move.

It is consider that in order to represent this complex network it is need to show the role

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 50, 2012

of humans and non-humans–entities of the material world that emerge as a product of science and whose identity refers to the practice and relationships they can establish. Thus, in each of the analyzed biographies it is searched for the presence of these seven categories defined by the attributes of Table 1 and through the rendering of each of their corresponding networks, using Gephi 0.8-beta, it was showed the connection between the different actors.

Table 1. Categories and attributes for classifying the different elements present in the analyzed biographies.

Category	Attributes
Mobilization	Instruments, laboratories, equipment, places
Autonomy	Association, institutions, disciplinary groups, disciplines
Funding	Financing, sponsors, scientific support, political support, prizes
Representation	Relations with the public
Links	Concepts, theories, laws, hypotheses, constants, formulas, principles, models
Non-humans	Entities of the material world defined by scientific practice and their relations with other nodes
Humans	Scientists, philosophers, poets, politicians, soldiers...

Results of Research

Initially, a few aspects were analyzed with respect to the two textbooks. Book 1, published in 1994, was characterized by presenting a few boxes found on the margin with the biographies of some scientists along with a few traditional contents for an eleventh-grade chemistry class. The information inside the box of Lord Ernst Rutherford is represented in Figure 1 with a network in which we can see elements from Table 1 and their connections.

Multiple connections are established around the node that represents Rutherford connecting him with other scientists, institutions, places, laboratories, non-humans (the finished products of science) and links (scientific concepts), which allow the contextualization and localization of scientific activity. In books that lack biographies these type of connections do not appear, the ties are established primarily between links, non-humans and a few disconnected humans that always appear on the periphery, generally only connected by one point to the network, a connection that usually refers to a discovery (Farías and Castelló, 2011).

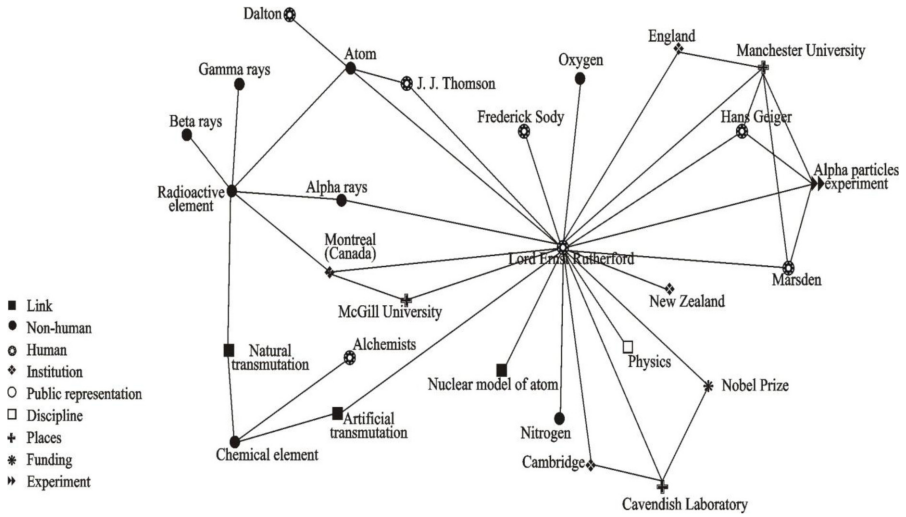

Figure 1: Network that represents the circulation of science in the biography of Lord Ernst Rutherford in Book 1.

On the other hand, in book 2 it was found that in most of the chapters biographies appear in the form of an epilogue. These biographies contribute a great deal of additional information about trajectories (places) and institutional links. Nonetheless, in many of the cases these new nodes are not connected to any other elements leaving the information disconnected (Figure 2). The way in which these biographies are presented, with short phrases and a great number of facts about places and dates, is a clear example of an aspect that has been greatly discussed and criticized in science education, as was mentioned in the introduction. This aspect refers to fact that biographies can limit themselves to only introducing large quantities of information regarding dates and places without contributing elements that reflect the social and historical contextualization of scientific activity.

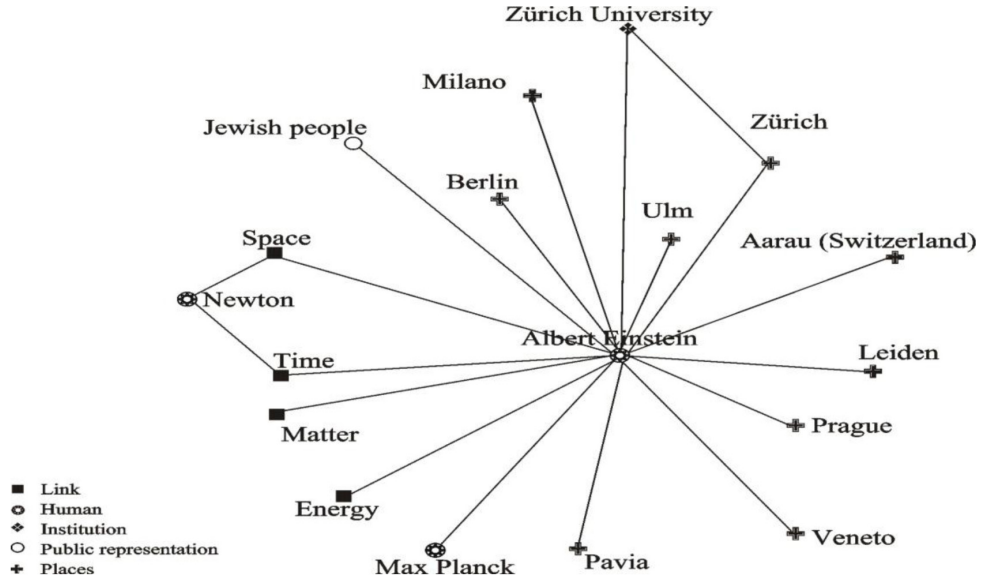

Figure 2: Network that represents the circulation of science in the biography of Albert Einstein in Book 2.

When comparing the two books through the possibility of finding a biography in common, in this case that of John Dalton, we can appreciate a few similar aspects, but also a few differences. Table 2 shows the types of attributes to which the elements in each biography belong. It is clear how in both cases the biography of Dalton is associated with a few places, disciplines, and non-humans, but especially with links. We can see how these are elements that are more important to the account of school science and how the biographies that end up in textbooks, despite contributing few contextual nodes, which can convey an image of scientists connected with other elements, focus instead on the relationship of these concepts that are the epicenter of scientific activity at school level.

Table 2. Comparison of elements present in the biography of John Dalton for the two textbooks published in Spain.

Attribute	Book 1 (1994)	Book 2 (1935)
Places	Manchester	Eaglesfield Cumberland Manchester England
Institutions		Manchester School
Disciplines	Mathematics, Physics, Modern Chemistry	Chemistry
Humans		Democritus
Non-humans	Chemical Substances, Atom	Atom
Links	Daltonism, Atomic Theory, Law of Multiple Proportions, Law of Partial Pressures, Gases, Chemistry Analysis, Chemical Synthesis, Chemical Symbol	Chemical Equivalent, Heat, Vapor, Atomism, Law of Multiple Proportions

This point is key if it is compared characteristics of the biographies from the textbooks with that of the animated series. Figure 3 shows the network that comes out of the analysis of the documentary. In this network it is possible to see how the educative scientific discourse, not necessarily constrained to the school sphere, but actually done with popularization in mind, shows a large number of elements that allow us to localize scientists in more rich spatiotemporal contexts. In this way these types of biographies allow us to see a relationship between scientists and other humans, not only with other scientists, but also with politics and the public. We can also see the relationship with institutions, the importance of prizes and recognition as a source of funding for future research, the trajectories as well as the ideals, emotions and other subjective aspects that have been left out of a discourse full of truths and finished facts, the discourse that dominates school science.

On the other hand, in the network representing how science circulates in the documentary about the life of Marie Curie we can observe the presence of links and non-humans, elements central to the science of textbooks, occupying less central positions although connected with scientists, places, institutions, etc. This means that the contextualization that is gained with a biography in order to speak about scientific concepts is not exclusive to the scientists, but is gained through the richness of the connections.

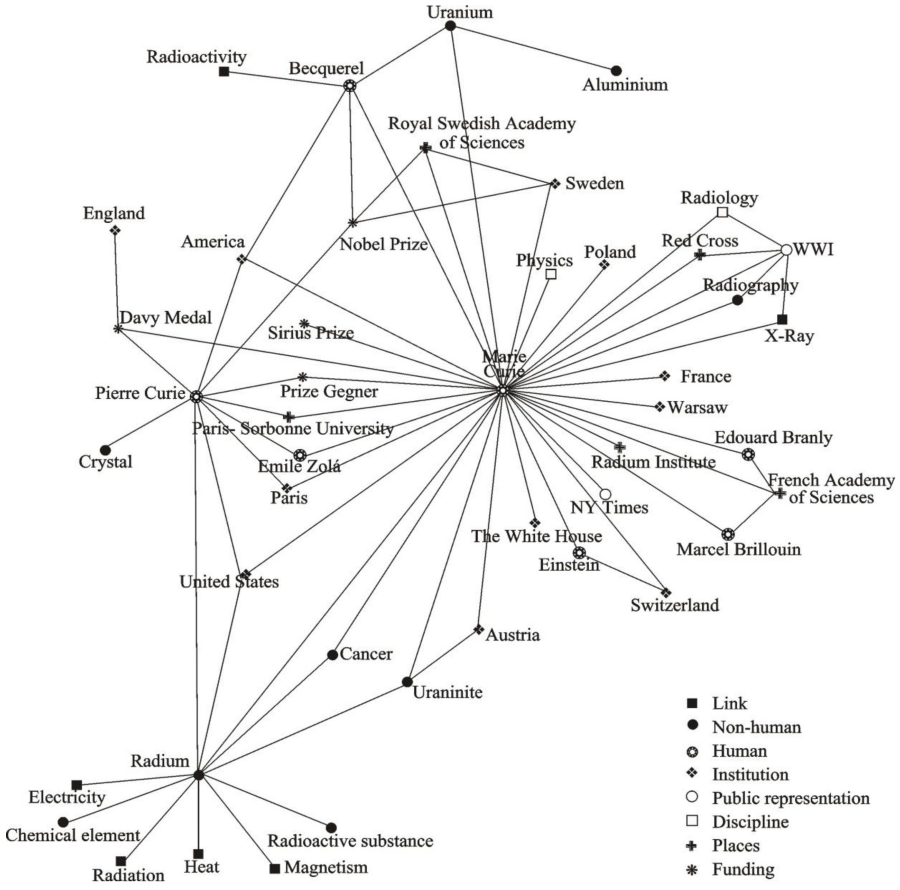

Figure 3: Network that represents the circulation of science in the biography of Marie Curie in the animated documentary about her life.

These examples show the elements that biographies can contribute and opens the door to being able to understand them as the potential axes of a scientific account different from the one in textbooks. In this new account other sources such as documentaries, interviews, or films, with the aim of making the lives of scientist known, could find their way into the classroom as elements that should be part of the science taught to teachers and students. These networks show how the elements that biographies contribute turn the scientists into central nodes and also how science grows radially around them. If it is understanding science through the analogy of networks it could be interesting to see how biographies can give a first push in bringing scientists to the center and also how later these networks can be "made to grow" by introducing connecting with aspects central to school science. This is a task in which neither the scientists nor the concepts are neglected.

Didactic Implications

The visualization of elements that biographies mobilize, through network analysis, has allowed us to understand how including biographies has a vast potential value. It consists of introducing discursive elements in textbooks that contribute to the contextualization as well as introducing connections that reflect aspects about the science that has stayed on the margin of school science. It would allow us to understand science as a more complex activity, while also

allowing us to bring scientists from their peripheral positions to more central positions; that is to say, to highlight the importance of scientists inside an account of science dominated by links.

The point, however, is that the type of biographies included in textbooks should be carefully designed for teaching school science. There the aim is to emphasize the importance of scientific activity, scientific nature, and the role of each different element that describes science.

Likewise, it is necessary to see biographies from a different perspective where they are not added like patches to textbooks which want to "humanize" scientific activity. This is a perspective in which biographies do not become endless source of dates and places or idealized descriptions of those super humans that do science. Instead, they serve as a bridge connecting those humans that do science with the elements that they produce so that we can speak about scientific knowledge. This perspective should show how theories, models, and concepts do not exist by themselves, but are actually a product of an activity carried out by people as human as the science students and teachers themselves. It is necessary also, to recognize the multiplicity and multiple ends with which biographies can be written: entertain, motivate young scientists who will surely be interested in the journeys of professional scientists, explain the technical work of scientists, honor the men of science (and more and more the women of science as well), establish modern and secular scientific heroes and heroines, instill moral values, and earn money (Söderqvist 2007b).

In this way, if in science education we recognize this multiplicity, if we accept that one of the faces of biographies could be highly didactic and we rescue their good qualities to transmit a new image of science in school, we could count on a "new" and very strong tool. By making the life of scientists the center of the narrative we can rescue from biographies, for the school discourse, the person, the scientist as a subject and individual. Hence, we can establish affective links between students and teachers with an estranged science centered only on the cognitive.

Conclusions

Like all elements that are part of the complex network of science biographies have suffered a series of transformation, generally unknown to the dynamics of the scientific educative sphere, throughout their history. The way in which some biographies have been traditionally treated in textbooks has led to their criticism and censoring in the science classroom. Nevertheless, in this work we have taken on the task of showing that they can contribute interesting elements when it comes to presenting a more contextualized science, but especially when it comes to regaining the attention of the scientific account by the people who make science and the way in which they are connected to scientific concepts who play the lead in the account of school science.

Thus, in a setting where students and teachers feel more and more attracted to science, the research in Science Education should join forces to show that school science can be increasingly more close to real science and increasingly farther from a rigid science that is based solely on concepts. Making the life of scientists relevant can be one of many strategies that allow the humanization of the science that is transmitted by textbooks and the classrooms in which these are used.

References

Arroio, A., Farías, 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.

Avraamidou, L., Osborne, J. (2008). Science as Narrative: The story of the discovery of penicillin. The pantaneto forum home page. Retrieved on 18 September 2010 from http://www.pantaneto.co.uk/issue31/

Farías, D. M., Castelló, J. (2011). Reading the history of science in science school textbooks from a sociological perspective. En: Seroglou, F., Koulountzos, V. y Siatras, A. (Eds) *Science & Culture: Promise, challenge and demand* (Proceedings Del 11th International IHPST and 6th Greek history, philosophy and science teaching joint conference). Epikentro publications: Thessaloniki, p. 224-230

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

Izquierdo, M. (1996). Relación entre la historia y la filosofía de la ciencia y la enseñanza de las ciencias. *Alambique*, *8*, 1-21.

Jaffe, B. (1938). The History of Chemistry and its Place in the Teaching of High-School Chemistry. *Journal of Chemical Education*, *15*, 383-389.

Kipnis, N. (1996). The "Historical-Investigative" Approach to Teaching Science. *Science & Education*, *5* (3), 277-292.

Kragh, H. (2007). Received Wisdom in Biography: Tycho Biographies from Gassendi to Christianson. En: Söderqvist, T. (Ed.) *The History and Poetics of Scientific Biography*, pp. 121-134. Ashgate: Cornwall.

Lasheras, A. L., Carretero, M. P. (1994). *Física y Química. Positrón*. BUP 2o. curso. (1 Ed.). Editorial Vicens-vives: Barcelona.

Latour, B. (2001). *La esperanza de Pandora*. Barcelona: Editorial Gedisa S.A.

Lindskov, S. (2007). The programmatic function of biography: readings of nineteenth – and twentieth–century biographies of Niels Stensen (Steno). En: Söderqvist, T. (Ed.) *The History and Poetics of Scientific Biography*, pp. 135-154. Ashgate: Cornwall.

Matthews, M. (1994). *Science teaching: The role of history and philosophy of science*. New York: Routledge.

Metz, D., Klassen, S., McMillan, B., Clough, M., Olson, J. (2007). Building a foundation for the use of historical narratives. *Science & Education*, *16*, 313-334.

Mingarro, A. (1935). *Ciencias Físico-químicas*. Sucesores de Rivadeneyra, S.A.: Madrid.

Norris, S., Guilbert, M., Smith, M., Shahram, H., Philips, L. (2005). A theoretical framework for narrative explanation in science. *Science Education*, *89* (4), 535-554.

Schank, R. C., Berman, T. R. (2002). The pervasive role of stories in knowledge and action. In M. C. Green, J. J Strange, & T. C Brock (Eds.), *Narrative Impact: Social and Cognitive Foundations* (pp. 287-314). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Söderqvist, T. (2007a). A New Look at the Genre of Scientific Biography. En: Söderqvist, T. (Ed.) *The History and Poetics of Scientific Biography*, pp. 1-15. Ashgate: Cornwall.

Söderqvist, T. (2007b). "No Genre of History Fell Under More Odium than that of Biography": The Delicate Relations Between Scientific Biography and the Historiography of Science. En: Söderqvist, T. (Ed.) *The History and Poetics of Scientific Biography*, pp. 241-262. Ashgate: Cornwall.

Advised ***by Laima Railienė, University of Siauliai, Lithuania***

Received: *October 27, 2012* Accepted: *December 08, 2012*

Diana M. Farías	Doctor, Professor, National University of Colombia, Bogota, Colombia E-mail: dmfariasc@unal.edu.co Website: http://www.unal.edu.co/
Agnaldo Arroio	PhD, Professor, Faculty of Education, University of São Paulo, Av. da Universidade 308, bloco A, sala 109, Butantã, 05508-040, São Paulo, Brazil. E-mail: agnaldoarroio@yahoo.com Website: http://www.fe.usp.br