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Nerdy, Brainy and Normal: Children's and Parents' Constructions of Those Who Are Highly Engaged with Science

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Abstract There is a continuing international concern about a decline in the pursuit of post-compulsory science. One suggested cause concerns the role that young people's narrow perceptions of scientists may play in deterring them from pursuing science qualifications and careers. Research would suggest that the ages of 10–14 appear to be a critical period for the development of such views. This paper looks at the early part of this period, when general liking for science is high, although views on science careers as 'not for me' also appear to be forming. Drawing on data collected from interviews conducted with 92 children and 78 parents (in which children described peers who are 'really into' science and parents described those who are likely to pursue a career in science), we examine the constructions children and parents have of those who are highly engaged with science. In the interviews, participants evoked a range of constructions, some of which were closely aligned with traditional stereotypical images of science and scientists (e.g. as 'geeky') while others moderated and/or challenged those images. Although very few participants held explicitly 'negative' representations of science/scientists, our analysis shows how popular constructions of science as 'specialist' and 'clever' may feed into an understanding of science as different and not for me. It is argued that more work needs to be done to open up science as a field that is accessible 'for all' and to increase students' awareness of the breadth of careers in and from science.

Keywords Attitudes · Aspirations · Identity · Images of scientists · Peers

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Introduction

There is longstanding and persistent concern internationally, and particularly in Western nations, about the low numbers of young people choosing to study science at post-compulsory levels and going on to pursue careers in science (Boe et al. 2011; European Commission 2004; HM Treasury 2006; Lyons and Quinn 2010; National Academy of Sciences 2005; Osborne et al. 2009). These concerns have led to policy initiatives to mitigate these trends and to increase young people's engagement with and participation in STEM (e.g. America Competes Act, UK Targeted Research Initiative in Science and Mathematics Education, EU 'La Main a la Pate' programme). One key area of activity has been to try to change young people's views of scientists, as existing research suggests that many seem to hold stereotypical, or certainly narrow, images of scientists. For instance, it is not unusual for students to subscribe to a view of scientists as white, male, intelligent, having limited social skills and working long hours alone in a lab (e.g. Chambers 1983; Finson 2002; Huber and Burton 1995; Koren and Bar 2009; Newton and Newton 1998).

Other research suggests that although the stereotype of scientists as white and male does begin to appear from quite a young age (Losh et al. 2008), many children actually hold complex and even internally contradictory views of scientists and their work (Driver et al. 1996; Mead and Metraux 1957; Palmer 1997; Solomon et al. 1994; Song and Kim 1999). These sorts of complex images seem to have changed little over the years. For instance, in 1957, Mead and Metraux reported that American high school students subscribed to an image of scientists as not only intelligent, altruistic and dedicated but also uninteresting and unsociable. Put succinctly, 'the image of the scientist contains extremes which appear to be contradictory… all represent deviations from the accepted way of life' (Mead and Metraux 1957, p. 388). Thus, even the positive aspects of students' perceptions reflect a positioning of those who pursue science as 'other'. Similarly, more recent research has found that although students' views of scientists are not uniformly negative, many students do seem to have narrow perceptions of what scientists are like and limited awareness of what their work might involve (Cleaves 2005; Scherz and Oren 2006). In addition, such perceptions can be resistant to change, with shifts generally requiring longer term, more intensive interventions, often involving extended personal interactions with scientists (Buck et al. 2008; Finson 2002; Flick 1990; Scherz and Oren 2006; Smith and Erb 1986).

In our research, we consider whether students' lack of interest in pursuing science at post-compulsory levels (and in becoming a scientist) may spring *in part* from a mismatch between images communicated about science and scientists and the developing identities of young people. Previous research has shown that young people's aspirations and educational and career-related decisions are highly influenced by factors associated with individuals' sense of identity (Archer et al. 2010; Boe et al. 2011; Hazari et al. 2010; Taconis and Kessels 2009). Moreover, research would suggest that identity also shapes students' proximal engagement with science and the extent to which they come to see science as 'for me' (e.g. Basu and Calabrese Barton 2007; Calabrese Barton and Tan 2010; Schreiner and Sjoberg 2007; Thompson 2011). Given this perspective, any narrow perceptions of science held by young people may be problematic because they may restrict the possibilities for individuals to find a place for themselves within science. Such perspectives can also serve to reinforce a view of science as being important but 'not for them' (Jenkins and Nelson 2005). The difficulty students might have envisioning themselves in a role connected to science is highlighted by work reflecting that there is often little overlap between students' perceptions of scientists and their images of themselves (Bennett and Hogarth 2009; Cleaves 2005).

In trying to understand and trace the decline in students' aspirations in science as they enter adolescence, our research has highlighted how children's ideas about 'being a scientist' are intertwined with their wider attitudes to science (DeWitt et al. 2011; Archer et al. 2010). Our survey conducted with over 9,000 10- to 11-year-old children found that, even though at this age the majority of children enjoy 'doing' science (e.g. nearly 75 % reported that they learn interesting things in their science lessons), less than 17 % expressed a clear desire for a science career ('being' a scientist). Although this disjuncture may have a clear implication for those concerned with increasing participation in the 'science pipeline', we also suggest that any perceptions that young people might hold of 'who does science' as being 'not people like me' may lead to a range of negative outcomes in their science engagement more generally. Indeed, our research to date has emphasised that children and parents typically perceive science qualifications as only leading to a very narrow range of 'science careers' (Archer et al. 2012) and we have speculated that this may be a factor in depressing post-16 science participation. In this paper, we attempt to explore these issues through a relatively novel focus on more immediate, personal contexts of students' identity development. Specifically, we examine students' views of peers who are perceived to be 'really into' science, as well as their parents' images of those who are likely to pursue a science career and we explore the discourses that seem to underpin these constructions.

The Context of Developing Science Identities

Comparatively little academic work has addressed specifically children's perceptions of science-keen peers, yet existing studies seem to indicate that the context of school and peers could be an important space where images of science and scientists may act as a formative element in the construction of a science identity. For instance, attention has been drawn to the diverse ways in which students negotiate 'science identities' within the classroom (Basu et al. 2009; Brickhouse et al. 2000; Brown 2004; Calabrese Barton et al. 2008; Carlone 2003, 2004; Olitsky 2006; Olitsky et al. 2010; Tan and Calabrese Barton 2008) and how students who are closely aligned with scientific and mathematical identities can be stereotyped by their peers as 'geeks' or 'socially inept', which are resisted by some as undesirable characteristics (Mendick 2005, 2006, 2008). Other work has highlighted the ways in which adolescents perceive a 'prototypical' student who chooses to pursue science as generally less attractive, popular, socially competent and creative, but more intelligent and motivated than the one who chooses humanities (Hannover and Kessels 2004; Taconis and Kessels 2009). Moreover, in a manner reminiscent of the way in which students' consider scientists to be other from themselves, the more distant students perceive themselves to be from such prototypes, the less interested they are likely to be in pursuing science themselves (Hannover and Kessels 2004; Lee 1998; Taconis and Kessels 2009). We are not arguing here that students' choices are largely driven by a desire to be popular, but rather we wish to highlight the role that identity—including how one perceives oneself and the characteristics one values—may play a part in influencing some children's values and decisions.

Research with students in secondary school (Shanahan and Nieswandt 2011), as well as primary school pupils (Carlone et al. 2011; Varelas et al. 2011) has explored students' notions of science and themselves as science students, as well as what they perceive to be a 'good science student' in their classroom. Although Carlone et al. (2011) found that grade 4 children are more willing to take up a science identity and to recognise themselves as 'good science students' than are grade 6 students, even in fourth grade their constructions and perceptions of what is valued in the science classroom, such as intelligence and a certain 'science mindset', could be foreshadowing an environment in which science may ultimately

be positioned as other to their developing identities. Moreover, as children progressed through the second half of primary school, the potential 'space' afforded by science to a student became narrower, offering less possibility for many students to find a place for themselves within science (Carlone et al. 2011). Finally, wider literature on student identities indicates that peer cultures also provide a highly salient context for students' negotiations of academic identities, generating spaces of resistance, negotiation and/or accommodation to particular stereotypical associations and notions, such as the 'good/bad pupil', 'lad', 'boffin' or 'geek' (e.g. Francis et al. 2010; Jackson 2002; Renold 2005).

The above findings suggest that the school context, including peers, plays a key role in how students negotiate their relationship with science. It provides an immediate, personal environment in which perceptions of science and scientists are formed and develop and in which students come to identify—or not—with science. A sense of self is constructed as much through a sense of what/who one *is not*, as much as through the sense of who/what one *is* (Said 1978), leading to powerful notions of what is/not appropriate or normal or acceptable for 'people like me' and peers would seem to be a critical reference point for who might be 'like me'. In particular, we decided to elicit students' opinions of their peers who they strongly associated with science in order to explore the extent to which they considered these peers as similar to or different from themselves. We used the popular terminology of being really into science, which students seemed to interpret as referring to their classmates who were highly engaged with science.[1] It seemed, then, that how students regard peers who are really into science could provide useful insights into the emerging trajectory of their relationship with science and the extent to which they might ultimately come to perceive science as other.

In addition to peers, parents are another element of the context in which children's identity and aspirations develop, and the study was interested in exploring whether parental attitudes toward science and those who pursue science careers may have the potential to influence the messages they are communicating to their children about science. Indeed, our own survey research found that year 6 children's perceptions of their parents' attitudes towards science were strongly related to the children's aspirations in science (DeWitt et al. 2011) and that family resources, values and practices can influence the likelihood of children developing science aspirations (Archer et al. 2012). Likewise, a longitudinal study of choices illustrated the relationship between mothers' early predictions of their children's abilities and career choices 12 years later (Bleeker and Jacobs 2004). Other research has highlighted the influence of parental attitudes and support on the formation of post-16 choices (Cleaves 2005; Gilbert and Calvert 2003), on academic and career development related to science (Ferry et al. 2000) and on career aspirations in science (Baker and Leary 1995; Gilmartin et al. 2006), although this influence is subtle and complex (e.g. Atherton et al. 2009). Previous research also suggests that parental encouragement and support can affect whether children, particularly girls, perceive careers in mathematics and science as appropriate for their gender (Turner et al. 2004). In light of such research showing the importance of parental attitudes for the development of children's aspirations, this paper explores a previously underresearched aspect of this influence, namely parents' constructions of those who pursue science careers.

[1] Obviously, this approach is asking students to reflect on an 'extreme' form of science identification, which carries its own limitations and which may not lend itself to eliciting discourses of 'normal' science engagement. However, it was used in the interviews as a discursive device and a means of prompting talk around different forms of science engagement. Questions were phrased in as open a way as possible, so as not to unduly set up the 'reality' (nor the desirability or undesirability) of this particular 'type' of engagement.

Thus, our interest in gaining a richer understanding of the context in which children come to identify—or not—with science led us to explore how children in the final year of primary school and their parents perceive individuals who are highly engaged with science. In the case of children, how do they perceive their peers who are really into science? In the case of their parents, how do they view individuals who pursue science careers? Given that one way parents may influence their children's developing science identity may be through the messages they communicate (consciously or unconsciously) about science careers, we also explore whether there are any relations between how children perceive their science-keen peers and how their parents perceive those who have pursued a career in science or engineering. Although the parental questions were not identical to those asked of the children, both were judged to provide a means for eliciting talk exploring views and attitudes pertaining to who does science. These research questions are of interest to us because such perceptions may underlie, or at least contribute to, the process of individuals coming to perceive scientists and those who work in science as other to them.

Methods

The data for this paper are drawn from a larger study, the ASPIRES (Science Aspirations and Career Choice: Age 10–14) project, a 5-year, longitudinal study exploring science aspirations and engagement among students aged 10–14. The project involves a quantitative online survey that has been administered to a sample of over 9,000 students in their last year of primary school (age 10, who will be tracked and surveyed again at ages 12 and 14) and in-depth qualitative interviews with pupils (ages 10–11, who will be tracked and reinterviewed at ages 12 and 14) and their parents (who will also be reinterviewed when their children are 14). The findings reported in this paper draw on an analysis of the phase 1 qualitative dataset, which comprises 160 interviews with 78 parents and 92 children ages 10–11 (year 6), drawn from 11 schools in England. However, at times, we refer to the survey results (reported in DeWitt et al. 2011) in order to provide a context for the qualitative findings.

Study Context

This study took place in England, with students in their final year of primary school. As in many countries, primary school teachers rarely have a university-level background in science. Although science is part of the national curriculum, national tests in science at primary level had been abolished at the time data were collected and students participated in at most two or three science lessons a week. In contrast, when students are in secondary school, science is taught more frequently and almost always by teachers with a degree in science, although their degree may not be in the particular area of science they are responsible for teaching.

Interview Sample and Data Collection

The students and parents interviewed were recruited from 11 primary schools in England. Potential schools were sampled from the list of 279 schools who responded to the phase 1 survey as part of the wider study, and we attempted to recruit from diverse school contexts and populations. A stratified sampling strategy was utilised in determining which schools to approach for participation and focused on six target categories of school: multiethnic urban; low achieving (one participating school); multiethnic, high-achieving (one school); working-

class suburban (three schools); predominantly White, middle-class suburban, high-achieving (two schools); independent single sex (two schools); and 'regular' (predominantly White British, mix of lower middle and middle-class students, average levels of achievement; two schools). Thirty-five schools across all six categories were approached, and 11 agreed to participate. Numbers of participating schools in each category are shown in parentheses above. While it was beyond the scope of the project to construct a 'representative' sample, we attempted to utilise sampling to ensure a range of school contexts and populations. Of the 11 schools that agreed to participate, two were located centrally, four in the east of England, two in the southeast and three in London. Nine of the schools were state primaries and two were independent schools.

Schools that agreed to participate were sent parental consent letters for distribution to all children in the last year of primary school (year 6, ages 10–11). All parent–child pairs who volunteered to participate were included in the study, although we were ultimately unable to interview parents of 11 children.[2] Participating students (and their parents) came from a broad range of socioeconomic classes and ethnic backgrounds. More specifically, although most participants were White (generally British but some from other European countries), approximately one third were from ethnic minority backgrounds, primarily of South Asian (including Sri Lankan, Indian and Pakistani) or Black (African and Caribbean) heritage. Students' socioeconomic backgrounds also reflected a wide spread, from working through to upper middle class.[3] The sample included more females than males, with 55 girls (37 boys) and 58 mothers (20 fathers) participating. There were three sets of twins in the sample.

For the interviews, topic guides for use with children and parents were developed and piloted. Interviews were semi-structured and covered attitudes, aspirations and experiences of science, including impressions of scientists and people who are really into science (for details of the interview questions, please contact the authors.) As noted previously, the analyses presented here focus on parents' responses to questions about impressions of scientists and students' responses to questions about their peers who were really into science. We aimed to interrogate these data to begin to gain some insight into the environment in which students' images of science and scientists develop. Data that we collected that seemed particularly likely to provide such insight included parents' views about scientists, which have the potential to be communicated to their children, and students' own impressions of their science-keen peers.

Semi-structured interviews were conducted in line with the social constructionist (Burr 1995) theoretical and analytical framework of the project. This perspective understands the social world as constituted through discourse—with interviews providing a useful means for eliciting talk about the phenomena to be explored. A key feature of this approach is that the talk generated during interviews is not taken as objective or a reflection of 'reality' but as a social product (i.e. socially constructed within the interview context between researchers and participants). Interviews were conducted by two of the paper authors, along with two others, with the majority of the interviews (58 students and 34 parents) being conducted by the first

[2] Not interviewing parents who had returned consent forms was generally due to logistical constraints (e.g. two mothers had recently given birth) which prevented finding a convenient time to conduct the interview. These 11 parents came from a variety of ethnic and social class backgrounds, and we have since been in contact with all but one, suggesting we may be able to interview them later in the project.

[3] While the sample is not representative of the ethnic make-up and social class backgrounds of the national population of year 6 students, it was generated purposively to capture a wide range of backgrounds and experiences. Additionally, we are aware that due to the voluntary nature of participation, children and parents who were interviewed may not be representative of the attitudes towards science held by the general population. Because our sample may not be representative, our conclusions are necessarily provisional and tentative.

author, who is American. Of the interviewers, three were White middle-class women (with American, English and French national backgrounds), one was a French female PhD student (conducting phone interviews only) and one was a British-Chinese male PhD student. All of the interviewers are based in a university education department but situated across subdisciplines (including science education and sociology of education). Participants were invited to choose their own pseudonyms and were informed that their chosen names would be used in all subsequent reporting of the research. Because the interviews were semi-structured in nature, there was some variability in the wording and number of questions, depending on the flow of the interview.

Student interviews were conducted at the students' schools, generally in a resource room or office. Interviews ranged from 30 min to over an hour in duration, with most taking about 35–40 min. Parent interviews were conducted at a location of the parent's choosing—often the home or the school, but occasionally in a coffee shop or café. Parent interviews were also sometimes conducted over the telephone, especially with parents who lived more than an hour from London. These interviews tended to be between 45 and 75 min in duration. All interviews were digitally audio-recorded and transcribed.

Data Analysis

Analyses drew broadly on constant comparative analysis techniques (Miles and Huberman 1994) and analysis of discourse approaches (as outlined in Burman and Parker 1993), which draw on Foucauldian conceptions of power (Burr 1995; Foucault 1980) in which analysis seeks to identify and understand discourses as practices that bear power. Discourses are understood as socially organised patterns/frameworks of language and meaning which constitute how particular ways of thinking come to be seen as taken for granted (or 'natural'). The goal of an analysis of discourse approach is to "open up meanings and understandings as part of a critical project of 'deconstruction'" (Archer and Francis 2007, p. 26). This form of discourse analysis is in alignment with the social constructionist framework of our work and is useful for looking at the role of power in society (e.g. highlighting dominant societal discourses) and the role it plays in creating and sustaining different social relations. This approach also recognises the flexible and differentiated nature of social life and enables engagement with the complexity of social lives and identities, understanding people as multipositioned social actors and treating interview texts as socially constructed phenomena, produced through relations of power.

Analysis began with a careful reading of all the transcribed data by two of the authors to develop initial impressions of how children and their parents perceived individuals who were highly engaged with science. Subsequently with the children's interviews, we focused more precisely on their responses to questions about peers who were really into science. With the parents' transcripts, we honed in on particular questions which tended to provide insight into their constructions of people highly engaged with science (generally scientists) as well as any related perceptions (e.g. references to stereotypes or images they felt were espoused by others).[4] However, we also perused the rest of the transcripts to glean any further information that could enrich our picture of children's and parents' constructions—

[4] For the children, these questions were 'Thinking of people who are really into science, what are they like? How would you describe them?' and 'Is it possible for someone at your school to be really into science and also be popular? Why do you say that?' For the parents, these questions included 'Do you think there is a particular type of person who tends to become a scientist? and 'Why do you think so few children continue to study science after age 16?' (science is a compulsory subject in the UK until age 16).

e.g. their use of the word 'clever' or their invocation of any stereotypes when describing those who pursue science. We moved back and forth between the transcripts and notes and reflections on participants' responses in order to build up a schema of the types of constructions children and parents invoked and of the discourses underpinning these constructions. This schema was, in turn, compared iteratively with the transcripts to confirm that it did capture the range of ways in which children spoke about their science-keen peers and in which parents referred to those who work in science. Additionally, the discourses evoked by parents and children were examined for possible patterns by the respondents' gender, ethnicity and social class.

In a final step, parents' impressions and constructions were compared to those offered by their children, in order to ascertain the nature of the relationship—if any—between parents' images of those who pursue science (as adults) and their children's views of their science-keen peers (or those who are pursuing science as children). Draft analyses were iteratively discussed with the second author for checking against her readings of the data.

Findings

Our survey of over 9,000 year 6 students (DeWitt et al. 2011) found that while many students are generally open to the idea of pursuing science qualifications (with 40 % agreeing they would like to study more science in the future) and science-related careers (with 29 % being interested in a job that uses science), the particular notion of 'becoming' a scientist was resisted (with only 17 % expressing an aspiration to be a scientist). Put differently, despite a range of positive views of science, even at the age of 10–11, there appears to be a reluctance among children to take up a formalised science identity, as encapsulated in the notion of being a scientist (cf. Carlone 2003, 2004). Here, we explore the environment in which this resistance may—or may not—flourish and query the extent to which it provides fertile ground for the growth of constructions of science and scientists as other. Findings are organised as follows: We begin by examining evidence of parents' and children's evocation of a stereotypical scientist discourse (the 'geeky/nerdy scientist'). We then discuss discourses that modify this stereotype and finally consider discourses that challenge it.

Stereotypical Scientist Discourse: the Geeky/Nerdy Scientist

Images that resonate with or reflect a discourse of the 'stereotypical scientist'—'geeky scientist' or 'scientist as boffin' (Chambers 1983; Koren and Bar 2009; Losh 2010; Losh et al. 2008)—did appear with some regularity in the transcript data. These almost always appeared when parents were describing those who were likely to become scientists, while only two children (both boys) used stereotypes to describe peers who were really into science (i.e. 'geekish', 'not sporty'). However, although 38 of 78 parents referred to stereotypes in some way, suggesting the predominance of this discourse, they often acknowledged that their characterisations were stereotypes and at times went on to challenge them.

Only a small minority of parents (nine) constructed those who were likely to pursue science careers in stereotypical ways, without somehow qualifying their statements, e.g. as geeks (Jeremy, White British, upper middle-class father). In another example:

> Oh you know like white lab coat you know, maybe a bit wooh, a bit bizarre you know. When I say bizarre I mean sort of loads of thoughts going on in the minds or you know, so… (Laura, White British, lower middle-class mother)

In contrast, many parents acknowledged that the images they held were stereotypical:

Int: So do you think there's a certain type of person then who becomes a scientist?
Naina: Yeah.
Jasim: I've always thought so.
Int: Yeah, how would… like how would you describe them, like what would they… what type of person is it?
Jasim: I don't know.
Naina: Crazy hairstyle.
Jasim: (laughs) Glasses. I don't know it's just from my experience from school, the people that were really good at science you could just tell from an early age. They were really like textbook people a lot. (British Pakistani couple, middle class)

We take the laughter of the parents above as an implicit acknowledgement that their descriptions are aligned with a traditional stereotype. Other parents more explicitly acknowledged that they were describing a stereotype, although they did not attempt to challenge this construction:

> Yes, and this is almost certainly a cliché but I'm not going to resist saying it… I think there's a slightly almost autistic type, and I'm being extremely unfair, but certainly from my experience in the City the very, very best technical training types with that intense mathematical background tended to, again this is really unfair, tended to stare at their shoes… Yeah. I have that unfair image of these intensely cerebral scientific types who stare at the floor. (Michael, White Irish, upper middle-class father)

Another parent (Ella, White British, middle-class mother) referred to 'the stereotypical boffin'. Other parents, however, more clearly attempted to challenge the stereotypes:

> People do think, when they think of people who work in science, to be geeky, wear glasses, but it's not the case, not at all. (Amelie, White British, lower middle-class mother)
> It's seen as a bit nerdy when it shouldn't be, you know, the cool kids don't do science and engineering. (Gertrude, White British, middle-class mother)
> Sort of a bit of a 'spod' really. (laughs) Like I said someone that's terribly intelligent and which is rubbish because it's only a matter of studying isn't it and working hard at it… (Stella2, White British, lower middle-class mother)

Amelie and Gertrude seem to distance themselves from the stereotype by describing it as something others believe, as well as challenging it directly. However, their comments do indicate the power or strength of the scientist as boffin discourse in that it is something that influences the perceptions and behaviour of others and, in their opinion, needs to be challenged. The influence of this discourse is also reflected in the way in which Stella2 not only deprecates the stereotype as 'rubbish' but goes on to describe how someone can become a scientist (by studying and working hard).

Even when parents did not endorse the geeky scientist stereotype, they were highly aware of its prevalence in society:

> You know if you think of a professor of science or a you know you sort of think of an older, white, greying man who is slightly you know very sort of engrossed in his world and perhaps not in touch with the rest of the world. (Tina, Black Caribbean, lower middle-class mother)

I suppose maybe children see scientists as in like white coats and …you know lab coats and goggles… (Martha, White British, working-class mother)
I suppose there's the nerdy kind of label over scientists as opposed to artists or something… is there a certain kind of person? More likely to wear glasses, it's that… but it's very superficial, I don't really think that there is more of a particular kind of… (Terri, White British, upper middle-class mother)

It is possible that the above parents agree with these stereotypical constructions, but the data do contain some ambiguity. For instance, although Terri describes the 'nerdy label over scientists', she expresses uncertainty as to whether or not there is a particular kind of person likely to follow such a career. The other two parents offered acknowledgement of the stereotype as a possible reason that children did not want to pursue science as a career. Other parents also invoke the construction of the stereotypical scientist as something that is held by others, but note that such images seem to be changing:

Larry: I suppose, um, you know sort of in some cases people might think of you know like boffins, nerds, that sort of type of people… Which unfortunately they seem to have that reputation…
Int: And do you think that's a particular image or is that, do you have to be like that…?
Larry: Yeah, just the image, but I think that image is changing with like these TV programs currently at sort of prime time on the telly BBC1 and that, which is obviously going to help. (White British, working-class father)
Not like the old days…You either looked a scientist, you're the mad scientist or you looked the mad professor… Yeah, and then everybody thought you were going to be that, but not anymore. (Geeta, South Asian, lower middle-class mother)

Although the stereotypical images may be changing, which is cause for optimism, their historic prevalence—and the way in which the stereotypical scientist discourse is invoked, even when challenged, among the parents we interviewed—suggests an environment that positions a scientist identity as that of an undesirable other. In addition, although only two children utilised this stereotype themselves, ten invoked this discourse when describing the way others regarded science-keen children.

Well my sister used to like science in school, they used to call her a 'Geek'. (Flower, White Polish, working-class girl)
Science is just a subject. Anyone can be good at something and still be popular. Like I see where you're going with it, like saying like some kids would say science people are quite you know, what would they say on Simpsons? Is it nucezoid? Like Professor Frink, they all call him the geek. (Yogi, South Asian, middle-class boy)

Thus, although the discourse of the 'nerdy' scientist was evoked by many parents when describing those who tend to pursue science, not all of these parents agreed with the stereotype and some made considerable efforts to challenge it. Although science educators may be encouraged by such challenges, we would caution that the prevalence of the geeky scientist discourse indicates that many children will be forming their aspirations in an environment in which scientists are popularly associated with 'otherness'. This association is currently epitomised by comedies such as *The Big Bang Theory*, in which, it could be argued, the characters are portrayed as interesting and entertaining, but still different from regular people.

Modifying/Qualifying Discourses: 'Scientist as Specialist'

While the vast majority of parents and, especially, children did not personally subscribe to the 'geek/nerd' stereotype of those who pursue science—although they were certainly aware of its existence—many parents did invoke discourses that suggested that there is something unique, different or special about those who are highly engaged with science. While these discourses are more 'positive' than the traditional stereotypes, we suggest they do assert some sort of 'special' characteristics of a scientist or science-keen individual, which contribute to the othering of science identities. Modifying discourses were invoked by both parents and children, with 52 parents and 57 children drawing upon them in their constructions of those who are highly engaged with science. Such constructions seem to fall into two main categories: representations of scientists and those who are really into science as clever or highly intelligent (the 'clever scientist' discourse) and the identification of characteristics that imply a particular science mindset. These are discussed in turn.

The Clever Scientist Discourse

Although 81 % of year 6 survey respondents agreed that scientists are 'brainy' (DeWitt et al. 2011), a more nuanced picture emerged from the interviews of the extent to which science is associated with cleverness or intelligence, particularly among one's peers. The construction of science as clever is highly prevalent in the interviews, being invoked by 43 (of 92) children when referring to those who are really into science and 27 (of 78) parents when describing those who are likely to pursue science.

In describing peers who were really into science, children used words such as 'smart', clever and 'intelligent', as well as 'good at science', implying that their constructions are closely aligned with the clever scientist discourse.

> Well, they're intelligent, they're clever and they just know everything about science. (Laura, White British, lower middle-class girl)
> Yeah, I think they're like normal people as well, but a bit brainy as well, which is kind of good because they know more things than ordinary people. (Victoria2, White Bulgarian, working-class girl)

Although Victoria2 initially describes those who are really into science as 'like normal people', she also evokes the clever scientist discourse ('a bit brainy as well'), highlighting its strength and pervasiveness in underpinning the children's perspectives.

The association between science and cleverness is not entirely straightforward, however. When questioned directly, 72 % of students (63 of the 87 asked) responded that someone did *not* have to be clever to be really into science. As Chloe, a White British, middle-class girl put it, 'anyone can do science'.

> Int: Do you think that you have to be clever to be really into science?
> Clay: No.
> Int: And so why do you say that?
> Clay: Because I know quite a few people who don't do that well in their tests and they're really into science as well. (White British, middle-class boy)

However, many of the students (26 of 63) who asserted that someone did not *have* to be clever to like science also invoked the clever scientist discourse when describing their science-keen peers. Such responses suggest an inherent tension in their views between seeing cleverness as something possessed by those who are really into science and espousing

a more meritocratic view that cleverness is not a necessary prerequisite for a strong engagement with science. Additionally, among the students who did not call upon this discourse in their characterisations of those who are really into science were some who explicitly refuted it: 'You don't have to be clever, I think you just need to do it' (Luna, White British, lower middle-class girl). We take such challenges as yet another indication of the strength of the clever scientist discourse—it is sufficiently pervasive that it needs to be explicitly contradicted, rather than simply left unmentioned.

The discourse of the clever scientist is also highly visible in parents' constructions of those who are strongly engaged with science. In response to questions about the type of person who is likely to pursue science, 27 parents invoked the discourse of science as something for those who are clever or intelligent:

> Clever, yeah, I mean that's my opinion. I just always think of scientifically minded sort of like a clever, clever person. (Laura, White British, lower middle-class mother)
> Clever people, intelligent people. (Arissa, Pakistani, working-class mother)
> You tend to think of like science and you tend to think people that are, um, highly academic, so maybe sort of like your top A* students, that type of thing. (Ben, White British, lower middle-class father)

Although some children seemed to think that this cleverness could be acquired, for at least some parents, there was a sense that it was inborn or innate:

> It feels like something that you're either good at or you're not good at… I mean I'm sure there are people who have got a natural aptitude for things, which then makes it much easier. . .Yeah, which then makes that path much easier. (PBMum, White British, middle-class mother)

The strength and prevalence of this discourse in our data suggest and reflect its wider pervasiveness (Hannover and Kessels 2004; Losh 2010; Mead and Metraux 1957; Palmer 1997; Song and Kim 1999). Its prevalence is also highlighted by the frequency with which it was invoked by parent–child pairs. That is, among the 23 pairs who invoked the same discourses, 12 involved constructions of the 'science-keen' as clever. For instance, Stella1 (whose image of scientists interwove the stereotypical boffin image with cleverness) is the mother of Josh, who offered a construction of his science-keen peers as 'really smart'. Similarly, Florence, whose daughter Lucy regards her peers who are really into science as 'good in every subject', noted that 'you have to be quite clever' to pursue science.

The Science Mindset Discourse

As with the clever scientist discourse, the science mindset discourse underpins constructions of scientists and science-keen individuals that are also 'specialist', in that they have distinct characteristics. These attributes are generally positive—and may not even be unique to science, but simultaneously mark those who are highly engaged with science as somehow different from the 'norm'. Fourteen children and 29 parents offered constructions that suggested some sort of (relatively) distinct science mindset.

One prevalent image of scientists is that of hardworking, highly focussed individuals, who have dedicated their lives to science (Koren and Bar 2009; Losh 2010; Mead and Metreaux 1957). In our interviews, 14 parents and eight children described those who were likely to pursue science, or their science-keen peers, in similar terms:

> Somebody who's basically committed to basically spending their whole life looking for breakthroughs in various areas you know… Not someone who's just a fly by night, you know I want to be a scientist blah, blah, blah. It's something that is in you basically, it's as simple as that. So yeah, I don't think I could be a scientist. I'd like to be, but I don't think I could be because I don't think I could ever be that committed to that kind of role, you know what I mean? It's something you have to, say, commit your whole life to… (Dave, White British, working-class father)

Dave's description of the type of person who is likely to pursue science not only reflects tremendous dedication but also an element of innateness ('something that is in you'). Moreover, although he has tremendous respect for scientists, the extreme dedication he perceives as demanded by such a career suggests how even ostensibly positive qualities of perseverance and dedication risk slippage into more negative stereotypes, such as narrowness or obsessiveness. Others also endorsed a view of those who pursue science as hardworking, dedicated and focussed, though perhaps not to the same extent as Dave:

> Yes, you have to be I think serious . . . And when I think of like a scientist yeah, they're people who are not . . . to me (inaudible) people who are not distracted by other people – their main focus is whatever they're working on. (Bunmi, Black African, working-class mother)
>
> I mean it's not the easiest of degrees or the easiest of careers to get into I don't think… So you've got to have the application to do it. (Maddison, White British, upper middle-class father)

Although Maddison's view of the dedication required to pursue science is quite moderate, his response also suggests the way in which this broadly positive characteristic also has the potential of positioning science as difficult and therefore other. That is, one must be highly dedicated to pursue science because of its difficulty, which may make it a path not open to everyone. Such a possibility is also echoed in the way some students described the hard work displayed by those who were really into science:

> Dedicated people… they're willing to give up their time to do science I think. (Finch, White British, lower middle-class boy)
>
> It's like if something goes wrong they re-start it. If you're doing a test and you're doing it wrong, you do it over again until you get it right and you don't give up or anything like that. (Carol, White European, lower middle-class girl)

Another characterisation consistent with the science mindset discourse involved constructions (by ten parents but only one child) of those who are likely to pursue science as logical, analytical and methodical:

> I suppose in my head it's somebody who would be, um, quite intelligent and as I've described methodical in their processing you know. (Tina, Black Caribbean, lower middle-class mother)
>
> I think it's probably got to be someone who's got quite a logical mind, who's quite methodical you know. And they've got to be able to apply themselves and be good at understanding. Because there are some people who just don't have brains that can understand stuff like that. (Jane2, White British, middle-class mother)

That these parents' constructions would seem to be underpinned by the discourse of a science mindset is not only reflected in terms like 'logical mind' and 'processing' but is also reinforced by references to needing a certain type of brain ('that can understand stuff like

that'). As with constructions of scientists as dedicated and hardworking, these perceptions also have the potential to contribute to the 'othering' of science by articulating the need for a particular kind of mind, which not everyone may possess. Moreover, though terms such as 'logical' are not inherently negative, or even unique to science, they are affiliated with stereotypical boffin images and can thus contribute to alienation from science by making it more difficult for individuals to visualise themselves as individuals who hold characteristics that are necessary to pursue science, an argument consistent with findings from previous research on perceptions of prototypical scientists and science students (Bennett and Hogarth 2009; Hannover and Kessels 2004; Taconis and Kessels 2009).

Different Discourses: Constructions that Challenge Stereotypes

Thus far, we have discussed representations that characterise those who are strongly engaged with science as somehow other. Some of these constructions were aligned with traditional 'geeky/nerdy' stereotypes, while others represented modifications of them. We now consider more radical challenges—notably the idea that scientists are normal and may even be 'popular'.

'Scientist as Normal'

In contrast to the stereotypical scientist discourses and the scientist as specialist discourses, we also found examples of participants who voiced constructions which specifically challenge/refute the 'stereotypical' discourse, in that they assert that that there is no special or distinctive character of the scientist (scientist as normal). This discourse was less prevalent among the parents we interviewed than the 'specialist scientist' discourse, with 30 parents offering constructions congruent with the scientist as normal discourse, but it was predominant among the children, with 52 making statements aligned with it. Individuals invoking these discourses often did not explicitly disagree with the geeky/nerdy scientist stereotype, but their constructions did challenge the traditional stereotypical discourse implicitly by articulating or implying either that those who are engaged with science are 'no different from you and me' or that being a scientist or science-keen is simply a reflection of an interest or activity, rather than a 'type' of person.

Eighteen parents insisted explicitly that there was not a 'type of person' who is likely to become a scientist:

> I don't think they're any different to the next man are they? (Lucy, White British, middle-class mother)[5]
>
> I don't think there's a type of person to do anything. (Patsy, White British, working-class mother)

A small number of children also insisted that there was not a particular type of 'science person' or that those who were really into science were *not* different or exceptional:

[5] Although Lucy uses the word 'man' rather than 'person', consistent with an underlying image of scientists as male, we classify this statement as normal because of her overt disavowal of the suggestion that certain 'types of people' might become scientists. In addition, she was the only parent of the 18 whose justification for there not being a type had any reference to gender. At the same time, it does highlight the complexity and problematic nature of trying to categorise statements which might be in some ways consistent with a stereotype of scientists (at least as male, if not as geeky), but not in others.

I'm not sure how you can describe them cos they're normal people, they just like science a bit more than you. (Mary, South Asian, working-class girl)
Normal people really. They just say 'I like science'. (Heather, White British, middle-class girl)

However, many more children (37) produced descriptions or constructions of their science-keen peers that suggest they do not consider being really into science as indicative of a type of person, but rather as merely a reflection of a person's interest or activity:

Yeah, I think they like doing the investigations like I said, like testing things as well. (Rebecca, White British, middle-class girl)
They're like, I don't know, they just like science. They just like doing it. (Michael, White Polish, working-class boy)

A small number of students also simply struggled to describe those who were really into science, unable to come up with any sort of description. We acknowledge the possibility that this nonresponse, as well as the above students' somewhat tautological descriptions of their science-keen peers as 'liking science' or engaging in science activities, could be an artefact of the interviews and simply reflect the only explanation they were able to articulate at that time. Nevertheless, other elements of the data set, including children's statements that refuted the stereotype of the geek/nerd scientist explicitly, suggest that students of this age are capable of formulating descriptions of those they perceive as strongly engaged with science.

Finally, five parents challenged the stereotypical scientist discourse by offering constructions of scientists as creative:

I mean people say it's not the creative ones. I think they're wrong. Um, I think you have to be creative to come up with a drug… You can't just rigorously follow, um, what's happened in the past, because to come up with a new, um, drug for cures or whatever, a new invention you've got to be creative. You have to have a very creative mind… (Claire, South Asian, upper middle-class mother)

Similarly, a few children described individuals who were really into science in ways that were antithetical to the stereotypical scientist image, using words such as 'imagination' and 'funny' to describe them.

The 'Popular Scientist'

A prevalent image, particularly in media portrayals of scientists, is that of the socially awkward scientist (e.g. Hannover and Kessels 2004; Mead and Metreaux 1957; Palmer 1997; Steinke et al. 2007; The Big Bang Theory television programme), and as discussed earlier, a number of parents endorsed this view. A few other parents (e.g. Stella2, Gertrude, Amelie) actively refuted it, although they did not offer an alternative conception. However, the student interviews specifically explored students' perceptions of the relationship between popularity and interest in science, which afforded them the opportunity to offer alternatives to the 'socially awkward scientist' and to invoke (or not) constructions of science-keen individuals as popular. More specifically, students were asked whether (or not) it is possible for someone who is really into science to be popular. Overall, the vast majority of students (73 of the 86 who were asked) expressed the view that it is possible for someone who is really into science also to be popular.

Some students justified their assertions that peers could be really into science and also popular by naming specific classmates who they felt managed to achieve both:

> Because [name of fourth friend]'s well liked and she's really into science, and so is my sister… they all have loads of friends, and um… they're just really into science as well. (Celina, White British, working-class girl)
>
> My friend, the really smart one again, he's really good at science and maths and things like that and he's really, really popular. (Gus, White British, upper middle-class boy)

Other students attempted to explain *how* science-keen individuals can also be popular:

> Charlie: You can be popular no matter what you like. Um, you could be like really… you could be the best at maths or something or you could be the worst at maths and like you'd still be popular. You could be like a really slow runner in PE or something, but you could still be popular.
>
> Int: Mmm, mmm, and why is that do you think?
>
> Charlie: Um, I don't know, probably because it's more about your personality than what you can do. (White British, working-class girl)
>
> It's not just about what you do, it's about your personality and stuff, if you want to be popular. (David, White British, lower middle-class boy)

These students seem to consider being really into science as irrelevant for popularity. For them, 'personality' and 'sociability' (having friends) can allow someone to be both popular and really into science.

Despite general agreement that being really into science is compatible with popularity, the construction of 'the popular scientist' was not entirely unproblematic. Some students' views suggest emerging barriers to this current compatibility:

> Int: Can someone be really into science and also be popular?
>
> JJ: Um, yeah if they probably don't look, like, smart and you think they're like a little bit dumb, then you ask like a 'sciencey' question they can like show you up. Basically like good looking people.
>
> Int: Yeah.
>
> JJ: Because like my brother's quite a nice, handsome boy and, um, basically he's a really 'sciencey' person.
>
> Int: Mmm, mmm, so it is possible, but it's sort of they would need to be like good looking as well or something like that if they're going to be…?
>
> JJ: Yeah, they don't have to always be good looking. They could just like not wear glasses. Because that makes it look a tiny bit geeky. (White British, lower middle-class boy)
>
> Pamela: I think a lot of boys think that you can't be cool if you like science.
>
> Int: Really?
>
> Pamela: Definitely a lot of boys in my class.
>
> Int: So what do they think again?
>
> Pamela: Um, you can't be like popular if you like science… They don't like, they don't want to do it because they think they can't be popular if they like it. (Black Caribbean, lower middle class)

The above attitudes resonate with previous findings about secondary students' negative attitudes towards their peers who are 'good at maths' (Mendick 2006) and with the work of Francis et al. (2010), which highlighted the way in which good looks are important in maintaining popularity among high achieving peers. They also foreshadow a less science-

benign environment in which the students in the current study may later find themselves, an environment in which they may struggle to maintain constructions of science-keen individuals that are broad enough to include popularity—and indeed to hold on to wider discourses of scientist as normal.

Discussion

In our analyses, we set out to identify the ways in which students and their parents may perceive individuals who are highly engaged with science but who, in terms of age or life stage (childhood vs adulthood), were (relatively) similar to themselves and could serve as reference points for notions of like me. Thus, we focused on students' perceptions of their peers who are really into science, while exploring parents' views of people who are likely to pursue science in their work. While considerable previous research investigating children's and adults' images of scientists highlights the ways in which science/scientists are frequently positioned as other (e.g. Hannover and Kessels 2004; Jenkins and Nelson 2005; Losh 2010; Solomon et al. 1994), we hoped to gain insights into the processes by which this othering happens, by focusing on the more proximal environments in which constructions of scientists are formed and develop. Thus, we asked children about their science-keen peers, rather than about scientists. We also elicited parents' views about those who were likely to 'go into' science, as parental attitudes form an important part of the environment in which children's science identity develops.

Our analyses identified a number of discourses invoked by the parents and children we interviewed, many of which have the potential of positioning science as other. As might be expected, the *stereotypical scientist discourse* (the 'geek/nerd scientist') was highly visible in the data, although it informed parents' and children's constructions in complex ways. That is, although nearly half of the parents interviewed referred to the geek/nerd scientist in some way, many did not subscribe to this image and at times refuted it explicitly. Similarly, very few children agreed with such images, although children and, especially, parents were aware of the strength of such discourses in influencing others' perceptions. Most of the time, the gender and race/ethnicity of the geek/nerd scientist were not explicitly mentioned (and social class was never referenced). However, when they were mentioned, they were always congruent with the stereotype of scientists as male and/or white.

Even more prevalent in the data than stereotypical scientist discourse were the moderating or qualifying discourses that position the scientist as specialist, namely the clever scientist and the science mindset. Over half of parents and children offered constructions of the science-keen that were aligned with these discourses, which highlight that there is something special or unique about those who are highly engaged with science. Notably, these differences generally involve positive characteristics. This discourse also resonates with other research on children's impressions of good science students as those who are smart and work hard in science lessons (Carlone 2003; Carlone et al. 2011; Shanahan and Niewwandt 2011; Varelas et al. 2011). Nevertheless, our thesis is that such discourses, as with the stereotypical scientist discourse, can contribute to the othering of those who pursue science. For instance, although we consider the clever scientist to be a moderating discourse, we acknowledge that it does run the risk of sliding into more negative, stereotypical images. Given the association of clever—an attribute of perhaps only a minority of the population—with 'scientist', such a discourse ultimately reinforces the construction of the scientist, or those who are really into science, as other. This association would seem to be heightened by the perception—held at least by some parents—that this cleverness is inborn, rather than acquired.

In contrast is a third category of discourse which offers an alternative, the scientist as normal, which challenges the stereotypical scientist discourse. Constructions aligned with this discourse were less frequent among the parents but were nearly as prevalent among children as understandings of the 'scientist (or science-keen peer) as specialist'.

No salient patterns based on the gender, ethnicity or social class of participants (parents and children) were found in our data, suggesting that these discourses cut across such groupings. However, our findings suggest that many students' constructions of science-keen peers have the potential to position them as other. At the same time, the prevalence of the scientist as normal discourse, which asserts that those who are really into science are not somehow special or different, suggests that for at least some of these year 6 students, science is not (yet) perceived as other. This would suggest then that this age is one in which there is no dominant discourse and that interventions might help students to crystallise an image which has greater validity than the standard, stereotypical image.

Nevertheless, the stereotypical scientist discourse and the highly prevalent scientist as specialist do position those who pursue science as other. Taken together, then, it would seem that the environment in which these children's constructions of scientists and those who pursue science are being formed is quite a fertile ground for the growth of 'science as other'. Such perceptions of science as other are likely to act against student openness and willingness to take up a science identity, as also suggested by previous research (Bennett and Hogarth 2009; Carlone 2003, 2004; Taconis and Kessels 2009).

Conclusions and Implications

Although our sample included individuals from diverse social and ethnic backgrounds and possessing a range of aspirations and interests, the voluntary nature of their participation cautions against generalising from our findings. Nevertheless, the data do provide evidence suggesting that students in their final year of primary school may already be situated in an environment with the potential to allow discourses that position science as other to grow and flourish. Indeed, even at this age, many of the students we interviewed are beginning to perceive those who are highly engaged with science in ways that are other from their own lives and identities. However, their interest and enthusiasm for science in and out of school (DeWitt et al. 2011), their resistance to traditional negative stereotypes of scientists and their still-forming constructions of those who would pursue science may present an opportunity to disrupt the othering trajectory. That is, it would seem that more could be done to capitalise on students' early interest in science, as well as the generally positive perceptions of scientists held by students and their parents (DeWitt et al. 2011; Ipsos Mori 2011; Widmeyer Research and Polling 2009), to encourage a greater consideration of careers in and from science and to facilitate greater openness to science. Indeed, the relative openness of children's views at this age might suggest that efforts could be usefully targeted at primary aged children, before attitudes to science start to decline. While not advocating 'careers advice' or 'career counselling' for 10 year olds, we would encourage schools and policy-makers alike to consider ways in which information and awareness about careers in and from science might be integrated into classroom teaching at the primary and even early secondary (or middle school) levels in order to facilitate incrementally the broader construction of those who pursue science careers.

However, the challenge of facilitating greater openness to science and science careers should not be underestimated, and efforts to increase young people's engagement and participation in science need to target their resistance to being a scientist. Our findings

suggest that there may be value in working with children and parents to broaden their relatively narrow images of scientists and their understandings of the breadth of careers available from science, in an attempt to disrupt the otherness of science and enable it to become for me. One strategy in this respect may be to encourage children to explore the validity of popular stereotypes, particularly those portrayed in the media, enabling them to understand how such views are produced and maintained (Davies 1993; Mills 2001; Salisbury and Jackson 1996). At the same time, our data on the pervasiveness of the stereotypical scientist discourse, despite its limited purchase among the children in our sample, suggest a need to be careful about which images of scientists are promoted in schools. Such care is also warranted by the prevalence of the scientist as specialist discourses. Although they are more positive and act to moderate the geeky/nerdy scientist stereotype, they can serve simultaneously to position science as other. Providing children and parents with the tools to broaden constructions of scientists (e.g. as individuals who are dedicated to science but not to the exclusion of other interests) may help in the wider project of building a vision of science that truly is accessible and 'for all'.

The *challenging* discourses—related to constructions of scientists as 'normal' or even popular—are consistent with this more inclusive image of scientists. Thus, building on these discourses may offer another route by which the othering of science may be disrupted. However, these discourses are less prevalent and may be relatively precarious due to their conditionality (e.g. being really into science and popular *may* be conditional upon the possession of other attributes, such as a 'good personality') and to the strength and pervasiveness of other discourses. Broadening popular constructions of scientists and facilitating greater openness to science is a challenging task and one that cannot be accomplished in a single lesson, or even a series of lessons. It is likely to require a 'steady drip' of messages throughout primary and into secondary school. We note here that the differences between science in primary and secondary schools serve as a caution against overgeneralisation of our findings from primary to secondary students. Nevertheless, it seems that the differing nature of secondary school science (including subject specialist teachers) could exacerbate the positioning of science as other. Thus, it seems critical to work with both primary and secondary school teachers—via continuing professional development, initial teacher education or both—to help them (and their pupils) deconstruct and reflect on images of science that may, even unwittingly, be promoted via commonplace classroom practices and discourses.

Promoting a more inclusive vision of science also faces additional challenges in the form of structural barriers. For instance, previous research suggests students' experiences of science, particularly for those from marginalised groups, often operate against their embracing science as something for all or 'for them' (e.g. Calabrese Barton 1998; Tan and Calabrese Barton 2008). That is, teachers' responses to students' ways of authoring and enacting their identities (or identities in practice) in science class have the potential to support or hinder their identification with science. When students' identities are not valued within the science classroom—a particular risk for students from minority backgrounds, their identification with the subject can be disrupted, leading them to dismiss science as not for them (Carlone et al. 2011; Tan and Calabrese Barton 2008). The education system itself—at least in England—presents another structural barrier by offering a very narrow range of options for those who wish to pursue science post-16. It would seem that a greater diversity of pathways could facilitate the pursuit of science by more diverse individuals.

Broadening awareness of the range of science careers, while far from a panacea, provides an opportunity to open up perceptions of scientists and to make more evident the ways in which the pursuit of science could align with students' developing identity. Portraying

science as a wider field, with 'fuzzier' boundaries (Calabrese Barton 1998) and highlighting the diversity and range of individuals who are scientists would offer then more opportunities for students to find a place for themselves within science and a place for science within their own developing identities.

References

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). 'Doing' science vs 'being' a scientist: examining 10/11 year old school children's constructions of science through the lens of identity. *Science Education, 94*(4), 617–639.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations and family habitus: how families shape children's identification and engagement with science. *American Educational Research Journal*. doi:10.3102/0002831211433290.

Archer, L., & Francis, B. (2007). *Understanding minority ethnic achievement*. London: Routledge.

Atherton, G., Cymbir, E., Roberts, K., Page, L., Remedios, R., Aimhigher Central London Partnership & University of Westminster. (2009). *How young people formulate their views about the future—exploratory research*. Research Report DCSF-RR152. London: University of Westminster.

Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32*(1), 3–27.

Basu, S. J., & Calabrese Barton, A. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching, 44*(3), 466–489.

Basu, S. J., Calabrese Barton, A., Clairmont, N., & Locke, D. (2009). Developing a framework for critical science agency through case study in a conceptual physics context. *Cultural Studies of Science Education, 4*, 345–371.

Bennett, J., & Hogarth, S. (2009). Would you want to talk to a scientist at a party? High school students' attitudes to school science and to science. *International Journal of Science Education, 31*(14), 1975–1998.

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: do mothers' beliefs matter 12 years later? *Journal of Educational Psychology, 96*(1), 97–109.

Boe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: young people's achievement-related choices in late-modern societies. *Studies in Science Education, 47*(1), 37–72.

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*(5), 441–458.

Brown, B. A. (2004). Discursive identity: assimilation into the culture of science and its implications for minority students. *Journal of Research in Science Teaching, 41*(8), 810–834.

Buck, G. A., Plano Clark, V. L., Leslie-Pelecky, D., Lu, Y., & Cerda-Lizarraga, P. (2008). Examining the cognitive processes used by adolescent girls and women in identifying science role models: a feminist approach. *Science Education, 92*(4), 688–707.

Burman, E., & Parker, I. (Eds.). (1993). *Discourse analytic research: repertoires and readings of texts in action*. London: Routledge.

Burr, V. (1995). *An introduction to social constructionism*. London: Routledge.

Calabrese Barton, A. (1998). Teaching science with homeless children: pedagogy, representation, and identity. *Journal of Research in Science Teaching, 35*(4), 379–394.

Calabrese Barton, A., & Tan, E. (2010). We Be Burnin'! Agency, identity, and science learning. *The Journal of the Learning Sciences, 19*(2), 187–229.

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*(1), 68–103.

Carlone, H. B. (2003). (Re)producing good science students: girls' participation in high school physics. *Journal of Women and Minorities in Science and Engineering, 9*(1), 17–34.

Carlone, H. B. (2004). The cultural production of science in reform-based physics: girls' access, participation, and resistance. *Journal of Research in Science Teaching, 41*(4), 392–414.

Carlone, H. B., Kimmel, J., Lowder, C., Rockford, J., Scott, C. (2011). *Becoming (less) scientific in the figured worlds of school science learning: a longitudinal study of students' identities*. Paper presented at the Annual meeting of the National Association for Research in Science Education. Orlando, Florida.

Chambers, D. W. (1983). Stereotypic images of the scientist: the Draw-a-Scientist Test. *Science Education, 67* (2), 255–265.
Cleaves, A. (2005). The formation of science choices in secondary school. *International Journal of Science Education, 27*(4), 471–486.
Davies, B. (1993). *Shards of glass: children reading and writing beyond gendered identities*. Cresskill: Hampton Press.
DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B., & Wong, B. (2011). Young children's aspirations in science: the unequivocal, the uncertain and the unthinkable. *International Journal of Science Education*. doi:10.1080/09500693.2011.608197.
Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buckingham: Open University Press.
European Commission. (2004). *Europe needs more scientists: report by the high level group on increasing human resources for science and technology*. Brussels: European Commission.
Ferry, T. R., Fouad, N. A., & Smith, P. L. (2000). The role of family context in a social cognitive model for career-related choice behavior: a math and science perspective. *Journal of Vocational Behavior, 57*(3), 348–364.
Finson, K. D. (2002). Drawing a scientist: what we do and do not know after fifty years of drawings. *School Science and Mathematics, 102*(7), 335–345.
Flick, L. (1990). Scientist in residence program improving children's image of science and scientists. *School Science and Mathematics, 90*(3), 204–214.
Foucault, M. (1980). *Power/knowledge: selected interviews and other writings 1972–1977*. New York: Pantheon.
Francis, B., Read, B., & Skelton, C. (2010). The simultaneous production of educational achievement and popularity: how do some pupils accomplish it? *British Educational Research Journal, 36*(2), 317–340.
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*(7), 861–878.
Gilmartin, S. K., Li, E., & Aschbacher, P. (2006). The relationship between secondary students' interest in physical science or engineering, science class experiences, and family contexts: variations by gender and race/ethnicity. *Journal of Women and Minorities in Science and Engineering, 12*(2–3), 179–207.
Hannover, B., & Kessels, U. (2004). Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science. *Learning and Instruction, 14*(1), 51–67.
Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: a gender study. *Journal of Research in Science Teaching, 47*(8), 978–1003.
Treasury, H. M. (2006). *Science and innovation investment framework: next steps*. London: HMSO.
Huber, R. A., & Burton, G. M. (1995). What do students think scientists look like? *School Science and Mathematics, 95*(7), 371–376.
Ipsos Mori Social Research Institute. (2011). *Public attitudes to science 2011*. London: Ipsos Mori.
Jackson, C. (2002). Laddishness' as a self-worth protection strategy. *Gender and Education, 14*(1), 37–51.
Jenkins, E. W., & Nelson, N. W. (2005). Important but not for me: students' attitudes towards secondary school science in England. *Research in Science and Technological Education, 23*(1), 41–57.
Koren, P., & Bar, V. (2009). Pupils' image of 'the scientist' among two communities in Israel: a comparative study. *International Journal of Science Education, 31*(18), 2485–2509.
Lee, J. D. (1998). Which kids can "become" scientists? Effects of gender, self-concepts, and perceptions of scientists. *Social Psychology Quarterly, 61*(3), 199–219.
Losh, S. C. (2010). Stereotypes about scientists over time among US adults: 1983 and 2001. *Public Understanding of Science, 19*(3), 372–382.
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*(6), 773–792.
Lyons, T., & Quinn, F. (2010). *Choosing science: understanding the declines in senior high school science enrolments*. Armidale: University of New England.
Mead, M., & Metraux, R. (1957). Image of the scientist among high-school students. *Science, 126*(3270), 384–390.
Mendick, H. (2005). A beautiful myth? The gendering of being/doing 'good at maths'. *Gender and Education, 17*(2), 203–219.
Mendick, H. (2006). *Masculinities in mathematics*. Maidenhead: Open University Press.
Mendick, H. (2008). Subtracting difference: troubling transitions from GCSE to AS-level mathematics. *British Educational Research Journal, 34*(6), 711–732.
Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks: Sage.
Mills, M. (2001). *Challenging violence in schools: an issue of masculinities*. Maidenhead: Open University Press.

National Academy of Sciences: Committee on Science Engineering and Public Policy. (2005). *Rising above the gathering storm: energizing and employing America for a brighter economic future*. Washington, DC: National Academy of Sciences.

Newton, L. D., & Newton, D. P. (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*(9), 1137–1149.

Olitsky, S. (2006). Structure, agency, and the development of students' identities as learners. *Cultural Studies of Science Education, 1*, 745–766.

Olitsky, S., Flohr, L. L., Gardner, J., & Billups, M. (2010). Coherence, contradiction, and the development of school science identities. *Journal of Research in Science Teaching, 47*(10), 1209–1228.

Osborne, J., Simon, S., Tytler, R. (2009). *Attitudes towards science: an update.* Paper presented at the annual meeting of the American Educational Research Association. San Diego, California.

Palmer, D. H. (1997). Investigating students' private perceptions of scientists and their work. *Research in Science and Technological Education, 15*(2), 173–183.

Renold, E. (2005). *Girls, boys and junior sexualities*. London: Routledge Falmer.

Said, E. W. (1978). *Orientalism*. London: Routledge and Kegan Paul.

Salisbury, J., & Jackson, D. (1996). *Challenging macho values: practical ways of working with adolescent boys*. London: Palmer Press.

Scherz, Z., & Oren, M. (2006). How to change students' images of science and technology. *Science Education, 90*(6), 965–985.

Schreiner, C., & Sjoberg, S. (2007). Science education and young people's identity construction—two mutually incompatible projects? In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The re-emergence of values in the science curriculum* (pp. 1–17). Rotterdam: Sense Publishers.

Shanahan, M.-C., & Nieswandt, M. (2011). Science student role: evidence of social structural norms specific to school science. *Journal of Research in Science Teaching, 48*(4), 367–395.

Smith, W. S., & Erb, T. O. (1986). Effect of women science career role models on early adolescents' attitudes toward scientists and women in science. *Journal of Research in Science Teaching, 23*(8), 667–676.

Solomon, J., Duveen, J., & Duveen, L. (1994). Pupils' images of scientific epistemology. *International Journal of Science Education, 16*(3), 361–373.

Song, J., & Kim, K.-S. (1999). How Korean students see scientists: the images of the scientist. *International Journal of Science Education, 21*(9), 957–977.

Steinke, J., Knight Lapinski, M., Crocker, N., Zietsman-Thomas, A., Williams, Y., Higdon Evergreen, S., et al. (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*(1), 35–64.

Taconis, R., & Kessels, U. (2009). How choosing science depends on students' individual fit to 'science culture'. *International Journal of Science Education, 31*(8), 1115–1132.

Tan, E., & Calabrese Barton, A. (2008). Unpacking science for all through the lens of identities-in-practice: the stories of Amelia and Ginny. *Cultural Studies of Science Education, 3*(1), 43–71.

Thompson, J. (2011). *Engaging girls' identities in science*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Orlando, FL.

Turner, S. L., Steward, J. C., & Lapan, R. T. (2004). Family factors associated with sixth-grade adolescents' math and science career interests. *The Career Development Quarterly, 53*, 41–52.

Varelas, M., Kane, J. M., & Wylie, C. D. (2011). Young African American children's representations of self, science, and school: Making sense of difference. *Science Education, 95*(5), 824–851.

Widmeyer Research & Polling (2009). *Attitudes toward math and science education among American students and parents*. Report commissioned by Carnegie-IAS.