Science for all: Empowering elementary school teachers
Irene Plonczak

*Education, Citizenship and Social Justice* 2008 3: 167
DOI: 10.1177/1746197908090081

The online version of this article can be found at:
http://esj.sagepub.com/content/3/2/167

Published by:

SAGE
http://www.sagepublications.com

Additional services and information for *Education, Citizenship and Social Justice* can be found at:

Email Alerts: http://esj.sagepub.com/cgi/alerts

Subscriptions: http://esj.sagepub.com/subscriptions

Reprints: http://www.sagepub.com/journalsReprints.nav

Permissions: http://www.sagepub.com/journalsPermissions.nav

Citations: http://esj.sagepub.com/content/3/2/167.refs.html

>> Version of Record - Jun 6, 2008

What is This?
Science for all
Empowering elementary school teachers

Irene Plonczak
Hofstra University, USA

ABSTRACT
This article addresses issues that are related to the empowerment of elementary teachers through teaching and learning science in socially and culturally meaningful contexts. It is based on the analysis of the attitudes and relationship to science of 10 elementary school teachers from inner city schools in Caracas, Venezuela. In the context of a workshop, teachers were asked to come up with a scientific explanation of a familiar physical phenomenon observed on a daily basis and related to their everyday tasks. The data were the teachers' discourse and were both written (a description of an ideal science class) and oral (semi-structured interviews). Academic/epistemic, professional, and social dimensions were used to analyze the discourse. These categories were based on two theoretical frameworks: an empirico-realistic one, held by the majority of teachers, and a socioconstructivist one, held by the researcher. The results illustrate how familiar contexts bring meaning and raise teachers' confidence to teach science, which contributes to the development of a more empowering attitude towards science.

KEYWORDS  elementary teachers, empowerment, everyday science, inner city schools, science education, socioconstructivism

introduction
Elementary school teachers' attitudes and relationship to science were studied in the context of a workshop where their everyday knowledge, experience, and culture were taken into account. The issues addressed in this research are related to the teachers being empowered through teaching and learning science in socially and culturally meaningful contexts. The topic is of interest education, citizenship and social justice
to a wider audience than those engaged in science education in as much as it touches on the enhancement of teacher's knowledge due to their expertise with familiar physical phenomenon related to their everyday tasks, and its importance for student learning. The study also has implications for the development of scientific and technological literacy, and ultimately citizenship and social justice.

Gérard Fourez (1997) points out that science is ‘made by humans for humans’, and therefore science education should be conceived as a historical construction conditioned by projects that are meaningful and relevant to people's specific needs and contexts. So, for example, teaching and learning about the greenhouse effect – which scientists agree is the main cause for the global warming of the planet – includes teaching and learning about the political and ethical debates that surround these topics. Learning the science related to global warming would include learning about the United Nations' Intergovernmental Panel on Climate Change (IPCC) report, which confirms that global warming is a reality that is jeopardizing our planet's future. It would therefore also include learning about laws and regulations approved by different countries to control human produced greenhouse gas emissions that cause global warming. Such an approach allows students to construct a clear understanding of the scientific knowledge as well as the social, economical, political and cultural issues at stake. As future citizens, it empowers them to make informed decisions, to embrace social justice agendas, and to take political action.

This humanistic approach (Aikenhead, 2005), which represents an alternative to traditional education that focuses on abstract and decontextualized curricular content, is of particular interest in urban contexts. Excelling in science is a symbol of academic success and represents an opportunity for higher education and socio-economic status (Barton, 1998; Barton and Yang, 2000), but this opportunity is denied for many due to the 42 percent dropout rate between first and sixth grade in urban or popular1 schools in Venezuela (Esté, 1996). According to Esté (2007), one of the reasons for this high dropout rate is that these children do not adapt to the traditional school culture. He suggests that teaching and learning in the context of everyday life situations could be a strategy for student retention, therefore offering the opportunity to provide a minimum of scientific literacy to those who would have otherwise been denied it.

From an analytical and methodological point of view, the focus of this research is to study elementary teachers' attitudes and relationships to science based on academic/epistemic, professional and social dimensions. The academic/epistemic dimension is based on their notions of scientific method, observation, experimentation and the use of models in science. The professional dimension is based on their experiences as teachers, and the social dimension is based on their personal and social experiences with science. According to research, these dimensions reveal the teachers' images of science (Désautels
and Larochelle, 1989; Lederman, 1999), as well as how teachers relate to science (Charlot et al., 1992).

**science education: a diagnosis**

Some of the issues addressed in this research are related to commonly held perceptions about elementary teachers' poor background in science content (Astolfi, 1995; Harlen and Holroyd, 1997; Hodson, 1988), which makes them feel uneasy teaching science, and often results in the exclusion of science from their teaching priorities. Due to their lack of confidence in science content areas, elementary teachers often implement classroom activities that are mainly worksheets based on copying and repeating from textbooks. These teaching practices affect students' understanding of scientific concepts. They often do not see the point of studying science, and fewer and fewer of them are enrolling in science classes (Fourez, 2000a, 2000b; Miller, 2001; Osborne et al., 2003).

Fourez (2000a, 2000b) considers that the very meaning of the science courses is at stake. He states that the main contradiction is that the school curriculum presents science in terms of physics, chemistry and biology – which refers to concepts and theories – while students want to see the connections with everyday applications. Layton et al. (1993), point out that teachers are also reluctant to take students' interests and experiences into account, even though students are usually interested in the social, political, economic and cultural aspects involved in the production of scientific knowledge. According to Aikenhead (2005), this is mainly because teaching and learning science content knowledge will become more complex if students raise real life situations. For example, explaining why an apple gets darker when cut in half is part of our everyday life experiences, and it can come up as an example of chemical change, but explaining the actual chemical reaction of oxidation to elementary- or middle-school students can be difficult. Examples such as this make teachers hesitant when it comes to embracing humanistic curricula where students may pose challenging questions that are not explained in the textbooks. Teachers, reluctant to move out of their comfort zone, would rather stay in the predictable and reliable world of pipeline science education.

As a result of the emphasis on lecturing, the teaching is too formal and the gap between theory and reality widens. In short, science education is too abstract, too removed from reality, and places the emphasis on teaching ready-made concepts rather than stimulating student thinking and experimentation (Brooks, 2002).

The failure of science education to encourage students to embrace science has created a real sense of urgency. In 2004, *Business Week* magazine reported a shortage in science and technology graduates in the USA. Additionally, other
industrialized countries such as Japan, South Korea and in Western Europe had much higher standards in these areas (Business Week Online, 16 March 2004). To address this urgency, President Bush, in his February 2006 State of the Union speech, said he would create a funding agency that would encourage children to take more math and science, train teachers, and give early help to students who struggle with math and science.

These policies may increase the numbers of students and teachers involved in scientific careers, but will they actually improve the quality of science education? Can we hope to engage students if we continue teaching science the way we have traditionally been doing it? Should not our students be able to understand the increasing amount of public policies and legislation based on science and technology that affect their everyday lives? Should not they be able to respond, for example, to the controversies surrounding global warming, electric powered cars, the Kyoto Accord or even teaching evolution in science classes? Shouldn't they be able to acquire what Fourrez (1997) calls 'scientific and technological literacy'? It's not just about increasing funding for science, it is also about making fundamental changes in the way we have traditionally been teaching and learning science.

changing the way we have traditionally been teaching and learning science

Traditional teaching practices are primarily based on a copy and repeat model, or as Layton et al. (1993) call it: the 'cognitive deficit model'. Students' knowledge is considered deficient, the teacher's main role is to transmit information and the students who are considered successful copy from textbooks. Layton et al. suggest that teachers assume that learners come to school like 'empty vessels' without their own ideas and explanations for the world that surrounds them.

This cognitive deficit model is increasingly viewed with skepticism, especially if one takes into account that information is now easily accessible to the learner through sources such as the Internet and other media. Science education must go beyond the mere transmission of information and must focus on better ways of understanding, using, and analyzing this information. Inquiry-based activities can encourage learners to construct their own viable understanding of scientific concepts (Appleton, 2005; Brooks and Brooks, 1999; Koch, 2005; Tippins et al., 2002).

From an epistemological point of view, Hodson (1988) points out that most of the traditional school science curricula do not question the notions of objectivity, neutral observation or absolute truth, which led to Kuhn's (1970) idea of paradigm shifts in science. As a result, even though these shifts have influenced contemporary science, they are still unaccounted for in the social sciences and
even less in science education (Steedman, 1991). Consequently, the majority of science teachers still hold empirico-realist conceptions of science, and these are inevitably transmitted to the students (Larochelle and Désautels, 1992). These views affect teachers' understanding of scientific knowledge and have an impact on their teaching practices (Brickhouse, 1990, 1994; Lederman, 1999; Roth and Lucas, 1997).

If learners are no longer required to copy or repeat information, they might be encouraged to construct their own understanding of the physical and social world surrounding them. If they are no longer required to 'discover' the world in the sense of uncovering something that is already known, they might be encouraged to construct their own 'viable' interpretation of the world surrounding them (von Glasersfeld, 1985).

Shifting the learner's role leads to a shift in the teacher's role, one where he or she can no longer be solely a source of information. The teacher now has to focus on providing an adequate learning environment that will allow learners to construct their own understanding of scientific phenomena. The learner's 'untutored ideas' (Hills, 1989) regarding the explanation of physical phenomena become the anchoring point of knowledge construction and must therefore be taken into account. The teacher can no longer perceive students' misunderstandings as errors or ignorance but must see them as a starting point in the process of constructing a more complex understanding of phenomena.

There is still a long way to go to achieve this level of empowerment in teachers. Indeed, as already noted, particularly at the elementary level, teachers are intimidated by science and feel insecure with science content. So, how can teachers be empowered in order to take the step from the mere quantitative changes in science education policies to qualitative changes as well? How can teachers encourage meaningful and authentic learning as opposed to copying and repeating? This problem was addressed through the following research question:

What attitudes towards science do elementary school teachers develop when the science content matter and context are related to their own everyday life experiences, expertise and culture?

**research methodology**

In order to study teachers' attitudes and relationship to science, a workshop for 10 elementary school teachers (eight females and two males) from urban or popular schools was implemented in Caracas, Venezuela. The teachers were asked to provide a scientific explanation of a physical phenomenon observed on a daily basis and related to their everyday tasks. The phenomenon was the rising of arepas, a form of bread made from corn flour and prepared almost everyday in Venezuelan households to accompany most meals. The idea to
center the workshop on the question ‘Why do arepas rise?’ was inspired by Englebert-Lecomte (1997) who designed an activity for secondary students based on the question: ‘How can you provide a scientific explanation for the rising of soufflés?’

Throughout the three hour workshop, the teachers went through a four-stage process of individual reflection, group work – where they came up with hypotheses as to why the arepas rise, experimentation where they actually prepared the arepas, and a plenary session where they shared their explanations of the everyday phenomenon from a scientific perspective.

As part of this study, written, oral and video data were collected, the video being used exclusively as review support for the discourse analysis. The written data consisted of a description of an ideal science class. This description indicated what each teacher thought the best scenario for a science class would be, regardless of the lack of resources or other difficulties that, according to most teachers, do not allow for engaging science classes. This data provided the basis for analyzing what teachers considered to be ideal teaching and learning practices in science. According to Charlot et al. (1992), spontaneous writing about personal practices reveals ways of thinking, intentions, priorities, expectations, etc., and is thus an important indicator of the way relationships are established with knowledge.

The oral data were the main source of information and consisted of semi-structured interviews that allowed the exploration of complex issues such as the teachers’ beliefs, perceptions and social representations regarding science as well as their relationship to science (Charlot, 1997). The interviews were conducted with a flexible and open framework, which allowed for focused, conversational communication. These semi-structured interviews, which lasted approximately 45 minutes, encouraged the teachers to develop their thoughts as the interview progressed (Flick, 1994). (See Interview Questionnaire in Appendix 2.)

Inspired by the work of Charlot et al., (1992) regarding the study of how individuals relate to knowledge, the interview was structured in order to take into account three main dimensions of the teachers' relationship to science: academic/epistemic, professional and social. The academic/epistemic dimension referred to the teachers' images of science. The professional dimension referred to the teachers' relationships to science taking into account their representations regarding teaching and learning science. Finally, the social dimension referred to their relationships to science according to past experiences like success or failure in science courses, as well as emotional aspects like fear, curiosity or frustrations they might have felt regarding science. Teachers were also asked about their social backgrounds, because individuals from low-income backgrounds may establish different relationships to science than those from middle-class or upper-class backgrounds (Barton and Yang, 2000).
The interview focused mainly on the academic/epistemic dimension of the teachers' relationship with scientific knowledge. To study the intellectual aspects of this dimension, the interview questions were directed towards the notions of scientific method, observation, experimentation and the use of models in science. All these notions are highlighted by researchers in the field as being crucial to study individuals' images of the nature of science (Désautels and Larochelle, 1989; Lederman, 1999).

**data analysis**

The teachers' discourse was analyzed with reference to two theoretical frameworks: an empirico-realist approach and a socioconstructivist approach. The empirico-realist approach represents the traditional views of science held by most teachers in the field and the socioconstructivist approach represents a more progressive view of the learner as constructing his or her knowledge through social interaction.

Demazière and Dubar's (1997) analytical procedure was followed to analyze the discourse. This consisted in extracting unities of sense and organizing them in categories according to the two theoretical frameworks as well as to the academic/epistemic, professional and social dimensions that structured the interviews. Similarities among the teachers led to a consideration of the teachers' discourse as one multiple case study rather than 10 individual case studies (Yin, 1993). Emergent categories provided a basis for a common analytical scheme (Demazière and Dubar, 1997), which represents a descriptive portrait of the teachers' relationships to science.

**academic/epistemic dimension**

Analysis indicated that the teachers' ideas of science are not different from what is reported by research in the field (Larochelle and Désautels, 1992; Lederman, 1999; Roth and Lucas, 1997). For example, throughout the interviews, when referring to the nature of science, the teachers used phrases such as, ‘When we work in science we go deep into the explanation of things' or ‘science, like philosophy, allows us to understand the “why” of things', or even, ‘Science is important because the student doesn't stop at the “what” but instead s/he goes further in his or her investigation in order to find the “why” and the “how” of things.' Teachers' discourse indicates that science allows them to understand ‘things' in a profound and deep way that requires a significant cognitive effort.

Conversely, teachers attributed a different cognitive status to everyday knowledge by implying that it is less demanding from a cognitive point of view, ‘We know “how” to do things in our everyday lives but we don't stop to think “why” we do them.' The hierarchical status attributed by the teachers
to scientific knowledge is also reported in other studies and is characteristic of traditional empirico-realist views of science.

Regarding teachers' views of scientific method, observation, experimentation, and use of models in science, they revealed having similar empiric-realist views as those reported in the research. For the teachers, ‘The scientific method is a linear set of steps that scientists have to follow’, ‘scientific observation is neutral and objective’. ‘Experiments in science prove the truth.’ Finally, ‘Models in science represent the reality of things.’

Despite these findings, when the teachers referred to the notion of observation there was an unexpected outcome. Indeed, teachers questioned the commonly held idea that observations in science are objective and neutral. This questioning seems to have been influenced by their own observations throughout the workshop's experimentation phase. The teachers, who considered themselves experts regarding the phenomenon of the rising of the arepas, had their doubts as to what they had observed during the experimentation. Not all the arepas rose, and it was hard to tell which ones actually did rise and which ones did not. The teachers gave a couple of explanations as to why their observations had not been conclusive, including the fact that they actually wanted to see their arepas successfully rise. In other words, teachers suggested that subjective factors played a role in the way they made their observations.

When asked if scientists would have been able to make better and more objective observations of the same phenomenon, the teachers were adamant that scientists could not have been more objective. Indeed, teachers considered themselves to be the experts and to have the know-how regarding the arepas, and if anybody could have observed minimal variations or changes regarding the rising of the arepas, it would have been they and definitively not the scientists because ‘scientists know nothing about arepas’. ‘Scientists could not have observed better than us, after all, we are the experts regarding the arepas.’ ‘If they [scientists] would have prepared them, they would have also wanted to see them rise.’

This confidence in their expertise and in their own capacity to adequately observe the phenomenon led teachers to consider the subjective factors involved in observations in science. This indicates that teachers in this research moved away from the traditional ‘objectivity-laden’ empiric-realistic towards a more socioconstructivist approach that takes into account the social and subjective aspects involved in the production of scientific knowledge.

The discourse analysis revealed a final relevant aspect regarding the academic dimension: that is that an empowering relationship to science emerged in the context of the workshop. Indeed, teachers were able to explain the scientific phenomenon based on their expertise and this fact led them, on the one hand, to have confidence in their own knowledge and to value it, and on the other hand to be less dependent on scientific explanations, textbooks or other sources
of scientific information. For example, in the context of the workshop, teachers were confident in their own explanations regarding the phenomenon of the rising of the arepas, ‘I can explain it because it’s something I do everyday.’ They did not request a sheet with scientists’ explanations for the phenomenon even though it was available for them throughout the workshop, and they used it only as a validation for their own explanations and to make some adjustments regarding the use of specific scientific terminology. However, when asked what they would do if they had to explain the phenomenon of photosynthesis, teachers expressed that they would have to, ‘investigate in textbooks’, or ‘check out other sources of information like films or videos’. This illustrates their confidence regarding their own spontaneous explanations of the rising of the arepas as opposed to the investigation required to explain photosynthesis.

### Professional Dimension

Teachers’ discourse revealed that the way they related to science was strongly influenced by the way they perceived their professional practice, that is, the way they perceived good teaching and learning practices. For them, traditional science classes ‘are boring because they are theoretical and there is nothing but formulas written on the blackboard’. On the contrary, they considered classroom activities related to everyday life to be ‘motivating’, ‘innovative, different and original’, ‘interesting and very important’. They also expressed that this type of learning context ‘takes into account the learners’ opinions and ideas’ and it also ‘encourages participation and reflection’. Moreover, ‘Teachers find it easy to teach because they can relate to something they do everyday (preparing the arepas) and they are experts in the subject.’ It also encourages ‘practical and hands-on activities’, it ‘stimulates curiosity’, is ‘meaningful to the students’ and ‘values students’ everyday knowledge’. Finally, some teachers mentioned that this type of classroom activity allows students to understand the concept in their own way, not reproduce it the way it is written in the textbook, or, as one teacher mentioned, ‘students can express it in their own words’.

### Social Dimension

Teachers expressed having had some rough experiences with science throughout their own school years, ‘My experience with math and science was negative and traumatic’, ‘my science teacher only screamed and never allowed us to think for ourselves’. At the same time they recognized the potential in science classes to develop ‘students’ natural curiosity’, to ‘encourage students’ creativity, their interest in nature’. Finally, they considered that ‘activities like the one they [we] did in the workshop are particularly appropriate to encourage a positive learning environment in science classes’. This positive learning
environment would also encourage students to continue taking science classes and eventually pursue careers in science that would allow them to ‘become someone in society’.

results and conclusion

The most interesting finding in this research is the unexpected way the teachers perceived the notion of objectivity in science. Having as a reference the context of the workshop, teachers questioned the commonly held idea that observations in science are objective and neutral. Indeed, their own observations throughout the workshop’s experimentation phase raised doubts in terms of the objectivity of their observations as experts. They also attributed a subjective character to observations, because they themselves realized that throughout the experimentation phase, they ‘wanted’ to see their arepas grow, which influenced their final observations. This led them to consider that scientists in the same situation would also encounter subjective dilemmas. After all, as one teacher expressed it, ‘We should not forget that scientists are humans too’. Therefore, teachers in this research portrayed some aspects of how scientists work in the lab as opposed to how they actually present the research that appears to be objective and sequenced.

Teachers’ expertise and know-how regarding the phenomenon related to their everyday knowledge and culture led them to value and have confidence in their own knowledge and therefore to be less dependent on scientific explanations, textbooks or other sources of scientific information. In the context of the workshop, their attitudes towards science changed from being submissive and even ‘scared’ of science to being enthusiastic and able to participate actively and creatively in the process of constructing scientific knowledge. Teachers felt empowered in a context where their everyday knowledge, expertise and culture were taken into account.

Moreover, pedagogy based on teachers’ expertise and knowledge related to their everyday life experiences represents an important option for teacher education and professional development programs. If during a four-hour workshop positive results were reported in terms of teachers being more confident in their own knowledge, this means there is a huge potential for medium- or long-term programs using this approach.

An additional value of this study is its contribution to the study of relationships to knowledge in the specific field of science education. Indeed, Charlot et al. (1992) have been studying general relationships to knowledge and have claimed the need to expand this field of study to specific disciplinary fields. Therefore, the integration of specific aspects of science education to the analytical procedures proposed by these researchers to study relationships to knowledge represents an important contribution to this field of research.
notes

1. In Latin America the term ‘popular’ education refers to the education of the 'people' and refers specifically to the low socioeconomic status of the population – which in the case of Venezuela is approximately 80 percent of the population (Esté, 2007).

2. Von Glasersfeld explains this notion of viability of constructed knowledge by using the metaphor of the key that can ‘fit’ many locks and is not limited to ‘matching’ only one lock. In other words, we construct knowledge that may ‘fit’ accepted knowledge but does not necessarily have to be its absolute ‘match’. Different constructions can therefore explain one phenomenon, and these constructions can be useful or viable in a determined setting or context. In another context where it is no longer suitable, there is the possibility of reframing it or reconstructing it in order to adapt it to new circumstances. Kuhn (1970) gives us an example of this notion of ‘viability’ as opposed to the ‘truth’ of scientific knowledge:

   An investigator who hoped to learn something about what scientists took the atomic theory to be, asked a distinguished physicist and an eminent chemist whether a single atom of helium was not a molecule. Both answered without hesitation, but their answers were not the same. For the chemist the atom of helium was a molecule because it behaved like one with respect to the kinetic theory of gases. For the physicist, on the other hand, the helium atom was not a molecule because it displayed no molecular spectrum. Presumably both men were talking about the same particle, but they were viewing it through their own research training and practice. (50–1).

3. The original title in French is: ‘Comment modéliser le gonflement d’un soufflé?’.

4. The teachers received a certificate (validated by the Ministry of Education of Venezuela) from Venezuela’s Central University research group FundaTEBAS/UCV – with whom I worked in close collaboration.

5. A copy of the forms handed out to the teachers is in Appendix 1 and 2. The reader should take into account that these are translations from Spanish (the language in which the research was conducted), and the original research project was presented in French (the language required by Sherbrooke University in Quebec).

6. It should be noted that the fact that the arepas rise indicates that they have been well prepared, and it is a matter of pride in Venezuelan households to prepare the best arepas.

references


Le Ligueur, 12(4), 2.

**appendix 1 (written data)**

1. **describe an ideal science class**

Describe an ideal science class in the sense that:

- There are no limits in the amount of resources you would be able to use
- There are no limits in terms of the pedagogical innovations you might think of.

To describe your ideal class you might want to be inspired by a real class that you have already done with your students or you can make up a new one. Explain why you consider this to be an ideal class.

2. **describe a personal event related to science**

Describe a personal event related to science that you might have experienced throughout your life and that might have influenced why you 'like' or 'dislike' science. Explain how this experience influenced you.

**appendix 2 (oral data: interview questionnaire)**

(1) In what school do you work? Why do you work there?
(2) Tell me about your experiences with science.
(3) Why do you think we teach science in elementary?
(4) What are, according to you, the advantages and disadvantages of doing the *arepas* activities in a classroom?
(5) Do you think the *arepas* activity was scientific? Why?
(6) Which explanation for the rising of the *arepas* did you consider the best? Why?
(7) Do you think that scientists also select explanations the way you did? Why?
(8) Did you use the reading to make your explanation of the rising of the *arepas*?
(9) How would you explain photosynthesis? Would you need a textbook?
(10) If you could choose, would you rather explain the rising of the *arepas* or photosynthesis?
(11) According to you, is it important to cook the *arepas* in the workshop?
(12) Did all the workshop teachers observe the rising of the *arepas* in the same way?
(13) Do you think all scientists observe the same way?
(14) How do you feel about the workshop activities?
(15) Would you do the same activities if you were not in an inner city school?
(16) Do you think science education is important in inner city schools? Why?

correspondence:
Irene Plonczak, PhD, Department of Curriculum and Teaching, 270 Hagedorn Hall, 119 Hofstra University, Hempstead, NY 11549, USA.
[email: irene.plonczak@hofstra.edu]