International Journal of Environmental & Science Education
Vol. 6, No. 2, April 2011, 141-159

Interest, attitudes and images related to science: Combining students' voices with the voices of school Science, teachers, and popular science

Vasilia Christidou

Received 24 November 2010; Accepted 11 March 2011

During the last decades students' science-related interests, attitudes, and images of science and scientists, and their differentiations according to gender, culture, and socio-economic status have been investigated by a multitude of research studies. These aspects of students' voices seem to be interrelated and to also affect students' achievement in science and their relevant study and career aspirations. Moreover, school science and teachers, as well as popular science are considered as factors determining students' voices. This paper attempts a mapping of relevant literature in order to highlight crucial outcomes and draw educational and research implications. It is suggested that a comprehensive and integrated investigation of the voices of students, of school science and teachers', and of popular science is required in order to make informed, research-based decisions on designing school science curricula and teaching.

Keywords: attitudes, images of science and scientists, interest, popular science, school science and teachers

Introduction

During the last decades science education research has focused on students' (i) negative attitudes, low self-efficacy, and declining interest about relevant subjects (Britner, 2008; Britner & Pajares, 2006; Dawson, 2000; Economic and Social Research Council, 2004; Gardner, 1985; Gough, 2002; Sjøberg, 2002); (ii) low achievement in international surveys on science literacy in various countries (Eurobarometer, 1993; OECD, 2002, 2004, 2006); (iii) inadequate and stereotypic conceptions about science and scientists (Chambers, 1983; Christidou, Hatzinikita, & Samaras, in press; Finson, 2002; Fung, 2002; Mason, Kahle, & Gardner, 1991; Newton & Newton, 1998; Schibeci & Riley, 1986; Song & Kim, 1999; Sumrall, 1995); and (iv) gender, race, and socio-economic status differences in respect to the aforementioned dimensions (Andre, Whigham, Hendrickson, & Chambers, 1999; Barman, 1999; Calabrese Barton, 2001; Chavous, 2002; Chavous, Rivas-Drake, Smalls, Griffin, & Cogburn, 2008; Joyce & Farenga, 1999; Mattern & Schau, 2002; Morgan, Isaac, & Sansone, 2001; Neathery, 1997; Rubin, Bar, & Cohen, 2003; She, 1998; Sjøberg, 2002; Song & Kim, 1999; Steinke, 1997, 2005; Weinburgh, 2003; Weinburgh & Steele, 2000).

ISSN 1306-3065

http://www.ijese.com/

These issues have generally constituted distinct lines of research. Nevertheless, they seem to be interrelated (Boylan, Hill, Wallace, & Wheeler, 1992; Finson, 2002; Fung, 2002; Häussler & Hoffmann, 2000; Schibeci & Riley, 1986; Siegel & Ranney, 2003), since students' interests, attitudes, self-efficacy beliefs and images of science and scientists interact (Boylan et al., 1992; Dimopoulos & Smyrnaiou, 2005; Finson, 2002; Fung, 2002) and consequently affect their achievement (Britner & Pajares, 2006; Häussler & Hoffmann, 2000; Schibeci & Riley, 1986; Siegel & Ranney, 2003) as well as their study and career choices, personal and social lives (Britner, 2008; Dawson, 2000; Schibeci & Lee, 2003; Song & Kim, 1999).

As already indicated these issues go beyond the concern of science education research and attract the attention of extensive international studies with broad resonance and effects on educational policies adopted by different countries, such as the OECD PISA (Programme for International Student Assessment) program. This international survey explores students' achievement in different disciplinary fields, including science. More particularly, it focuses on students' knowledge, competencies, and –recently- on their science-related attitudes and interests. Therefore, young peoples' level of scientific literacy, apart from content knowledge, is additionally assessed by means of a) their understanding of the contribution of science to society and its relevance to their personal and social lives; b) their perceptions of science as a particular type of human knowledge, of the constitution of scientific communities and the specificities of their activity; and c) their science-related interests and activities along with their intentions to act responsibly and critically towards the environment (OECD, 2006). The recent concentration on these dimensions reflects an official conviction that science-related interests, perceptions, motivations, values and actions constitute crucial components of scientific literacy (Gardner, 1975, 1985; Schibeci & Riley, 1986; Weinburgh & Englehard, 1994).

The significance and relevance of the investigation of perceptions, interests and attitudes related to science is additionally underlined by the fact that at least the last two Framework Programs launched by the European Commission (Framework Program 6, 2002-2006 and Framework Program 7, 2007-2013) have included "Science & Society" as a central pillar. In this context research funding is provided to promote an effective and democratic society in Europe, based on knowledge and pursuing harmonious integration of scientific and research achievements and relevant research policies in European society. This general framework encompasses education-oriented research and encourages actions aiming at improving the level of scientific literacy in young people, so as to render them capable of understanding the impact of science in society and to increase the number of young people opting for scientific careers. Indicative actions funded in the course of international projects involve: a) introduction of new methods in science education to make science more attractive and relevant to students; b) investigation of the role and image of scientists held by non-experts and particularly by young people; c) strengthening the role of women and promoting gender equity in science and science teaching (European Commission, 2006).

Moreover, education is not a linear or predictable causal system allowing for accurate and uniform regulations of the factors that determine learning, as conventional educational research and policy lines of thinking might suggest. Instead, education should be considered as an open, complex and recursive system, of an intersubjective nature, within which relations and communication between members of the classroom community (i.e. teacher and students) create new, common worlds and contribute to the co-construction of meaning and the constitution of students' identities (Biesta, 2004). Thus, the complexities and interrelations described so far, indicate that investigation of the aforementioned issues would be significantly more fruitful and informative if they were studied in combination (Chavous, 2002).

This paper attempts to map the research literature relevant to students' voices, that is their science-related interests, attitudes and images of science and scientists, in order to highlight critical research outcomes and implications for resolving adjacent issues. To complete this mapping, the voice of school science and teachers, and the voice of popular science will also be recorded, since these are considered as critical factors influencing the voice of students. Implications for science education and research will also be formulated.

The Voice of Students

Students' Images of Science and Scientists

Students' k*n*owledge about scientific professions is often confused. They lack a well-rounded appreciation of the nature of science and the work which scientists and technologists undertake (Hill & Wheeler, 1991). Their relevant knowledge is superficial, ambiguous, and sometimes reflects complete ignorance of scientific professions, which also deters them from selecting a pertinent career (Scherz & Oren, 2006). Their conceptions of science and scientists are restricted, inaccurate, stereotypic, and controversial (Finson, 2002; Rubin et al., 2003; Song & Kim, 1999).
Mead and Metraux (1957) made the first attempt to systematically describe the image of scientists held by American high school students. This image revealed a stereotypic and complex perception of scientists, as elderly or middle aged men, who wear glasses and/or beards and work in laboratories surrounded by equipment -test tubes, Bunsen burners, flasks and bottles-, taking notes and reading books. One day the scientist may straighten up and shout: "I've found it!"
A similar image of scientists has been revealed by subsequent studies over the last decades, indicating that stereotypic images of young people about scientists have remained relatively stable (Basalla, 1976; Beardslee & O'Dowd, 1961; Hills & Shallis, 1975; Krajkovich & Smith, 1982; Ward, 1977). Other studies, using different versions of the DAST (Draw-A-Scientist-Test) technique initially proposed by Chambers (1983), confirmed that the stereotypic image of scientists (with lab-coat, eyeglasses, facial hair, presence of research, knowledge and technology symbols) is particularly powerful and stable, appears at about the age of 8 and is gradually reinforced with age (Chambers, 1983; Christidou, Hatzinikita, & Samaras, in press; Finson, 2002; Losh, Wilke, & Pop, 2008; Mason et al., 1991; Newton & Newton, 1998; Schibeci & Riley, 1986; Schibeci & Sorenson, 1983; She, 1998; Turkmen, 2008). This image is dominant among students with different national and cultural characteristics (Barman, 1999; Buldu, 2006; Finson, 2002; Fung, 2002; She, 1998; Song & Kim, 1999; Sumrall, 1995).

These studies have also revealed gender stereotypes regarding professions perceived as scientific: in majority, students depict male scientists (Buldu, 2006; Chambers, 1983; Finson, 2002; Flick, 1990; Fort & Varney, 1989; Hill & Wheeler, 1991; Mason et al., 1991; Schibeci & Sorenson, 1983; Sumrall, 1995; Turkmen, 2008), while female scientists tend to be drawn exclusively by girls (Maoldomhnaigh & Hunt, 1988; She, 1998). Others report that boys exhibit greater gender and overall stereotyping of scientists than girls (Huber & Burton, 1995; Steinke, 1997; Steinke et al., 2007).

Students' perceptions regarding the personality of scientists are varied and controversial. They are typically thought of as intellectually gifted geniuses, dedicated to the conquest of knowledge (Rubin et al., 2003; Ward, 1977). Frequently scientists are considered as immoral and unreliable (Song & Kim, 1999); inept, isolated and unsociable (Finson, 2002; Mason et al., 1991; Rubin et al., 2003); distant (Flick, 1990; Ward, 1977); performing laboratory experiments in secrecy (Chambers, 1983; Mead & Metraux, 1957; Ward, 1977); indifferent about other people and with extremely limited interests (Schibeci, 1986). What is prevalent among such features is

that scientists are considered as eccentrics with weird –often robotic- characteristics (Huber & Burton, 1995) and this stereotypic perception has dominated for more than fifty years. Even young children often portray scientists as 'mad, bad and dangerous' (Mead & Metraux, 1957; Haynes, 2003); as atheists, arrogant and brutal, but also as positive role-models devoted to society's well-being (Mead & Metraux, 1957; Turkmen, 2008).

Stereotypic qualities in students' drawings reflecting their distorted, superficial and inaccurate perceptions of science and scientists (Pion & Lipsey, 1981) could be interpreted as deficits in their scientific literacy (Palmer, 1997).

Young people's perceptions of science and scientists are related to their views of scientific knowledge and practice, to their attitudes towards science (Boylan et al., 1992; Finson, 2002; Fung, 2002; She, 1998), as well as to their personal, professional, and social aspirations (Song & Kim, 1999; Schibeci & Lee, 2003). Clearly, students who attribute negative features and roles to scientists are hardly expected to pursue a scientific career (Gardner, 1980). This seems to be especially true for girls: different researchers have reported that girls –more than boys- regard science as competitive, impersonal, abstract, rule-founded, certainty-bounded, deprived of imagination and as a product of individual effort made exclusively by male scientists, without moral or social inhibitions (Brickhouse, Lowery & Schultz, 2000; Buldu, 2006; Chambers, 1983; Flick, 1990; Fort & Varney, 1989; Gilbert & Calvert 2003; Hill & Wheeler, 1991; Mason et al., 1991; She, 1998; Steinke, 2005; Turkmen, 2008; Yager & Yager, 1985).

Students' Science-Related Interests and Attitudes

In regards to the relevance of science, students view scientific knowledge as an important component of their education, acknowledging its value for explaining everyday experience. However, they primarily stress the instrumental value of science (e.g. for pursuing a career) than its intrinsic interest (Osborne & Collins, 2001).

More particularly, students' interest in science involves three dimensions (Häussler & Hoffmann, 2000): a) interest in a particular context in studying science; b) interest in a particular content connected with that context; and c) interest in a particular activity a student is engaged in, in conjunction with that content. Therefore, the context in which science is studied is a powerful predictor of students' interest. Contexts that stimulate interest involve science as a) a means to promote practical competence; b) a socio-economic enterprise; c) a vehicle to enhance emotional experience; d) an intellectually challenging endeavor; and e) a vehicle to qualify for professional life.

As far as different science subjects are concerned, chemistry seems to be the subject that lacks appeal and relevance for students in general. The features of physics and chemistry found interesting to students are those that involve concrete, observable and directly manipulable entities, and the activities that involve experimentation and investigation (Osborne & Collins, 2001). Apart from these general trends, students' interests and attitudes related to science are significantly differentiated according to age and gender, as well as to socio-economic and cultural background (Brickhouse & Potter, 2001; Catsambis, 1995). These factors -combined with the classroom environment and science teaching practices employed- are considered as particularly important in shaping students' multiple and fluid identities (Brickhouse et al., 2000; Buck, Cook, Quigley, Eastwood, & Lucas, 2009; Calabrese Barton 1998; Crawford & Unger, 2000; Tan & Calabrese Barton, 2008a, 2008b). As they advance from primary to secondary education, students rapidly lose their interest in science (Baird & Penna, 1992) and cease seeing it as a viable option for their future, or associating it with their success aspirations (Bowtell, 1996; Kahle & Meece, 1994). Also, boys tend to be more interested in science than girls (Catsambis, 1995; Dawson, 2000; Evans, Schweingruber, & Stevenson, 2002; Gardner, 1975; Tamir, 1991; Weinburgh,

1995) –especially girls from low-income and minority backgrounds (Calabrese Barton, Tan & Rivet, 2008; Weinburgh, 2003)- and to engage more often in relevant activities (Joyce & Farenga, 1999; Kahle & Lakes, 1983; Mattern & Schau, 2002; Morgan et al., 2001; Neathery, 1997; Sjøberg, 2002). Similarly, boys tend to opt for scientific professions more frequently than girls (Britner, 2008; Semela, 2010), who value careers with a strong interpersonal and communicative dimension (Zeldin, Britner, & Pajares, 2008), and these preferences are also correlated with students' stereotype images of scientists described above (Buldu, 2006; Maoldomhnaigh & Mhaolain, 1990, Tamir & Gardner, 1989). Moreover, gender differences deepen from primary to secondary education, pertain in different countries and maintain over time (Jones, Howe, & Rua, 2000; Osborne, Simon, & Collins, 2003).

Physics is the least attractive discipline for girls, who exhibit significant preference to biology (Britner, 2008; Joyce & Farenga, 1999; Osborne & Collins, 2001; Tamir, 1991). Male students are interested in topics such as atomic bombs, atoms, computers and scientific applications in technology (e.g. the application of mechanics on cars), and they often report using tools and instruments (like batteries, electric toys, or microscopes). On the other hand, female students engage in science in a variety of ways, which might diverge from the conventional gendered identities promoted by school science teaching (Brickhouse et al., 2000). Girls are mainly interested in topics such as animal communication, healthy diet, or in topics with an aesthetic dimension (e.g. rainbows), while their typical out-of-school, science-related experiences include bread-making, observing birds and stars, knitting, or planting seeds. Moreover, girls' scientific interests and experiences often have a powerful affective and interpersonal dimension, that is they are strongly influenced by the presence of other people who they love and admire (Baker & Leary, 1995; Calabrese Barton et al., 2008; Jones et al., 2000; Osborne & Collins, 2001; Sjøberg & Imsen, 1988).

Nevertheless, there are significant and interesting convergences between the interests of male and female students: what interests girls, tends to interest boys as well –but not the reverse. For instance, both genders regard topics related to human biology (health, diet and fitness, diseases and cures), plants and animals, light and sound, space and astronomy as particularly interesting. At the same time, girls' interest in these areas is significantly higher than boys' (Christidou, 2006; Osborne & Collins, 2001).

Research in the field of students' interests and attitudes towards science indicates that these factors affect students' achievement (Häussler & Hoffmann, 2000; Schibeci & Riley, 1986; Siegel & Ranney, 2003), as well as their course and career choices (Dawson, 2000). Especially young women are frequently uncertain about choosing a scientific career because of the 'superwoman' role that is required to balance a science career and family life. Previous studies have examined girls' science self-concept, i.e. their confidence in their ability to perform and succeed in science-related careers. Girls are more likely to have gendered self-concepts and perceptions of science that keep them from science careers. Also, the stereotypic view of male-dominated science seems to negatively affect adolescent girls' attitudes toward science. Thus, commonly held beliefs related to the nature of scientific research make science seem a rather unattractive career choice for young women. To be a scientist requires total commitment to and immersion in the scientific enterprise. Extreme competitiveness is essential for the pursuit of excellence in science (Gilbert & Calvert 2003). Such an environment is not hospitable for women, who apparently prefer an environment of cooperation rather than competition. Therefore, having a family and a scientific career are incompatible endeavors. These perceptions have the potential to further reduce the number of women who choose science as a career (Monhardt, Tillotson, & Veronesi, 1999; Steinke, 1997).

The Voice of School Science and Teachers

Students' –and especially girls'- low interest in science and their relatively negative attitudes are at least partially attributed to the way relevant disciplines are taught at school. Science curricula, school textbooks, teachers and their teaching practices are crucial factors considered to negatively affect students' attitudes towards and interest in science, since they tend to emphasize its academic, strongly intellectual and abstract character, and to present it in a decontextualised way, distanced from everyday life (Häussler & Hoffmann, 2000; Semela, 2010). Students state that science as a school subject is irrelevant, and therefore not useful in everyday life (McSharry & Jones, 2002; Siegel & Ranney, 2003). In their view there is a considerable mismatch between science-in-society and science-in-school. School science is unattractive since it does not involve topics of interest; it does not provide students with opportunities for creative expression; and it is fairly alienated from society (Brickhouse et al., 2000; Buck et al., 2009; Gibson & Chase, 2002; Gough, 2002; Häussler & Hoffmann, 2000; Kelly, 2000; Millar & Osborne, 1998; Osborne & Collins, 2001; Osborne et al., 2003; Ryder, 2002; Sjøberg, 2002). More particularly, the thematology usually included in school science curricula has been found to significantly diverge from secondary students' interests, while topics of interest for adolescents cover a very small part of their subject matter (Christidou, 2006; Dimopoulos & Smyrnaiou, 2005). School science fails to expose state-of-the-art research as presented in the public field (e.g. by the mass media) and as perceived by the general public.

Moreover, school science is usually fragmented in different, strictly isolated disciplines, and/or presented in contexts of limited interest for students, thus failing to provide students with a coherent picture (McSharry & Jones, 2002; Siegel & Ranney, 2003).

In contrast, science-in-society (i.e. science as it is presented and perceived by the general public) is highly contextualized: it tends to focus on complex, topical, and controversial issues, often interdisciplinary and with compelling social aspects related with the production of scientific knowledge, with moral, political, and religious values, or with conflicting interests of different social groups (Bauer, 1994; Dimopoulos & Koulaidis, 2003; Driver, Leach, Millar, & Scott, 1996).

Science curricula and school teaching apparently fail to highlight these dimensions. Therefore, the image cultivated to students through science teaching at school is that science consists of objective and value-free knowledge, over and above moral and human values and of a cluster of concepts and facts to be 'learnt' (Gibson & Chase, 2002; Gough, 2002; Häussler & Hoffmann, 2000; Kelly, 2000; Millar & Osborne, 1998; Osborne & Collins, 2001; Osborne et al., 2003; Ryder, 2002; Sjøberg 2002). Thus, traditional science instruction at school fails to introduce students to the real world of scientific environments or to the professionals who work there (Scherz & Oren, 2006).

At school, science teachers play an especially crucial role in the formation and reorganization of students' conceptions and attitudes towards science and scientists (Turkmen, 2008). In particular, teachers' conceptions and attitudes towards science and scientists establish a 'hidden curriculum' and determine to a large extent their teaching practices (Lunn, 2002). Teachers' inadequate understanding of the nature of science may pose difficulties in introducing coherent and compelling teaching practices addressing their students' interests and experiences and perpetuate to implement traditional, teacher-centered instruction (Bianchini, Johnston, Oram, & Cavazos, 2003). Hence, the teachers' views and attitudes towards science have an impact on the respective views and attitudes of their students. Previous studies have confirmed that teachers with a positive view towards science tend to inspire analogous positive stances in their students (Koch, 1990). On the other hand, many teachers have been found to adopt stereotypic images of scientists identical to those of students (Finson, 2002; Hatzinikita, 2007; Hatzinikita, Christidou, &

Bonoti, 2009; Moseley & Norris, 1999), which often go hand in hand with negative attitudes towards science. These teachers are expected to have a negative impact on the ways their students conceive of science and scientists (Moseley & Norris, 1999; Quita, 2003), as well as on the students' likelihood of selecting and pursuing school science courses and, accordingly, of opting for a future career related to science (Finson, 2002; Quita, 2003).

What is more, both science teachers and school textbooks frequently promote gendered images of science (Scantlebury & Baker, 2007): in science classrooms, girls are generally positioned with less power and gain teachers' attention less often than boys (Brickhouse et al., 2000; Buck et al., 2009; Calabrese Barton et al., 2008); science textbooks also fail to eliminate barriers to women in science, vastly including illustrations of males (Bianchini, 1993). These factors could be expected to particularly discourage female students from engaging in science.

The Voice of Popular Science

Popular science, communicated by the mass media, the internet, comics, films etc, pervades information sources widely used by young students -and the public in general- and is therefore considered as greatly influencing students' conceptions, interests and attitudes towards science (Aikenhead, 1988; Driver et al., 1996; Flick, 1990; Fung, 2002; Gardner, 1980; Lewenstein, 2001; Long & Steinke, 1996; Matthews & Davies, 1999; Mead & Metraux, 1957; Reis & Galvao, 2004; Schibeci & Sorensen, 1983; She, 1998, Song & Kim, 1999; Steinke, 1997; Turkmen, 2008). These information sources often promote intense, outdated, controversial, stereotypic and gender-biased images of science and its people. Besides, many students base their representations of scientists on popular stereotypic figures of mad and eccentric professors (e.g. Dr Jekyll and Mr Hyde, Frankenstein).

Therefore, there is a widespread premise that the public -because of a widespread lack of science literacy- is relatively defenseless to negative public representations of science and technology (Nisbet, et al., 2002). Indeed, young people may not have many positive scientist characters to identify with, since depictions of scientists are quite stereotypic across a wide range of media (Long, Boiarsky, & Thayer, 2001).

Although different information media do not present a universal or consistent description of the scientist, there are several "clusters" of public images that are seen across time period, medium, and genre. Distorted and stereotypic images are frequently conveyed, representing the scientist as an evil, violent, obsessed and eccentric caricature who works alone in a laboratory, committed to secret controversial projects (Reis & Galvao, 2004; Schibeci, 1986). He is socially irresponsible, ethically and mentally unstable (Basalla, 1976). On the other hand, scientists are sometimes portrayed as 'powerless' individuals, easily manipulated or dominated (Basalla, 1976; Nisbet et al., 2002).

Thus, different information sources have essential limitations when aiming to divulge scientific and technological matters to the public. Among different information sources, television seems to have the strongest influence on the public and is considered to directly produce reservations that are reinforced through the medium's negative relationship with science knowledge. Many of the programs shown on television do not promote quality discussion about scientific activity; instead, they focus on the negative effects caused by science and technological innovations, thus promoting negative images of scientists and their work (Reis & Galvao, 2004; Schibeci, 1986).

Therefore, a myth of "dangerous" knowledge is cultivated and maintained, which pervades the public image of science (Weingart, Muhl, & Pansegrau, 2003). This prevalent image constitutes a relatively stable amalgam of traditional stereotypes originating from the pre-scientific pe-

riod (even from 14th century alchemists) and contemporary, constantly transforming conceptions of scientific and technological progress and their influences (positive and negative) on society and the planet (Hüppauf & Weingart, 2008; Schummer & Spector, 2008).

Scientific research is misleadingly presented in the public sphere as a primarily practical and mechanistic activity of proof and demonstration, of an experimental and quantitative nature, collection of data, foundation of rules, certainties, and positive knowledge (Steinke, 2005).

These findings reveal the low level of public understanding of professions related with scientific and technological research as reflected in the public sphere. The public image of science and scientists reflects ambivalence between trust and mistrust towards science, between faith in progress and fear of the uncontrollable effects of science on society or the planet (Flicker, 2008).

This indicates that there is a strongly consolidated public conception of science that has remained unaffected by the rapid and radical processes of scientific development in the course of the last two centuries. Given that these two centuries were also marked by the improvement of public education, one can assume that such progress had little effect on the popular image of scientists. In conclusion, the old-fashioned, stereotypic and inaccurate public image of science is not apt to change (Schummer & Spector, 2008).

Despite inconsistencies in the different "clusters" of images of science and scientists, they all clearly suggest that the scientist is not "someone like us", but is the central hero of a widespread mythology concerning the world of science and the big adventure of the conquest of knowledge.

This dominant public image is evidently gendered in favour of men. Female scientists are hardly present in public representations of science (Flicker, 2008; She, 1998; Schummer & Spector, 2008). Moreover, in their sporadic representations, women scientists mainly bare features of gender rather than scientists' stereotypes. Their role is secondary and differentiated from those of their male colleagues. Male scientists are mainly represented as independent and dominant, while females as dependent and predestined to endow with care. In more traditional versions of this stereotype, the woman works under the supervision of a man as a student or assistant. In more contemporary versions, the "only" barrier for female scientists to undertake a leading or at least equal role to that of men is the male-dominated scientific system, but also their "immature" and sentimental nature (Flicker, 2008; Schummer & Spector, 2008).

On the other hand, some public information sources (such as newspapers, science television, and science magazines) tend to promote positive images of science (Nisbet et al., 2002). Educational science programs for youngsters generally promote an image of science as truth, fun, a part of everyday life and an activity for everyone. These programs may have a positive effect on students' attitudes towards science (Long & Steinke, 1996). Accordingly, the internet constitutes an alternative channel of information for young women, promoting more gender-balanced and accurate representations of scientists (Steinke, 2004).

Educational Implications

Research findings outlined in the previous sections indicate the necessity of a reform in science education to enhance people's interest in science and readiness to process scientific information, so that their personal interests and needs are well served (Aikenhead, 1988; Häussler & Hoffmann, 2000; Ryder, 2002; Sjoberg, 2002; Rennie & Stocklmayer, 2003; Osborne et al., 2003). More particularly, there is a need for science curricula to become more appealing to secondary students, more consistent with calls for scientific literacy (i.e. curricula that will enable future citizens to critically process scientific information in contexts of personal relevance that provide

an insight to the nature and development of scientific knowledge), and more culturally and socially relevant (Tamir, 1991; McSharry & Jones, 2002; Osborne & Collins, 2001; Ryder, 2002). Science education could aim at fostering an appreciation and understanding of science, by taking into account those aspects that are valued by students in their everyday lives, and in a variety of contexts, such as health, or environmental issues. Moreover, diversifying science literacy according to the interests and cultures of all students (Buck et al., 2009; Calabrese Barton & Yang, 2000) and merging science practices with culturally relevant everyday knowledge and discourse can enhance students' –especially minority girls'- participation in the classroom science learning community (Brickhouse et al., 2000; Calabrese Barton et al., 2008).

Along with uncontested, pre-established knowledge, science-in-the-making could also constitute an important part of contemporary curricula opening new perspectives for students' future possibilities and involvement as citizens. Additionally, in order to help students develop enduring interest in science, affective aims could also be incorporated in the curricula together with cognitive ones (Osborne & Collins, 2001).

School science –implemented by science curricula, school textbooks and teachers- along with popular science can play a decisive role in these directions. Both are regarded not as mere "transmitters" of social models, but as key agents of any attempt of improving young people's interests, attitudes and images related to science. For instance, positive attitudes and increase of interest towards science can be instigated through inquiry-based (Buck et al., 2009; Bulunuz & Jarrett, 2010; Fraser, 1980; Freedman, 1997; Gibson & Chase, 2002; Kelly, 2000) and issue-oriented instruction (Bianchini et al, 2003; Choi and Cho, 2002; Gough, 2002; Hofstein, Aikenhead, & Riquarts, 1988; Siegel & Ranney, 2003); the introduction of a variety of contextualized examples of the epistemology of science relating to issues of contemporary concern (e.g. the health effects of smoking, or use of mobile-phone), involving elements of scientific method such as empirical data collection and interpretation (Ryder, 2002).

At the same time, in order to enhance students' involvement in science, the relevant thematology (Choi & Cho, 2002; Christidou, 2006; Gough, 2002; Hofstein, Aikenhead, & Riquarts, 1988; Siegel & Ranney, 2003), teaching methods and techniques (Christidou, 2006; Fraser, 1980; Freedman, 1997; Gerber, Cavallo, & Marek, 2001; Gibson & Chase, 2002; Kelly, 2000; Tamir, 1990, 1991) in school science could be thoughtfully selected so as to reflect students' interests and preferred, familiar practices.

Moreover, involvement in informal out-of-school science activities (for instance after-school discussions, museum visits, or television watching) seems to be strongly associated with a commitment to science and science learning, a positive perception of the relevance of science (Bulunuz & Jarrett, 2010; Tamir, 1990, 1991), and development of scientific reasoning abilities among students (Gerber et al., 2001; Kelly, 2000), thus contributing to the development of more scientifically literate adults. Also, the media are considered as particularly influential in shaping young peoples' professional aspirations, as well as in balancing gender inequalities (Steinke, 2004).

Therefore, a new philosophy in science teaching should be adopted, which would present science as equally appropriate for boys/men and girls/women and focus on reinforcement of girls' interest, self-efficacy beliefs, and engagement in science (Britner, 2008; Britner & Pajares, 2006; Jones et al., 2000; Sjøberg & Imsen, 1988), since girls tend to lose their interest faster and are more easily discouraged from actively participating in science lessons than boys. At the same time, adjusting science curricula to girls' interests is expected to favor boys too, given that the fields and topics preferred by girls are equally attractive to boys (Christidou, 2006; Heering, 2000). A presentation of scientific knowledge as a human-centered investigative construction, progressive and constantly evolving, produced by broad communities of researchers independently of gender, race, or nationality, and in continuous interaction with society, along with pedagog-

ical practices legitimating diverse identities and roles for girls (Buck et al., 2009; Calabrese Barton et al., 2008; Tan & Calabrese Barton, 2008a) would also contribute to this direction.

Furthermore, if students construct more adequate conceptions about the nature of science and the image of scientists, they could reasonably be expected to develop more positive views and attitudes, to achieve the fundamental objective of scientific literacy for all and make more informed study and career choices in the future (Bianchini et al., 2003).

Also, teachers, who will be invited to implement this new philosophy, could be encouraged to be reflexive upon their own changing identities and adapt their beliefs and teaching practices to involve equitable teaching strategies and provide opportunities for all students, particularly females and those belonging to minority ethnic groups (Bianchini et al., 2003; Capobianco, 2007; Scantlebury & Baker, 2007; Tan & Calabrese Barton, 2008a), thus cultivating more appropriate conceptions about scientists and the nature of their activity to students. Therefore, targeted interventions are required in order for them to first explore and acknowledge their own stereotypic and gendered views and attitudes, revise them, and accordingly modify their teaching practices in order to promote appropriate images and educational and career aspirations to their students (Moseley & Norris 1999).

Implications for Research

The preceding analysis has highlighted critical facets of students' voices (images, attitudes, interests related to science) and discussed factors considered as particularly influential in shaping them, namely the voices of school science and teachers, as well as the voice of popular science. Previous studies focused on different aspects of the three voices. However, important research questions have not been systematically investigated thus far. For instance, research outcomes reflecting students' voices regarding their images of scientists and science, and related attitudes and interests have not been adequately interpreted and elaborated so as to allow their pedagogical exploitation (Jenkins, 2006). Therefore, additional, mixed methods (Buck et al., 2009), cross-cultural (Weinburgh, 1995) and systematic research is required to provide informed answers and well-documented implications for science teaching concerning the following issues (Brickhouse et al., 2000; Catsambis, 1995; Cleaves, 2005; Ford, Brickhouse, Lotero-Perdue & Kittleson, 2006; Jenkins & Pell, 2006):

- What is the relationship between students' images of science and scientists and the way these are presented through school science and negotiated in the classroom?
- What values are connected with scientific endeavor and how are these values related with students' interest, attitudes and aspirations for future engagement in science?
- How do students' voices change and why do gender differences deepen with age? Such an investigation would require that the students' multiple social identities and the contexts in which they choose to engage in science be examined to provide comparable data for a wide age range and therefore contribute to determining the development of students' interests, attitudes and conceptions.
- How and to what extent are factors like teachers' conceptions and pedagogical views, or the representations of science in school science textbooks, or in popular, informal information sources related with the development of stereotype conceptions about science and scientists in students?

Furthermore, school science textbooks, as well as other types of information sources, such as the mass media –and especially television-, or children's books have a massive, almost inevitable influence on students. This makes analysis of their content particularly important in order to determine their aspects or features negatively affecting youngsters' conceptions, interests and attitudes related to science and formulate relevant suggestions for their design.

Moreover, since lack of relevance of the science curriculum affects learning and interest negatively, determining specific factors related to the relevance of the contents and the contexts of science curricula should provide a basis for informed discussions on how to improve curricula and enhance interest in science in a way that a) respects social and cultural diversity and gender equity; b) promotes personal and social relevance; c) empowers the learner for democratic participation and citizenship. In this context, science teachers should reexamine their experiences, principles and teaching practices, adopt a philosophy of teaching and learning to allow for a multiplicity of student identities to evolve and to be valued (Brickhouse & Potter, 2001; Calabrese Barton, 1998, 2001; Tan & Calabrese Barton, 2008a, 2008b; Scantlebury & Baker, 2007), therefore promoting equity and diversity in science education (Capobianco, 2007).

On the other hand, while changing students' perceptions of science and improving relevant interests and attitudes is crucial in order to encourage young people –and especially girls- to consider careers in science (Catsambis, 1995), relevant intervention strategies aimed at influencing students' gender stereotypic images of scientists have not always been effective (Steinke, 1997). Therefore, it is essential to determine the image of science and scientists promoted by school science –including science curricula and textbooks-, by teachers and by popular information sources in order to design appropriate interventions.

The combined investigation of students' attitudes, interests and conceptions about science, their differentiations according to the different identities students construct, their evolution with age, as well as the contribution of school science, teachers and popular information sources to their formation can constitute an important first step for developing appropriate teaching and training science programs for both students and teachers. Besides, valuable insight for determining appropriate orientations for reforming school science textbooks, for constructing formal and informal educational material of different types, as well as for critically using the popular media –e.g. newspaper articles- in science teaching (Dimopoulos & Koulaidis, 2003; Steinke, 1997) would be obtained. Such developments could aim at counterbalancing relevant stereotypes (Sumrall, 1995) and at promoting a more accurate consideration of science and its relation with society, by highlighting a variety of scientific professions, the organization and operation of the scientific community and the participation and contribution of women in the production of scientific knowledge (Andre et al., 1999; Barman, 1999; Crawford & Marecek, 1989; Moseley & Norris, 1999; Rubin et al., 2003; Song & Kim, 1999).

More importantly, an integrated and cohesive exploration of the voices of students, school science and teachers, and popular science would determine particular relations between them, since they are considered to interact and play a key role in students' disposition to engage in science-related studies and careers. Therefore, a synthetic investigation of the three voices would produce an accurate mapping of young peoples' images of science and key factors determining them, with direct pedagogical implications and applications. Also, such an investigation would reveal crucial correlations between students' conceptions, attitudes and interests related to science with a) the ways in which these subjects are taught at school; b) relevant views of their teachers; and c) images of science and scientists promoted by formal and informal educational materials and information sources of different types, widely accessible by students.

In addition, the combination of age, gender, race, and socio-economic status differentiations with the above-mentioned correlations would enable a more comprehensive interpretation of

relevant outcomes. Since relevant gaps are particularly apparent and deepen considerably between primary and secondary education, explicit and detailed suggestions emanating from such an integrated and holistic investigation would specify a) the means by which young peoples' (more particularly girls', low SES, and minority students') interest in science could increase; b) the best practices to draw attention to women's –and underprivileged groups'- participation in the production of scientific knowledge and to counterbalance relevant gender stereotypes; c) the crucial elements required for a complete, contemporary and accurate consideration of science and its relationships with society, everyday life, and the environment.

Therefore, an integrated and comprehensive exploration of students' science-related attitudes, interests and images along with the relevant school science, teachers' and popular science's voices is expected to broadly address critical issues in science teaching, as acknowledged by the research community and policy makers internationally. These include the promotion of a more accurate and updated image of science as an interesting and attractive activity, combined with a more realistic and 'humane' image of scientists, their professions, and personalities, liberated from negative and gender stereotypes, thus allowing all voices to be heard and valued (Calabrese Barton, 1997) and providing relevant role models to young people –and especially girls-, to encourage their engagement in science-related studies and careers.

References

Aikenhead, G. (1988). An analysis of four ways of assessing student beliefs about STS topics. *Journal of Research in Science Teaching*, *25*, 607–629.

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching*, *36*, 719-747.

Baird, J. R., & Penna, C. (1992). Survey research. In R. Baird (Ed.), *Shared Adventure: A View of Quality Teaching and Learning (Second Report of the Teaching and Learning Science in Schools Project)* (pp. 185–274). Victoria: Monash University.

Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching*, *32*, 3-27.

Barman, C. R. (1999). Students' views about scientists and school science: Engaging K-8 teachers in a national study. *Journal of Science Teacher Education*, *10*, 43-54.

Basalla, G. (1976). The depiction of science in popular culture. In G. Holton & W. A. Blanpied (Eds.), *Science and its public* (pp. 261-278). Dordrecht-Holland: Reidel Publishing Company.

Bauer, H. H. (1994). *Scientific literacy and the myth of the scientific method*. Urbana, IL: University of Illinois Press.

Beardsley, D. C., & O'Dowd, D. D. (1961). The college-student image of the scientist, *Science, 133*, 997-1001.

Bianchini, J. (1993, April). *The high school biology textbook: A changing mosaic of gender, science and purpose*. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Bianchini, J. A., Johnston, C. C., Oram, S. Y., & Cavazos, L. M. (2003). Learning to teach science in contemporary and equitable ways: the successes and struggles of first-year science teachers. *Science Education, 87*, 419-443.

Biesta, G. (2004). "Mind the gap!": Communication and the educational relation. In C. Bingham & A. Sidorkin (Eds.), *No education without relation* (pp. 11-22). New York: Peter Lang.

Bowtell, E. (1996). Educational stereotyping: Children's perceptions of scientists: 1990's style. *Investigating: Australian Primary and Junior Science Journal, 12*, 4-10.

Boylan, C. R., Hill, D. M., Wallace A. R., & Wheeler A. E. (1992). Beyond stereotypes, *Science Education, 76*, 465-476.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching, 37*, 441-458.

Brickhouse, N. W., & Potter, J. T. (2001). Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching, 38*, 965-980.

Britner, S. L. (2008). Motivation in high school science students: A comparison of gender differences in life, physical, and earth science classes. *Journal of Research in Science Teaching, 45*, 955-970.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*, 485–499.

Buck, G., Cook, K., Quigley, C., Eastwood, J., & Lucas, Y. (2009). Profiles of urban, low SES, African American girls' attitudes toward science. *Journal of Mixed Methods Research, 3*, 386-410.

Buldu, M. (2006). Young children's perceptions of scientists: A preliminary study. *Educational Research, 48*, 121-132.

Bulunuz, M., & Jarrett, O. S. (2010). Developing an interest in science: background experiences of preservice elementary teachers. *International Journal of Environmental and Science Education, 5*, 65-84.

Calabrese Barton, A. (1997). Liberatory science education: Weaving connections between feminist theory and science education. *Curriculum Inquiry, 27*, 141-163.

Calabrese Barton, A. (1998). Teaching science with homeless children: pedagogy, representation, and identity. *Journal of Research in Science Teaching, 35*, 379-394.

Calabrese Barton, A. (2001). Science education in urban settings: seeking new ways of praxis through critical ethnography. *Journal of Research in Science Teaching, 38*, 899-917.

Calabrese Barton, A., Tan, E., & Rivet, A. (2008). Creating hybrid spaces for engaging school science among urban middle school girls. *American Educational Research Journal, 45*, 68-103.

Calabrese Barton, A., & Yang, K. (2000). The culture of power and science education: Learning from Miguel. *Journal of Research in Science Teaching, 37*, 871-889.

Capobianco, B. M. (2007). Science teachers' attempts at integrating feminist pedagogy through collaborative action research. *Journal of Research in Science Teaching, 44*, 1-32.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching, 32*, 243-257.

Chambers, D. W. (1983). Stereotypic images of the scientist: The Draw-a-Scientist Test. *Science Education, 6*, 255-265.

Chavous, T. (2002). African American college students in predominantly White institutions of higher education: Considerations of race and gender. *Perspectives, 8*, 142-150.

Chavous, T., Rivas-Drake, D., Smalls, C., Griffin, T., & Cogburn, C. (2008). Gender matters: The differential influences of school racial discrimination and racial identity on academic engagement among African American boys and girls. *Developmental Psychology, 44*, 637–654.

Choi, K., & Cho, H. (2002). Effects of teaching ethical issues on Korean school students' attitudes toward science. *Journal of Biological Education, 37*, 26-30.

Christidou, V. (2006). Greek students' science-related interests and rxperiences: Gender differences and correlations. *International Journal of Science Education*, 28, 1181-1199.

Christidou, V., Hatzinikita, V., & Samaras, G. (in press). The image of scientific researchers and their activity in Greek adolescents' drawings. *Public Understanding of Science*. First published on November 1, 2010 as doi: 10.1177/0963662510383101.

Cleaves, A. (2005). The formation of science choices in secondary school. *International Journal of Science Education, 27*, 471-86.

Crawford, M., & Marecek, J. (1989). Psychology reconstructs the female: 1968-1988. *Psychology of Women Quarterly, 13*, 147-165.

Crawford, M, & Unger, R. (2000). *Women and gender: a feminist psychology*. New York: McGraw-Hill.

Dawson, C. (2000). Upper primary boys' and girls' interests in science: have they changed since 1980?. *International Journal of Science Education, 22*, 557-570.

Dimopoulos, K., & Koulaidis, V. (2003). Science and technology education for citizenship: The potential role of the press. *Science Education, 87*, 241-256.

Dimopoulos, K., & Smyrnaiou, Z., (2005). Factors related to students' interest in science learning. In D. Koliopoulos & A. Vavouraki (Eds.), *Science Education at Cross Roads: Meeting the Challenges of the 21st Century* (pp. 135-142). Athens: Association for Science Education.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young People's Images of Science*. Buckingham: Open University Press.

Economic and Social Research Council [ESRC]. (2004). ESRC network project: Consulting pupils about teaching and learning. Retrieved from http://www.consultingpupils.co.uk (visited June 28, 2004).

Eurobarometer. (1993). *Europeans, science and technology: Public understanding and attitudes*. Brussels: European Coordination Office and Report International.

European Commission (2006). *Capacities Work Programme: Science in Society*. Retrieved from http://cordis.europa.eu/fp7/dc/index.cfm?fuseaction=UserSite. CapacitiesDetailsCall-Page&call_id=33 (visited July 17, 2007).

Evans, E. M., Schweingruber, H., & Stevenson, H. W. (2002). Gender differences in interest and knowledge acquisition: The United States, Taiwan, and Japan. *Sex Roles, 47*, 153-167.

Finson, K.D. (2002). Drawing a scientist: What we do and do not know after fifty years of drawings. *School Science and Mathematics, 102*, 335-345.

Flick, L. (1990). Scientist in residence program improving children's image of science and scientists. *School Science and Mathematics, 90*, 204-214.

Flicker, E. (2008). Women scientists in mainstream film. In B. Hüppauf, and P. Weingart, (Eds), *Science Images and Popular images of the Sciences* (pp. 241-256). N.Y.: Routledge.

Ford, D. J., Brickhouse, N. W., Lotero-Perdue P., & Kittleson, J. (2006). Elementary girls' science reading at home and school. *Science Education, 90*, 270-288.

Fort, D. C., & Varney, H. L. (1989). How students see scientists: Mostly male, mostly white, and mostly benevolent. *Science and Children, 26*, 8-13.

Fraser, B. J. (1980). Science teacher characteristics and student attitudinal outcomes. *School Science and Mathematics, 80*, 300-308.

Freedman, M. P. (1997). Relationship among laboratory instruction, attitude towards science, and achievement in science knowledge. *Journal of Research in Science Teaching, 34*, 343-357.

Fung, Y.Y.H. (2002). A comparative study of Primary and Secondary School Students' Images of Scientists, *Research in Science and Technological Education, 20*, 199-213.

Gardner, P. L. (1975). Attitudes to science: a review. *Studies in Science Education, 2*, 1-41.

Gardner, H. (1980). *Artful scribbles*. New York: Basic Books.

Gardner, P. L. (1985). Students' interest in science and technology: An international overview. In M. Lehrke, L. Hoffmann & P. L. Gardner (Eds.), *Interest in Science and Technology Education* (pp. 15-34). Kiel: Institute for Science Education.

Gerber, B. L., Cavallo, A. M. L., & Marek, E. A. (2001). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. *International Journal of Science Education, 23*, 535-549.

Gibson, H. L., & Chase, C. (2002). Longtitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education, 86*, 693-705.

Gilbert, J., & Calvert, S. (2003). Challenging accepted wisdom: Looking at the gender and science education question through a different lens. *International Journal of Science Education, 25*, 861-878.

Gough, A. (2002). Mutualism: a different agenda for environmental and science education. *International Journal of Science Education, 24*, 1201-1215.

Hatzinikita, V. (2007). Images of the scientist held by educators in Greece. *International Journal of Learning, 14*, 145-154.

Hatzinikita, V., Christidou, V., & Bonoti, F. (2009). Teachers' pictorial representations of the scientist. Στο A. Selkirk & M. Tichenor (Eds.,) *Teacher Education: Policy, Practice and Research* (pp. 233-249). Hauppauge NY: Nova Science Publishers.

Häussler, P., & Hoffmann, L. (2000). A curricular frame for Physics education: Development, comparison with students' interests, and impact on students' achievement and self-concept. *Science Education, 84*, 689-705.

Haynes, R. (2003). From alchemy to artificial intelligence: Stereotypes of the scientist in Western literature. *Public Understanding of Science, 12*, 243–253.

Heering, P. (2000). Getting shocks: Teaching secondary school physics through history. *Science & Education, 9*, 363-373.

Hill, D., & Wheeler, A. (1991). Towards a clearer understanding of students' ideas about science and technology: an exploratory study. *Research in Science and Technological Education, 9*, 125-137.

Hills, P., & Shallis, M. (1975). Scientists and their images. *New Scientist, 67*, 471-475.

Hofstein, A., Aikenhead, G. & Riquarts, K. (1988). Discussions over STS at the Fourth IOSTE Symposium. *International Journal of Science Education, 10*, 357-366.

Huber, R. A., & Burton, G. M. (1995). What do students think scientists look like? *School Science & Mathematics, 95*, 371-376.

Hüppauf, B. & Weingart, P. (2008). Images in and of Science. In B. Hüppauf, and P. Weingart, (Eds), *Science Images and Popular images of the Sciences* (pp. 3-31). N.Y.: Routledge.

Jenkins, E.W. (2006). The student voice and school science education. *Studies in Science Education, 42*, 49-88.

Jenkins, E.W., & Pell, R.G. (2006). *The Relevance of Science Education Project (ROSE) in England: a summary of findings.* Centre for Studies in Science and Mathematics Education, University of Leeds.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84*, 180-192.

Joyce, B. A., & Farenga, S. J. (1999). Informal science experience, attitudes, future interest in science, and gender of high-ability students: an exploratory study. *School Science and Mathematics, 99*, 431-437.

Kahle, J., & Lakes, M. (1983). The myth of equality in science classrooms. *Journal of Research in Science Teaching, 20*, 131-140.

Kahle, J. B., & Meece, J. (1994). Research on gender issues in the classroom. In D. L. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning* (pp. 542–557). New York: Macmillan.

Kelly, J. (2000). Rethinking the elementary science methods course: a case for content pedagogy, and informal science education. *International Journal of Science Education, 22*, 755-777.

Koch, J. (1990). The science autobiography. *Science and Children, 28*, 42-43.

Krajikovich, J. G., & Smith, J. K. (1982). The development of the image of science and scientists scale. *Journal of Research in Science Teaching, 19*, 39-44.

Lewenstein, B. V. (2001). Who produces science information for the public? In J. H. Falk (Ed.), *Free-choice Science Education: How We Learn Science Outside of School* (pp. 21-43). New York: Teachers College Press.

Long, M., Boiarsky, G., & Thayer, G. (2001). Gender and racial counter-stereotypes in science education television: A content analysis. *Public Understanding of Science, 10*, 255-269.

Long, M., & Steinke, J. (1996). The thrill of everyday science: images of science and scientists on children's educational science programmes in the United States. *Public Understanding of Science, 5*, 101-119.

Losh, S. C., Wilke, R., & Pop, M. (2008). Some methodological issues with "Draw a Scientist Tests" among young children, *International Journal of Science Education, 30*, 773-792.

Lunn, S. (2002). 'What we think we can safely say…': Primary teachers' views of the nature of science. *British Educational Research Journal, 28*, 649-672.

Maoldomhnaigh, M. O., & Hunt, A. (1988). Some factors affecting the image of the scientist drawn by older primary school pupils. *Research in Science and Technological Education, 6*, 159-166.

Maoldomhnaigh, M. O., & Mhaolain, V. N. (1990). The perceived expectation of the administrator as a factor affecting the sex of scientists drawn by early adolescent girls. *Research in Science and Technological Education, 8*, 69-74.

Mason, C. L., Kahle, J. B., & Gardner, A. L. (1991). Draw-A-Scientist Test: Future implications. *School Science and Mathematics, 91*, 193-198.

Mattern, N., & Schau, C. (2002). Gender differences in science attitude – achievement relationships over time among white middle-class students. *Journal of Research in Science Teaching, 39*, 324-340.

Matthews, B., & Davies, D. (1999). Changing children's images of scientists: Can teachers make a difference? *School Science Review, 80*, 79-85.

McSharry, G., & Jones, S. (2002). Television programming and advertisements: help or hindrance to effective science education? *International Journal of Science Education, 24*, 487-497.

Mead, M., & Metraux, R. (1957). The image of the scientist among high school students: A pilot study. *Science, 126*, 384 – 390.

Millar, R., & Osborne, J. (Eds) (1998). *Beyond 2000: Science Education for the future*. London: King's College. Retrieved from: http://www.kcl.ac.uk/depsta/education/ be2000/be2000.pdf (visited September 23, 2005).

Monhardt, R. M., Tillotson, J. W., & Veronesi, P. D. (1999). Same destination, different journeys: A comparison of male and female views on becoming and being a scientist. *International Journal of Science Education, 21*, 533-551.

Morgan, C., Isaac, J. D., & Sansone, C. (2001). The role of interest in understanding the career choices of female and male college students. *Sex Roles, 44*, 295-320.

Moseley, C., & Norris, D. (1999). Preservice teachers' views of scientists. *Science and Children, 37*, 50-53.

Neathery, M. F. (1997). Elementary and secondary students' perceptions toward science and correlation with gender, ethnicity, ability, grade, and science achievement. *Electronic Journal of Science Education, 2* (1).

Newton, L. D., & Newton, P. D. (1998). Primary children's conceptions of science and the scientist: Is the impact of a National Curriculum breaking down the stereotype? *International Journal of Science Education, 20*, 1137-1149.

Nisbet, M.C., Scheufele, D.A., Shanahan, J., Moy, P., Brossard, D., & Lewenstein, B.V. (2002). Knowledge, reservations, or promise? A media effect model for public perceptions of science and technology. *Communication Research, 29*, 584–608.

OECD. (2002). *PISA 2000 technical report*. Paris: OECD.

OECD. (2004). Learning for tomorrow's world. First results from PISA 2003. *Paris: OECD.*

OECD. (2006). *Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006*. Paris: OECD.

Osborne, J., & Collins, S. (2001). *Students' views of the role and value of the science curriculum: a focus-group study. International Journal of Science Education,* 23, *441-467.*

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education, 25*, 1049-1079.

Palmer, D. H. (1997). Investigating students. Private perceptions of scientists and their work. *Science & Technological Education, 15*, 173 – 183.

Pion, G. M., & Lipsey, M.W. (1981). Public attitudes toward science and technology: What have the surveys told us? *Public Opinion Quarterly, 45*, 303-316.

Quita, I. N. (2003). What is a scientist? Perspectives of teachers of color. *Multicultural Education, Fall 2003*, 29-31.

Reis, P., & Galvao, C. (2004). Socio-scientific controversies and students' conceptions about scientists. *International Journal of Science Education, 26*, 1621–1633.

Rennie, L. J. & Stocklmayer, S. M. (2003). The communication of science and technology: past, present and future agendas. *International Journal of Science Education, 25*, 759-773.

Rubin, E., Bar, V., Cohen, A. (2003). The images of Scientists and Science among Hebrew- and Arabic-speaking pre-service teachers in Israel. *International Journal of Science Education, 25*, 821-846.

Ryder, J. (2002). School science education for citizenship: strategies for teaching about the epistemology of science. *Journal of Curriculum Studies, 34*, 637-658.

Scantlebury, K., & Baker, D. (2007). Gender issues in science education research: Remembering where the difference lies. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 257-285). Mahwah, NJ: Lawrence Erlbaum Associates.

Scherz, Z., & Oren, M., (2006). How to change students' images of science and technology. *Science Education, 90*, 965– 985.

Schibeci, R. A. (1986). Images of science and scientists and science education. *Science Education, 70*, 139-149.

Schibeci, R., & Lee, L. (2003). Portrayals of science and scientists, and 'science for citizenship'. *Research in Science and Technological Education, 21*, 177-192.

Schibeci, R. A., & Riley, J. P. (1986). Influence of students' background and perceptions on science attitudes and achievement. *Journal of Research in Science Teaching, 23*, 177-187.

Schibeci, R. A., & Sorenson, I. (1983). Elementary school children's perceptions of scientists. *School Science and Mathematics, 83*, 14-19.

Schummer, J., & Spector, T. I. (2008). Popular images versus self-images of science. In B. Hüppauf and P. Weingart (eds), *Science Images and Popular images of the Sciences* (pp. 69-95). N.Y.: Routledge.

Semela, T. (2010). Who is joining physics and why? Factors influencing the choice of physics among Ethiopian university students. *International Journal of Environmental and Science Education, 5*, 319-340.

She, H. C. (1998). Gender and grade level differences in Taiwan students' stereotypes of science and scientists. *Research in Science and Technological Education, 16*, 125-135.

Siegel, M. A., & Ranney, M. A. (2003). Developing the Changes in Attitude about the Relevance of Science (CARS) questionnaire and assesing two high school science classes. *Journal of Research in Science Teaching, 40*, 757-775.

Sjøberg, S. (2002). Science and technology education in Europe: Current challenges and possible solutions. *Connect: UNESCO International Science, Technology, and Environmental Education Newsletter, 27*, 1-5.

Sjøberg, S., & Imsen, G. (1988). Gender and science education I. In P. Fensham, (Ed.), *Development and dilemmas in science education* (pp. 218-248). London: The Falmer Press.

Song, J., & Kim, K.S. (1999). How Korean students see scientists: the images of the scientist, *International Journal of Science Education, 21*, 957-977.

Steinke, J. (1997). A portrait of a woman as a scientist: breaking down barriers created by gender-role stereotypes. *Public Understanding of Science, 6*, 409-428.

Steinke, J. (2004). Science in cyberspace: science and engineering world wide web sites for girls. *Public Understanding of Science, 13*, 7-30.

Steinke, J. (2005). Cultural representations of gender and science: portrayals of female scientists and engineers in popular films. *Science Communication*, *27*, 27-63.

Steinke, J., Lapinski, K. M., Crocker, N., Zietsman-Thomas, A., Williams, Y., Evergreen, H. S., & Kuchibhotla, S. (2007). Assessing media influences on middle school-aged children's perceptions of women in science using the Draw-A-Scientist Test (DAST). *Science Communication*, *29*, 35-64.

Sumrall, W. J. (1995). Reasons for the perceived images of scientists by race and gender of students in grades 1-7. *School Science and Mathematics*, *95*, 83-90.

Tamir, P. (1990). Factors associated with the relationship between formal, informal, and non-formal science teaching. *Journal of Environmental Education*, *22*, 34-42.

Tamir, P. (1991). Factors associated with the acquisition of functional knowledge and understanding of science. *Research in Science and Technological Education*, *9*, 17-37.

Tamir, P., & Gardner, P. (1989). The structure of interest in high school biology. *Research in Science & Technological Education*, 7, 113-140.

Tan, E., & Calabrese Barton, A. (2008a). From peripheral to central, the story of Melanie's metamorphosis in an urban middle school science class. *Science Education*, *92*, 567-590.

Tan, E., & Calabrese Barton, A. (2008b). Unpacking science for all through the lens of identities-in-practice: the stories of Amelia and Ginny. *Cultural Studies of Science Education*, *3*, 43-71.

Turkmen, H. (2008). Turkish primary students' perceptions about scientist and what factors affecting the image of the scientists. *Eurasian Journal of Mathematics, Science & Technology Education*, *4*, 55-61.

Ward, A. (1977). Magician in a white coat. *Science Activities*, *14*, 6-9.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: a meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, *32*, 387-398.

Weinburgh, M. H. (2003). The effects of systemic reform on urban, African American fifth grade students' attitudes toward science. *Journal of Women and Minorities in Science and Engineering*, *9*, 53-72.

Weinburgh, M. H., & Englehard, G. Jr. (1994). Gender, prior academic performance and beliefs as predictors of attitudes toward biology laboratory experiences. *School Science and Mathematics*, *94*, 118-123.

Weinburgh, M. H., & Steele, D. (2000). The modified attitudes toward science inventory: Developing an instrument to be used with fifth grade urban students. *Journal of Women and Minorities in Science and Engineering*, *6*, 87-98.

Weingart, P., Muhl, C., & Pansegrau, P. (2003). Of power maniacs and unethical geniuses: science and scientists in fiction film. *Public Understanding of Science*, *12*, 279-287.

Yager, R. E., & Yager, S. O. (1985). Changes in perceptions of science for third, seventh and eleventh grade students. *Journal of Research in Science Teaching*, *22*, 347-358.

Zeldin, A. L., Britner, S. L., & Pajares, F. (2008). A comparative study of the self-eficacy beliefs of successful women in mathematics, science, and technology careers. *Journal of Research in Science Teaching*, *45*, 1036-1058.

Author

Dr. Vasilia Christidou is an Associate Professor at the University of Thessaly, Greece. Her research interests include teaching and learning in science, the promotion of Public Understanding of Science, and the process of recontextualization of scientific texts addressed to non-experts. **Correspondence:** Department of Preschool Education, University of Thessaly, Argonafton & Filellinon, 38221, Volos, Greece. E-mail: vchristi@ece.uth.gr

Fenle alakalı ilgi, tutum ve imajlar: Öğrencilerin ifadelerini okul feni, öğretmen ve popüler bilimle bağlama

Son on yılda öğrencilerin fenle ilişkili ilgileri, tutumları ve fen imajları, bilim adamları ve bunların cinsiyet, kültür, sosyo-ekonomik durumlar bağlamında farklılaşması birçok çalışmada araştırılmıştır. Öğrenci ifadeleri de bu yönlerin onların fendeki başarıları, kariyer istekleri ile ilgili ve etkiliyor gözükmektedir. Hatta okul fenni ve öğretmenler gibi popüler bilim, öğrencilerin ifadelerini belirleyen faktörler olarak düşünülmektedir. Bu makale önemli çıktıları aydınlatmak amacı ile ilgili literatürü haritalamayı, eğitsel ve araştırma imalarını resmetmeyi denemektedir. Okul fen müfredatı ve öğretiminin tasarımında, yeterli, araştırma tabanlı kararlar almak amacı ile öğrenci, okul fenni ve öğretmenlerin ifadelerinin, kapsamlı ve bütünleşmiş araştırmasının gerekliliği önerilmiştir.

Anahtar kelimeler: Tutumlar, fennin ve bilim insanlarının imajları, ilgi, popüler bilim, okul feni ve öğretmenler