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Addressing the science in schools crisis: media images, scientific literacy and students' lives[1]

Annette Gough
School of Education
RMIT University

Although students entering their first secondary school science classes have little background knowledge in science, they are usually enthusiastic about the subject. After four years of secondary science education very few continue on to study senior level science subjects and most hate the subject. Despite their teachers' best efforts, what has happened to the students' engagement with science in the intervening four years? The need for a scientifically literate citizenry is great as society struggles to come to terms with a myriad of issues that are scientifically related. Yet surveys consistently tell us that students cannot see the relevance of school science to their lives. Various solutions have suggested more qualified science teachers and a national curriculum, but I believe a different approach is needed. This paper moves beyond investigating the problematic relationships between scientific knowledge, the learning of science, and pedagogy and approaches the crisis from the perspective of the students. It discusses students' disengagement with science in junior secondary school science classrooms through an analysis of students' attitudes to science and their identity construction in science classrooms compared with media images of science and scientists as an alternate inquiry path to address the crisis.

Introduction

Although students entering their first secondary school science classes do not have much background knowledge in science (which is an issue in itself), they are enthusiastic about the subject. In many countries, after four years of secondary science education very few students continue on to study senior level science subjects and most hate the subject. Despite their teachers' best efforts, what has happened to the students' engagement with science in the intervening four years? It is this question which frames this paper.

In recent years there have been considerable reforms of curriculum for the middle years of schooling but there is little evidence that these efforts have resulted in improved levels of achievement or attitudes to science, in Australia at least. For example, Masters (2005, p. 10) argues from a performance testing perspective that

> If Australia is to lift its performance in mathematics and science over the next decade, then greater attention will need to be given to the teaching of basic factual and procedural knowledge and the development of teachers' confidence and competence in teaching primary school mathematics and science. The focus of the past decade on *what* is taught (the curriculum) needs to be accompanied by a greater focus on *how* subject matter is taught (research-based pedagogy).

This perspective is consistent with the findings from the Science in Schools Research Project (Deakin University 2003), but as a solution it is much too simplistic because it constructs the students as passive participants in a space where they actually assert themselves through engagement and interest in the subject matter. Students' disengagement with science education can be found in many countries. For example, the findings from the ROSE study (Sjøberg and Schreiner, 2005) are that students in industrialised countries, in particular, are ambivalent about the benefits of science, indicate sound scepticism to what scientists have to say and that science and technology are problem solvers for the environment, do not think science has opened their eyes to exciting jobs and few dream a bout becoming scientists. These findings also recently influenced the 2007 World Conference on Science and Technology Education where its final Perth Declaration released at the end of the conference

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"Observed a widespread lack of student interest in current school science and technology and of its relevance to them" and resolved to recommend to governments "To initiate revisions of the curriculum for school science and technology that will increase student interest in and recognition of the roles of science and technology in society".

The Perth Declaration also noted "the lack of recognition of science education as a vehicle for meeting national educational goals, and social and economic needs" which drew attention to the lack of students' interest in science being a threat to future societal development. Given this, in this paper I argue for different educational inquiries that investigate what happens in junior secondary school science education through an analysis of students' attitudes to science and their identity construction in science classrooms compared with media images of science.

The paper has, as its starting point, students' attitudes to science from the 1990s; I then compare these with more recent findings from the ARC and Victorian Department of Education and Training funded Improving Middle Years Mathematics and Science Project to see if the positive changes in public perceptions of science (see, for example, MORI 2005) are matched in secondary school students.

Background

The research project of which this paper is a part spans the past decade. It is concerned with constructions of identities by students in secondary school science classrooms and, in particular, strategies which recognise and encourage the development of postcolonial and poststructuralist student identities in science classrooms. Notions of identity and constructions of self in science classrooms are relatively new to science education research. Some science educators might even consider such notions to be heretical. However, the creation of intellectual conceptions of science has long been a concern of science teachers. As Fensham (1985, p. 421) argued two decades ago:

> Science educators, part of the educated in science, have tended to set out to create science education for schools that mirror their own (or science's) priorities. Hence the emphasis on conceptual knowledge and on the intellectual processes that are used with, and in the generation of, this sort of knowledge.

The separation of mind and body in science education is longstanding and goes largely unchallenged. Even the challenges to science's claims of objectivity from Kuhn (1962/1970) and others have not engaged the mind/body hierarchical dualism, however feminist epistemological studies have argued this point as well as drawing attention to the non-objective nature of scientific knowledge (see, for example, J. Harding 1996, S. Harding 1993, 1998, Merchant 1980, 2003). These arguments and research are yet to make a significant impact on science education, although a start has been made (see, for example, Gough 1998, 2001, Hines 2003, Weaver et al 2001).

A major focus in science education research has been the disembodied student and cognitive learning, as exemplified in the emphasis on constructivist views of science teaching and learning and other cognitive learning research over the past two decades (see, for example, Driver, Leach, Millar and Scott 1996, Fensham 1988, Fensham, Gunstone and White 1994, Gunstone 1990, Osborne and Freyberg 1985, Tobin, Kahle and Fraser 1990, White 1988). The concern has been with students' mental constructions of science rather than with how they construct their bodily selves and identities within science. The emphasis has been psychological rather than ontological. Driver (1989, p. 85) makes this point quite clearly in her definition of constructivism as "the perspective... whereby individuals through their own mental activity, experience with the environment and social interactions progressively build up and restructure their schemes of the world around them".

Although this constructivist approach challenges science's notions of objectivity by accepting that individuals construct meaning, the emphasis in most constructivist research in science education is concerned with personal rather than social constructions. This is very evident in the large body of research that has been conducted on students' images of science and, although these images actually cross the supposed boundary between personal and social constructions, the emphasis in much constructivist research has been on individual personal constructions and the meanings made by individuals.

However, some researchers see learning science as being both personal construction and social construction. For example, Driver et al (1994, p. 7) argue that "whereas the individual construction of knowledge perspective places primacy on physical experiences and their role in learning science, a social constructivist perspective recognises that learning involves being introduced to a symbolic world". The problematic relationships between scientific knowledge, the learning of science, and pedagogy are also now on the science education research agenda together with the notion that learning science involves students entering a new culture with its attendant socialisation and enculturation (see, for example, Aikenhead 1996, Hines 2003).

It is this symbolic world, together with the representations of reality and constructions of self and identity, and the reconciliations of mind and body that are made by students in secondary science classrooms that are the focus of my long term research project. However, it is also important to look at the context in which students experience public images of science and scientists. Thus, in recognition of the emphasis that has been given to images of science and scientists in research in science education and the relationship that this is purported to have with how students construct themselves in science classrooms, I firstly review discussions on images of science and scientists, research on students' images of science, and the use to which such research has been put. I then discuss the significance of this research in terms of more recent findings on students' attitudes to science from research studies such as the Relevance of Science Education (ROSE) Project (Schreiner and Sjøberg 2004, Sjøberg and Schreiner 2005) and the recently completed Australian Research Council (ARC) project on improving middle years mathematics and science (Tytler, Groves and Gough, 2003-2006).

Images of science and scientists

Images can be powerful in forming beliefs and attitudes, and they can play a role in the construction of identities. Although images are frequently acquired through social transmission, they are also formed from experiences (Howard 1992, White 1988).

Chambers (1983) and Haynes (1994), among others, provide useful short histories of verbal and visual images of scientists. During the eighteenth and nineteenth centuries the images were many and different, but invariably male: diabolical madmen, distinguished professors, harmless eccentrics, learned buffoons, and fashionable dilettantes were shown – often in conflict with religious authority or disputing among themselves – as naturalists in the field, physical scientists in laboratories, and as alchemists. According to Chambers (1983, pp. 255, 256):

> With few exceptions, these images are now seldom seen. As science has transformed its organizational structure, improved its general social status, and firmly established its social authority, a new professional image has emerged in the popular media. This image... differs in significant ways from earlier stereotypes. The naturalist has been almost entirely displaced by the laboratory scientist. Reference to alchemy and sorcery has all but disappeared. Controversy rarely reaches the public arena, though in recent years this element has begun to reappear especially in connection with environmental issues. In short, the image has been 'cleaned up' and, in a sense, standardized...
>
> The modern sanitized standard image has never fully replaced the older mythic images of the 'man of knowledge', yet it has achieved a ubiquitous and relatively unambiguous place in the forefront of the twentieth century mind.

Haynes (1994) also discusses the changing nature of the image of science and scientists, but she seems less convinced than Chambers that science and scientists have 'cleaned up' their image. Although Chambers tends to concentrate on the externalities of scientists' images, Haynes (1994, p. 313) also looks at other characteristics of these fictional scientists:

> The archetypal figures of Faustus, Frankenstein, Jekyll/Hyde, the Time Traveller, Doctor Moreau, and the Invisible Man have allowed the construction of cultural myths that each successive generation deconstructs for its own situation. It is not accidental that the Gothic novel *Frankenstein*, which has continued to acquire new relevance throughout the twentieth century, emanated from Mary Shelley's own subconscious fears concerning the future progress of science, the effect that the obsessive pursuit of power and knowledge might have on the emotional state of the scientist, and the eventual consequences for his family and community. While the details have changed, the essential fears remain: deep-rooted fears of the new, of a

> loss of emotional roots and even of extinction of the entire human race; fears concerning loss of individuality and the stability engendered by accepted values; fears of the cargo cult of technology, bringing with it immense power and unanswered questions about its control.

From her research Haynes (1994, p. 3) proposes six recurrent stereotyped representations of scientists in Western literature:

- *The alchemist*, who appears at critical times as the obsessed or maniacal scientist – most recently as the genetic engineering biologist.
- *The stupid virtuoso*, out of touch with the real world of social intercourse – both comic and sinister, the absent-minded professor.
- *The Romantic depiction of the unfeeling scientist*, who has reneged on human relationships and suppressed all human affection in the cause of science: the most enduring and common image in popular thinking.
- *The heroic adventurer* in the physical or intellectual world: a character who emerges at times of scientific optimism, but often a neo-imperialist.
- *The helpless scientist*, who has lost control either over his discovery or over the direction of its implementation.
- *The scientist as idealist*: the one unambiguously acceptable scientist who sometimes holds out the possibility of a scientifically sustained utopia, but who often is engaged in conflict with a technology-based system that fails to provide for individual human values.

According to Haynes (1994, p. 4):

> The majority of these stereotypes represent scientists in negative terms, as producing a long term liability for society. Yet these depictions have not only reflected writers' opinions of the science and scientists of their day; they have, in turn, provided a model for the contemporary evaluation of scientists and, by extension, of science itself.
> Realizations of this ongoing connection permits us to confront the widespread, often unacknowledged, fear of science and scientists in Western society. It also enables us to explore the basis of these fears, to deconstruct what the creators of fictional scientist characters were trying to express, and to ask which of those explicit anxieties are still relevant and should be addressed and which are anachronisms, relics of quite different social circumstances, irrelevant to our own society.

Research into stereotypical images of scientists dates from the mid 1950s. Mead and Metraux (1957) were the first to attempt to systematically describe this standard image in an informal study of a population of American high school students. The composite portrait which they drew has itself become a standard image of scientists in the media (Mead and Metraux 1957, pp. 386, 387, italics in original):

> The scientist is a man who wears a white coat and works in a laboratory. He is elderly *or* middle aged and wears glasses. He is small, *sometimes* small and stout, *or* tall and thin. He *may be* bald. He *may* wear a beard, *may be* unshaven and unkempt. He *may be* stooped and tired.
> He is surrounded by equipment: test tubes, bunsen burners, flasks and bottles, a jungle gym of blown glass tubes and weird machines with dials...
> He spends his days dong experiments... he writes neatly in black notebooks...
> One day he may straighten up and shout: 'I've found it! I've found it!'... Through his work people will have new and better products... he has to keep dangerous secrets... his work may be dangerous... he is always reading a book.

Chambers (1983, p. 256) notes that this image is drawn by children, adults and even scientists "who wish to convey graphically the concept of 'scientist'. Every element of the standard image either portrays directly some part of the scientist's actual world or else may be taken as symbolic of some part of that world". For example, according to Chambers (1983, pp. 256-257),

- the eyeglasses are associated with eyestrain and intense observation
- lab coats are associated with dirty (experimentation and empirical knowledge), and with purity (symbolically, as priestly white robes, or like a Klansman, according to Bleier 1986)

- beards, or being unshaven, may be seen in terms working long and unusual hours, or may represent "deviation from the accepted way of life" (as suggested by Mead and Metraux 1957), or they may represent wisdom and possession of knowledge.

The challenge is to deconstruct the images of science and scientists with which we are confronted – or which we imagine – and to explore the fears of them that may be present and the influence these may have on the development of a scientific identity by students in science classrooms, and their attitudes to science.

The scientist publicly rehabilitated?

On a seemingly regular basis there is a flurry of activity in the media about public images of science and particularly scientists, using headlines such as "Geeks bearing gifts" (Courtis 2006), "Revenge of the nerds" (Brown 1996) and "Revenge of the boffins" (Zinberg 1996). In each instance there is an argument for changing the image of scientists as portrayed in the media, perhaps to "show people who are motivated by ego or greed or passion, scientists who are compelling dynamic and, yes, even sexy" (Lederman 1996, as quoted in Zinberg 1996, p. 17). Brown (1996, p. 2), for example, reports that American scientists are angry at their portrayal in the media as "myopic, absent-minded, unkempt of hair, even crazed" and they believe that such portrayals are "not healthy".

Zinberg (1996, p. 17) reports that the American public maintains a largely negative attitude towards scientists as individuals. She is keen to see scientists explore the roots of the public's antipathy to science, and concludes by asserting that "an attribute of good science might just be 'nerdy' scientists– people who dream different dreams in their quest for answers. But in an increasingly antagonistic world, scientists might just have to learn more about themselves" (Zinberg 1996, p. 17).

Haynes (1994) is not so pessimistic about the portrayal of scientists in literature: for example, in a chapter on "The Scientist Rehabilitated" (p.312) she writes that

> the ideal scientist of the seventies and early eighties was required to be a philosopher and effective communicator with nonscientists. This particular role was emphasized in literature long before the need was acknowledged by real-life scientists, most of whom considered the popularization of science an activity to be denigrated, if not actively opposed...
> [There is] evolving a new role model for the scientist hero, replacing the crude, macho Martian-basher with a multidisciplinary and socially aware communicator.

This view, that scientists in literature are now much more socially aware, is also supported by movies such as *Adaptation* (dir: Spike Jonze, 2002), *Jurassic Park* (dir: Steven Spielberg, 1993), and *The Day After Tomorrow* (dir: Roland Emmerich, 2004), by literary characters such as Tony Hill, the criminal profiler in Val McDermid's crime fiction, and by television series such as *House* and *X Files*. It is within the context of these movies, stories, television series, advertisements and media reports – as well as classrooms – that students develop their images of science, and perhaps their attitudes to science and their identities in science classrooms. This then provides a context and a challenge for the conduct of educational inquiries into students' perceptions of science.

A turnaround in public perceptions of science is confirmed by recent research (Office of Science and Technology and the Wellcome Trust 2000, MORI 2005) which indicates that the British public, at least, are changing their attitudes to science. The 2000 survey "found that three-quarters of the British population are 'amazed' by the achievements of science. Largely this is because they can see the benefits for themselves – two-thirds agree that science and technology are making our lives healthier, easier and more comfortable. Only a fifth claim that they are not interested in science and do not see why they would be, and a partially overlapping fifth agree that the achievements of science are overrated." (Public Engagement with Science and Technology Team, 2000). Even more interesting, the MORI (2005) survey found that only 4% of respondents said that "boffins", "nerds", "mad professor" and similar associations came to mind in response to the word "science".

But what are present day secondary school students' images of science and their attitudes to science?

Students' images of science

There are many different strategies for probing students' understanding of, attitudes to, and images of science, and scientists. White and Gunstone (1992), for example, describe the strategies of concept mapping, prediction–observation–explanation (P–O–E), interviewing (about concepts, and about instances and events), drawings, fortune lines, relational diagrams, word association, and question production.

Other science education researchers, who are also interested in personal constructivism, tend to make use of a subset of these strategies. For example, in one of the classic texts on "children's science", Osborne and Freyberg (1985) make great use of interviewing and interpretation of (other people's) drawings as methods for investigating children's understandings of science concepts and events. Driver, Leach, Millar and Scott (1996) use similar research methods. Gunstone (1990), in a review of the first ten years of investigations of "children's science" in Australia, also describes the use that has been made of P–O–E and word associations. The authors collected by Fensham, Gunstone and White (1994) discuss the usage of many of the strategies in their research on ways in which scientific phenomena are experienced and conceived by learners.

Another direction in science education research which has relevance to the development of identity and the construction of self in science classrooms has been that which can be loosely categorised as an interest in science stereotypes and "Draw–A–Scientist Test"-ing (DAST). Chambers (1983, p. 257) developed the DAST procedures "to determine at what age children first develop distinctive images of scientists". He saw it as an instrument that "is probably more useful in identifying than measuring attitudes" (1983, p. 265). Prior to his work, research into images of and attitudes to scientists, such as that of Mead and Metraux (1957) mentioned above, had focussed on college students and adolescents rather than children. Chambers' (1983, p. 258) concern was with when some of the standard and mythic images of scientists first appeared, with particular reference to seven "indicators of the standard image of the scientist":

- lab coat (usually but not necessarily white)
- eyeglasses
- facial growth of hair
- symbols of research (scientific instruments and laboratory equipment of any kind)
- symbols of knowledge (principally books and filing cabinets)
- technology (the 'products' of science)
- relevant captions (formulae, taxonomic classification, the 'eureka!' syndrome, etc).

As could perhaps be expected, Chambers found that the number of indicators of the standard image increased with student age (fifth grade students included more of indicators in their drawings than kindergarten students, and adults included more than fifth graders). Similarly, the percentage of students drawing mythic stereotypes (alternative images) also increased with age. He also found direct correlations between the number of indicators drawn by students and the socio-economic classification of the school, and the number of indicators drawn and the student's IQ.

An interesting outcome of Chambers' research which he glosses over, and which most others who have replicated his procedures ignore (Jarvis 1996 is an exception), is that in one fourth grade class the students were instructed to draw another scientist after they had completed the first. His intention was to elicit possible distinctions among scientific specialities, but the results were quite different. No such distinctions were clearly found and, whereas the first set of drawing included no mythic stereotypes, the second set included two Frankensteins and nine drawings which included clearly dangerous elements such as bombs and poisons. Chambers (1983, p. 263) notes that "this may indicate that nearly half the children in this class felt a certain ambivalence about the social value of science which did not emerge in the first drawing", but he discusses this finding no further.

Chambers' DAST procedure has been used in a variety of ways by other researchers in the past two decades. One of the more prolifically published users has been Kahle (see, for example, Kahle 1987, 1988, 1990 and Mason, Kahle and Gardner 1991). Through a number of papers reporting on her research studies she has used DAST, supplemented by student interviews, in both primary and secondary school classrooms as a means of measuring the effectiveness of intervention programs towards a more equitable science education. She has also used DAST results as evidence for science education in schools supporting a masculine image of science and for arguing the need for this to be changed. She argues that this masculine image of science is one reason for girls not studying science in upper secondary school and university. However, for more than a decade Year 12 science subject enrolments and results in the state of Victoria, and enrolments in first year science subjects at universities, indicate that girls are now out-numbering and out-performing boys in most science subjects at these levels. How this turnaround in enrolments has occurred and how it relates to students' identity construction in science classrooms and their attitudes to science is a focus for my larger research project.

Others who have used DAST to research into students' views of science and scientists include Bowtell (1996ab), Jarvis (1996) and Schibeci (1986). Jarvis reports on her exploration of how young children's views of science and scientists vary with respect to age and gender (which is similar to Chambers' original study) and her intervention program to broaden children's views of science and scientists. Reflecting the glossed over aspect of Chambers' research, Jarvis (1996, p. 30) asked the children "to produce two pictures, because some children appear to record what they feel to be the socially acceptable answer first and then record a wider view in their second illustration".

One aspect of Jarvis' research that makes her work particularly interesting, in terms of how identity is constructed and performed (Butler 1990), is that she is conscious of both the gender and racial composition of her sample and the representation of both gender and race in the students' responses. She found that the vast majority of the scientists drawn by the students were Caucasian and male, but that they did not reject photographs of scientists on the basis of gender or race (except on one occasion). These results indicated to Jarvis (1996, pp. 33-34) that "the narrow stereotypes depicted in the children's drawings are not entirely representative of their understanding of scientists, but it seems probable that these limited images, nevertheless, are likely to have an effect on the children's attitudes". The results of her intervention strategies indicated that girls are more likely to extend their views of scientists than are boys, which has implications for the types of interventions which are used to achieve "a more equitable science education" such as that described by Kahle (1987, 1988, 1990, 1996) if we are to achieve equal participation and outcomes for both girls and boys.

Bowtell (1996ab) studied children's perceptions of scientists using (a slightly modified version of) DAST, a questionnaire and an interview to see if Chambers' standard image was still held by children and by scientists. She reported little variation from Chambers' findings using DAST. However she found through interviews that although they drew a stereotyped image of a scientist "Grade five and six students said that scientists are normal" (Bowtell 1996a, p. 12). Unfortunately she does not discuss the results from her survey questions "How does science make you feel?", and "Do you want to be a scientist?" as these would perhaps have given a better idea of how the students construct their identities in science classes. For Bowtell (1996a, p. 12), her findings suggest that "a wider range of scientific fields should be explored within schools".

Although I do not disagree with this conclusion I would also suggest that DAST might be too simplistic and not an effective research instrument from which to argue some of the conclusions for which it is used as evidence. It is useful to remember Chambers' own words in this regard. He did not construct his standard image as a *negative* stereotype, which is how it is often used. Rather, as quoted above, "every element of the standard image either portrays directly some part of the scientist's actual world or may be taken as symbolic of some part of that world" (Chambers 1983, p. 256). Researchers should keep this description in mind when using DAST.

Where DAST has been used with other research methods its results are still often given greater weight in discussion of findings than the findings from other forms of research (e.g. interviews). Bowtell (1996b, pp. 24-25), for example, argues that "stereotypes are an excellent indicator of people's prejudices and feelings about others and actually assist in forming these opinions and perceptions" and proceeds to give more emphasis to the DAST results in her papers. That people – both adults, including scientists (Chambers 1983, Bowtell 1996b), and children – when asked to draw a single instance of a scientist usually draw a standard image stereotyped male, including Chambers' indicators, is perhaps not surprising. A consistent finding throughout the various research studies which use DAST is that few women scientists are drawn by children and women scientists usually are drawn by girls. Even in Bowtell's (1996b) sample of six scientists two of the female scientists drew androgynous stick figures and the other drew a standard image, and two of the males drew males while the other drew a female (holding a baby in a beaker). While this might relate to the portrayal of scientists in the media and literature, it also corresponds to the situation in the workforce where male scientists dominate. Is it therefore surprising that scientists are drawn as male? And, in contemporary society is there any encouragement for males to think of scientists as females?

In this study, rather than getting the secondary students to draw scientists, during the interviews the students were asked to describe what the word 'scientist' meant to them as the basis for further discussion. Their responses included both elements from DAST (and several of them recalled previously being asked to draw a scientist) and more everyday elements ('normal people', 'male or female') and specific references to scientists in the media:

- White coats, safety glasses
- Finding out things
- Crazy people in movies
- Designing and doing experiments
- Boring, nerdy, having a bit of fun, spastic hair, giant glasses, lab coat
- Crime shows – DNA, fingerprints, examining bodies
- Normal people
- Male or female.

Reconciling images, attitudes and identities

In a research project conducted for the Victorian Department of Education in 1997 I interviewed science teachers in ten high schools about the teaching and learning of science in their schools. "When the students finish Year 10 science they hate it" was a common comment from these teachers about the students' feelings about learning science (Gough 1997). In the same year a survey of Victorian secondary science students (Galeforce Strategic Marketing 1997, p. 5) concluded that

> science is seen as lacking in social interaction. Words such as *isolation, sterile, clinical, test tube* and *cold* emerged.
> Students mentioned the comparison between an arts environment and a scientific one at school. They would sometimes wander in to visit colleagues studying arts. The environment would be warm, cluttered, creative and welcoming. The radio would often be left on.
> In contrast, the science lab was meticulous in its tidiness and layout. It was highly organised and sterile. It did not engender creativity.

Nearly ten years later, do students still feel the same?

In the ARC Improving Middle Years Mathematics and Science project (IMYMS), we have surveyed the students' attitudes to science in the project schools (Years 5 and 6 in primary schools and Years 7-10 in secondary schools) and conducted supplementary interviews with students in four of the schools. The data reported here comes from four of these schools and comprises:

- Four schools
  - 2 urban (one primary, one secondary)
  - 2 rural (one primary, one secondary)
- Written surveys of perceptions and learning preferences from students
- Group interviews in each school (total of 13 groups of 4-6 students: 3 rural primary, 4 rural secondary, 3 urban primary, 3 urban secondary)
- Students were in classes taught by teachers participating in the IMYMS Project.

The data has not been analysed by gender which is a weakness given the ROSE project findings (Sjøberg and Schreiner, 2005) that girls in industrialised countries were less positive about science that boys.

The survey results from the student learning preferences and perceptions surveys from these four schools are shown in Table 1 (first six preferences) and Table 2 (as a percentage agreeing with the statement) respectively.

In Table 1, while there was convergence across all four categories of learning activities – doing worksheets was given third preference in all schools – it is significant to note that only rural students gave high preferences to

- Asking questions about things that interest me
- Watching videos
- Listening to the teacher explain ideas

- Doing projects
- Playing games
- Using computers or calculators

The urban school students all rated doing hands on activities and taking part in class discussions as their first two preferences.

Table 1: IMYMS Project students' learning preferences in science survey results (2006)

Student learning preferences in science – activities that are most helpful in learning science	*Rural Primary students N=49*	*Rural Secondary students N=147*	*Urban Primary students N=341*	*Urban Secondary students N=215*
Doing hands on activities	3	3	2	1
Taking part in class discussions	1	4	1	2
Doing worksheets	3	3	3	3
Doing homework				4
Copying notes off the board		2		4
Searching for info using library books	1	1	4	
Watching the teacher show us how to do things			4	
Doing investigations or projects of my own choice	1			5
Searching for info using internet or CD ROM	2			6
Listening to a visiting speaker	1	3	5	

Table 2: IMYMS Project students' perception of learning science survey results (2006)

Student perception of learning science	*Rural Primary students (%)*	*Rural Secondary students (%)*	*Urban Primary students (%)*	*Urban Secondary students (%)*
1 It is OK to say what I think in my science class	92	86	94	88
26 In my science class we are encouraged to work things out for ourselves	91	84	92	81
3 The science we do in class makes me think and ask questions	95	81	86	75
27 Sometimes the activities we do in science are hard but they help us learn	85	71	86	75
4 My teacher tries to find out what I know when teaching something new in science	**92**	**77**	**91**	**73**
5 I am expected to explain my thinking in science	92	78	84	75
29 In my science class we often talk about our ideas	86	73	**87**	**70**
6 In science we study things that interest me	**82**	**62**	**79**	**57**

18 The science we do is often connected to things I am interested in outside school	60	50	**56**	**38**
30 My teacher tries to make science interesting for everyone	94	80	92	73
8 In my science class we work on projects outside school or have people come to talk to us	**87**	**24**	**63**	**30**
20 We learn about ways that science is used in everyday life	**91**	**75**	74	72
32 In my science class we look at things in the news or work on problems that affect our lives	60	50	**62**	**40**
10 I enjoy the work I do in my science classes	**89**	**66**	**87**	**62**
22 Learning science at my school is fun	**96**	**67**	**82**	**58**
34 I enjoy learning science at my school	**96**	**72**	**84**	**62**
11 I really want to learn about science at school	**89**	**71**	**86**	**61**
23 I really want to do well at science	100	94	94	90
12 What I learn in science will be useful to me when I leave school	**91**	**74**	**87**	**65**
24 What I learn in science will help me in the future	81	76	**90**	**68**
36 What I learn in science helps me in everyday life	**70**	**55**	**74**	**48**

In Table 2 the specific constructs where there is a significant deterioration (difference ≥15%) between primary and secondary school students are shown in bold. In most cases this deterioration is happening in both rural and urban schools, but there are exceptions. These large drop questions tend to be the constructs related to students' views on the relevance of their learning in science, their attitudes to it and their interest in continuing to a science career.

Looking at the results for the specific questions underlying each of the component constructs shown in Table 2, students' perceptions of science are further revealed (rural schools decrease, urban schools decrease). The largest drop from primary to secondary school is in "In my science class we work on projects outside school or have people come to talk to us" (63%, 33%) which tends to indicate that secondary science classes are less connected with the community. The responses to "My teacher tries to find out what I know when teaching something new in science" is particularly worrying as it indicates that secondary teachers are not engaging constructivism in their teaching. Other statements of particular relevance are the students' responses to questions such as "I enjoy the work I do in my science classes" (23%,25%), "I really want to learn about science at school" (18%, 25%), "What I learn in science helps me in everyday life" (15%, 26%), "Learning science at my school is fun" (19%, 24%) and "In science we study things that interest me" (20%, 22%). That for so many statements the secondary students' responses is significantly lower than that for the primary students indicates that something is definitely going wrong in the secondary science classrooms.

Although there are many possible explanations for this decline of interest in science and positive attitudes to science, the trend is global, as evidenced by the results from the ROSE project(Sjøberg and Schreiner 2005). The findings from surveys of 15 years old include:

- Students in most countries see more benefits than harmful effects in science but in many industrialised countries the feelings are more ambivalent, in particular among girls

- Students in most countries indicate sound scepticism to what scientists have to say (and girls have less trust than boys)
- Students in most countries indicate doubt that scientists are neutral and objective (and girls have more doubt than boys)
- Students in all countries strongly agree that science and technology are important for society
- Students differ in their views about science and technology as problem solvers for the environment, and girls are much more sceptical than boys, but in the industrialised countries the level of confidence is less than the mean
- In many industrialised countries science is less popular than other subjects, especially among girls
- In many industrialised countries students do not think that science has opened their eyes to exciting jobs, especially girls
- In industrialised countries few students dream about becoming scientists, in particular girls.

It is clear that the science students of today are not seeing themselves as “the heroic adventurer” in science, nor “the scientist as idealist”, but more likely as “the alchemist”, “the stupid virtuoso”, “the unfeeling scientist” or “the helpless scientist” (Haynes 1994). Whatever identity the students are constructing for themselves within science the overall conclusion is the same – although the students strongly agree that science and technology are important for society, they do not see themselves as part of it and they are not interested in pursuing a future career in science or interested in studying science at secondary school. This has been a challenge for science education for some time, and tinkering with curriculum and pedagogy has not had much effect on students’ perceptions of science.

Students’ images of scientists are not being engaged in their science classrooms, yet being aware of the images that students hold of science and scientists is an important consideration in teaching: “mental imagery is one of the most important of all human abilities: it enables many everyday tasks, such as navigation and understanding of verbal descriptions... and helps us to perform high-level activities such as creating art and doing research” (Howard 1992, p. 33). The area of science education research concerned with personal constructivism, discussed earlier in this paper, takes some of these aspects into account, albeit from a cognitivist perspective. However, much of this research treats science and scientists as objects for study by students. They are engaged at the level of the mind, but not the subjective body. Even if there is acceptance that knowledge is personally and socially constructed, much of science still purports to be objective – which has led to the previously mentioned large body of literature which is concerned with gender and science and postcolonial critiques of Western science.

Although treated as if disembodied, students construct themselves in science classrooms in a number of ways. They bring with them a range of previous experiences and media images, as well as understandings, beliefs, attitudes and behaviours. The teacher, the texts, the discourses and their fellow students position them. They construct themselves and perform their identities within this context.

Much research indicates that the secondary school science classroom is a gendered (masculine) environment through the content of the texts, the pedagogy and the discourses (see, for example, Kahle 1987, 1988, 1990, Kenway and Willis 1993, McLaren and Gaskell 1995, Rennie 1990, Rennie, Parker and Kahle 1996, Sjøberg and Imsen 1988), and it is to be expected that this would have an influence on how students construct and perform their identities. The recent ROSE project provides further support for this in terms of the differences in the perceptions of science between boys and girls (Sjøberg and Scheiner 2005).

Although there have been some action to change the content of the texts, the pedagogy and the curriculum (see, for example, Kenway and Willis 1993, Kreinberg and Lewis 1996), little has been done to date to disrupt the discourses, and yet it is through discursive practices that we construct ourselves. The discourses available to students with respect to the images of science and scientists are perhaps limited – as indicated by the six stereotypes described by Haynes (1994, p. 3) and listed earlier in this paper. Similarly Schibeci (1986, p. 146) points out,

> Images of science and scientists in popular culture represent a proportion (possibly not a very significant proportion) of the range of practices and behavior in modern science. There is

> sufficient evidence to indicate that scientists engage in a very diverse range of behavior, of which the more outlandish have been seized on by those who control the images presented in popular culture.

Images and metaphors have a constitutive force is identity formation. It is therefore important for students that they deconstruct the images in popular culture and elsewhere in their experiences, and recognise that there are wider options available for them to consider in terms of gender, colour, sexuality, ethnicity, class, ablebodiedness and other aspects of signification in asserting their identity in science classrooms. Such disruptive discourses and notions of identity are new to science education, but they should not be ignored, and some work is already underway (see Hines 2003).

Conclusion

It is a great concern to me as a science educator that something is going seriously wrong in the junior years of secondary science education. Instead of becoming scientifically literate students, the majority of students are not interested in studying science and there are declining enrolments in science subjects at senior secondary and university levels. Change *is* difficult in schools, but something needs to be done to break this cycle and it needs to be done quickly. A starting point is to change the pedagogy and design curriculum which is grounded in students' interests and current issues (such as a science-technology-society-environment orientation) rather than teachers covering what they think needs to be there and teaching it as dry facts and procedures. But much more is needed to interrupt the dominant discourses and engage the discourses that the students bring to science classes. Science teachers need to engage with the media images of scientists with which the students are familiar and students' attitudes to science.

Students aren't disembodied subjects in our science classrooms: they are influenced by media images of scientists and their reactions to these, and construct themselves accordingly in science classrooms. Recognising this is an important first step, but we also need to deconstruct their fears and disinterest in science. We need to reimagine educational practices in science education to take on the global challenges posed by students' lack of interest in pursuing science studies and careers – the opportunities here are many for educational researchers in investigating what constitutes the nature of and production of knowledge about science education. Students' interests need to be seen as an opportunity for conducting new forms of educational inquiries, recognising that, as Ted Mooney (1982, p. 80) so succinctly stated, "here we are getting older, and there they are getting different".

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