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High school students' perceptions of school science and science careers: A critical look at a critical issue

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Abstract
Disproportionate representation of males and females in science courses and careers continues to be of concern. This article explores gender differences in Australian high school students' perceptions of school science and their intentions to study university science courses. Nearly 3800 15-year-old students responded to a range of 5-point Likert items relating to intentions to study science at university, perceptions of career-related instrumental issues such as remuneration and job security, self-rated science ability and enjoyment of school science. Australian boys and girls reported enjoying science to a similar extent, however boys reported enjoying it more in relation to other subjects than did girls, and rated their ability in science compared to others in their class more highly than did girls. There was no significant difference between the mean responses of girls and boys to the item "It is likely I will choose a science-related university course when I leave school" and the strongest predictors of responses to this item were items relating to students' liking for school science and awareness from school science of new and exciting jobs, followed by their perceived self-ability. These results are discussed in relation to socio-scientific values that interact with identity and career choices, employment prospects in science, and implications for science education.
Keywords: Gender, science education, science careers, self-concept, perceptions of science, high school

Introduction

This article explores gender differences in Australian high school students' perceptions of and attitudes towards school science, and how these differences relate to their intentions to study university science courses. In Australia, as in many highly developed countries, males and females are disproportionately represented in a number of science subjects and career fields. Females tend to be overrepresented in the life and health sciences, and underrepresented in physics, earth science and engineering (Ainley, Kos, & Nicholas, 2008; Bell, O'Halloran, Saw, & Zhao, 2009; Dobson, 2007).

This disparity is a significant issue for two reasons. First, research suggests that it is due in part to underlying socio-cultural impediments to participation by women in some science fields. If this is the case it is important to identify these impediments. Second, it is generally considered that workforce shortages are most critical in those science and technology fields where women are underrepresented. Likewise, there is a relatively low demand in science fields in which women have a high representation (European Commission, 2009; Graduate Careers Australia, 2009; Taeb, 2005). A more proportionate representation would not only help address the supply and demand problems, but also bring greater gender parity to these fields.

Mapping of attrition from the school-to-career science "pipeline" in culturally comparable countries (Jacobs, 2005; Jacobs & Simpkins, 2005; Schoon, Ross, & Martin, 2007; Simpkins, Davis-Kean, & Eccles, 2006) shows that girls' disengagement from science begins in the early school years and continues all the way through to post-doctoral and workplace situations. Much recent literature is offering rich and nuanced insights into the interrelated factors (including gender) that contribute to students' science choices, particularly how science fits with the developing identities of high school students (Eccles, 1989, 2005, 2009; Simpkins, et al., 2006).

This paper reviews a wide range of international literature addressing these issues, and contributes findings from an Australian study of nearly 3800 15-year-old students who had recently selected their elective subjects for the final two years of secondary school (Lyons & Quinn, 2010). Elsewhere we have outlined gender differences in these students' attitudes to school science and their subject choices (Quinn & Lyons, 2010). Here we extend this work by focusing primarily on the intentions of Australian Year 10 students to study science at university in relation to gender differences in:

- perceptions of career-related instrumental issues such as remuneration and job security
- self-rated science ability
- enjoyment of school science

The paper also discusses the implications of these gender differences for initiatives aimed at removing impediments to participation by women in a broader range of science careers.

Background

Intentions to study at university or choose a science career

Students' intentions regarding potential careers are often formed in early high school. They play an important role in the perceived instrumental value of science subjects for senior high school, with students considering a science career more likely to choose science subjects as a useful step towards their longer-term goals (Eccles, 1989, 2005, 2009).

Two recent quantitative longitudinal studies support the importance of early career aspirations on subsequent decisions. In a 12 year long study of the career intentions and study trajectories of American high school students (Tai, Qi Liu, Maltese, & Fan, 2006), 13-year-old students were asked whether they anticipated doing science-related work at age 30. Those who responded in the positive were later found to be twice as likely to have completed a life-science degree than those who had disagreed. A similar pattern was detectable for physical sciences although this was strongly mediated by mathematics achievement. No gender differences were detected in these results. A longitudinal study of nearly 10,000 UK students (Schoon, et al., 2007) found that aspirations to a science career are formed early, especially among women, and that the association between early aspirations and later occupation was stronger for women than men.

Taken together, these findings highlight the crucial importance of career intentions formed in high school. These findings take on a greater significance however when we appreciate that in some countries, boys and girls exhibit different expectations about science careers from the age of 11 or 12 (e.g., Farenga & Joyce, 1999; Jones, Howe, & Rua, 2000). In the Relevance of Science Education (ROSE) study (Schreiner & Sjøberg, 2007), the item "I would like to become a scientist" was consistently endorsed more strongly by 15-year-old boys than girls in many developed countries. While no ROSE study reports on Australia data were available, results from PISA 2006 show that 15 year old boys agreed more strongly than girls that they intended to study or work in science after secondary school, although the difference in means appeared to be relatively small (Thomson & De Bortoli, 2008, p. 132).

While the general picture emerging from recent research is that high school boys are slightly more inclined than girls to think they would like a career in science, evidence for gender-related differences in students' views about science careers is not unequivocal and does not apply to all countries (OECD, 2007a, 2009). In addition, a recent American study (Masnick, Valenti, Cox, & Osman, 2010) has found that both sexes had similar conceptions of science careers as not very creative and relatively non-social and that these beliefs were "entrenched" relatively early and before the point of making career-related choices. A study of Australian high school and university students (Hassan, 2008) detected no gender difference in students' aspirations to a science career.

Instrumental issues: remuneration and job security

Student perceptions of instrumental issues related to remuneration and ease of finding a job in science relate to what Eccles refers to as utility value (Eccles 2005, 2009). For example, a number of studies have found that choosing post-compulsory school science is strongly related to its strategic value for university and career options (Lyons, 2004; Osborne & Collins, 2001).

The strategic value of school science subjects in Australia has been eroded from a number of directions. In the current market-driven higher education climate, many Australian tertiary institutions have relaxed entry prerequisites for university-level science courses, while "Foundation" or "Bridging" science units for underprepared students are common. Although there is currently strong demand for science teachers in Australia (Edwards & Smith, 2008; Harris & Farrell, 2007), concerns continue to be expressed about the "brain drain" from Australian science (e.g., Wood, 2004). This is attributed in part to poor job security and remuneration, which relates to increasing insecure short-term or casual employment of science graduates and relatively poor job prospects (Giles, Ski, & Vrdoljak, 2009). Of the graduates from Australian universities in 2008 seeking full-time employment, over a third (36%) of Life-Science graduates, a fifth (22%) of Chemistry graduates and a quarter (24%) of Physical Science (excluding engineering) graduates were still looking for fulltime work four months after graduating. The Life-Sciences statistic was the second highest after Visual and Performing Arts graduates (Graduate Careers Australia, 2009). These findings point to a somewhat pessimistic employment outlook for many physical and life-science graduates, particularly relative to other fields of study requiring tertiary education. It seems that this is not solely an Australian issue, with similar supply and demand issues being noted in the UK science context (Osborne 2008).

Self efficacy and self-concept

Two related constructs that influence students' study and career choices are self-efficacy and science self-concept. Following Pajares and Schunk (2001) self-efficacy is here defined as the confidence in one's abilities to succeed while self-concept is more broadly conceptualised as "a description of one's own perceived self accompanied by an evaluative judgment of self-worth". In the Eccles' expectancy-values model (e.g., Eccles, 2005; 2009) the construct "ability self-concept" is a predictor of, but empirically difficult to separate from, expectations for success, that is, from self-efficacy beliefs.

Both self-efficacy and self-concept are strongly linked to students' attitudes and decisions about science. Self-efficacy influences aspirations, persistence and motivation (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996; Britner & Pajares, 2006) and students are more likely to make science-related secondary, post secondary choices and career choices if they have high science-self concepts and accordingly high expectations of success in science (Eccles, 2005, 2009; Jacobs & Simpkins, 2005; Simpkins, et al., 2006). Domain-specific self-concept in academic fields has been found to be highly correlated with success (for review see Pajares and Schunk (2001)) and low perceived science ability in relation to achievement inhibits students from choosing senior secondary science (Cleaves, 2005).

Much research (reviewed by Simpkins, et al., 2006) has shown that boys report higher science self-concepts than girls. Other studies (Britner & Pajares, 2006, p. 491) found no difference in self-efficacy between boys and girls at similar levels of prior achievement, and no significant difference in self-concept in science (p. 493). The 2006 PISA study (OECD, 2007a, p. 134; 2007b, p. 90) found no significant gender differences on the index of self-efficacy in science for students from Australia (and most other countries) but that Australian 15-year-old boys reported a slightly better self-concept in science than did girls. Another study of Australian students found that the "Self-concept of ability" of boys was higher than girls and we calculated this from data presented in the paper as a small effect (Cohen's $d = 0.32$) (Hassan, 2008).

Although science-related self-efficacy and self-concept are reciprocally related to success and performance in science related tasks, it is also apparent that they do not necessarily reflect ability or performance. For example, in one study middle school boys reported higher science self-concept than girls despite having worse achievement (Britner & Pajares, 2006) and girls reported declining self-rated ability despite equivalent achievement to boys in a study by Jovanic and King (1998). A recent meta-analysis by Hyde and Linn (2009) has highlighted the parity between boys and girls in performance and traits related to the ability to succeed in science. The lower self-efficacy and self-concept that is often (but not always) reported by girls does not appear to be justified by lower overall ability or performance (Blickenstaff, 2005; Lyons, 2007).

Enjoyment of school science

In terms of Eccles' expectancy/value model, if students enjoy school science, remain engaged in it and develop competence, their developing identities are more likely to become consonant with science-related behaviours and choices (Eccles, 2009). Studies reviewed by Osborne (2008) suggest that at age 10 there is little if any gender difference in students' interest in science, but that interest in science subsequently declines. Research has generally found that high school girls hold less positive attitudes to school science than do boys (e.g., Barmby, Kind, & Jones, 2008; Bennett & Hogarth, 2009; Osborne, Simon, & Collins, 2003; Simpkins, et al., 2006). In its wide-ranging exploration of students attitudes to school science across 34 countries, the ROSE project compared boys and girls' responses to the item "I like school science better than most other school subjects". Boys generally (but not always) endorsed this statement more than girls, especially in countries most culturally comparable to Australia such as England, Scotland and northern Ireland (Schreiner & Sjøberg, 2007).

It seems, though, that in many studies this gender difference is not large. A meta-analysis by Weinburgh (1995) of studies prior to 1991 found that although boys enjoyed science more than girls this was an extremely small effect (0.16). A similar result was found in an Australian context (Hassan, 2008), where although effect size was not reported, we calculated Cohen's d from the data presented as 0.17; also a very small effect. Australian boys reported higher levels of Enjoyment of Science than girls in the 2006 PISA study (Thomson & De

Bortoli, 2008), although the difference is small and may not be significant. There was no apparent difference between Australian boys and girls in their responses to the PISA Interest in Learning Science scale.

Contributions from the *Choosing Science* study

The themes discussed above were some of those explored in *Choosing Science* (Lyons & Quinn, 2010), a large-scale study of the reasons behind declines in senior high school science enrolments in Australia. A subsequent paper (Quinn & Lyons, 2010) reported some of the gender differences in students' subject choices and rationales found by this study. This paper expands on these results and then goes a step further, identifying the contributions of particular variables to boys' and girls' stated intentions towards university science courses. Before introducing these, however, it is pertinent to briefly touch on how the results were obtained (a comprehensive description of the methodology is found in Lyons and Quinn 2010).

The phase of the study described here required students to respond to a range to 5-point Likert items and scales, generating data which are essentially ordinal. Some of the items were taken from the Test of Science Related Attitudes (TOSRA) instrument developed by Fraser (1981). Two others were borrowed from the ROSE instrument (Schreiner & Sjøberg, 2007), while the remainder were developed specifically for *Choosing Science*. Sex differences in these data were explored using parametric analytic techniques, in line with studies in comparable contexts (e.g., Kessels, 2005; Sheehan & DuPrey, 1999; Woolnough, et al., 1997). We followed Gaito's (1980) line of argument that there is no theoretical reason for avoiding parametric techniques for ordinal data, with the only requirements that mathematical assumptions be at least approximated. This position is supported reasonably widely (e.g., Carifio & Perla, 2008), with Norman (2010) arguing recently on theoretical and empirical grounds that tests of central tendency such as ANOVAs (because of the Central Limit Theorem) and correlation/regression coefficients are robust to the ordinality characteristics of Likert items (not only scales). We have tested the robustness of parametric techniques on our data set by using parametric and non-parametric analyses on the same item-level data (Lyons & Quinn, 2010), which showed entirely consistent findings from both sets of techniques. In terms of measurement theory, we acknowledge the validity and reliability constraints of results from single items in comparison to more desirable psychometrically robust multi-item scales. However, single item scales are frequently used and can highlight useful findings that inform and guide the development of more detailed studies.

Gender differences in students' responses

The *Choosing Science* study found little difference in the percentages of boys and girls opting out of senior secondary science. However, girls were underrepresented in physics and more likely to choose biology, a pattern found more widely. Table 1 reports the mean responses of girls and boys to variables pertaining to their intentions to study science at university.

Intentions to study science at university and views on science careers

As shown in Table 1, there was no significant difference between the mean responses of girls and boys to the item "It is likely I will choose a science-related university course when I leave school" or the Career Interest scale, although there was a tendency for boys to agree more with both of these. This is consistent with the finding (from the same cohort) of no significant difference in the frequency with which boys and girls opted out of senior secondary science (Quinn & Lyons, 2010). It did however challenge to some extent our initial expectations based on previous research such as the ROSE (Schreiner & Sjøberg, 2007), and PISA studies (Thomson & De Bortoli, 2008, p. 132) that boys would be more likely to express an intention to study science at university. In Australian PISA data, though, the difference in means between girls' and boys' intentions to study or work in science after secondary school also appeared to be relatively small. The relative gender parity in Year 10 intentions in this study, although encouraging, does not necessarily equate to parity in later university and career choices, with a multitude of reasons for attrition from science subsequent to this decision point (Jacobs & Simpkins, 2005).

As also indicated in Table 1, both girls and boys agreed to a similar extent that science is well paid, and that it is easy to get a job in science. In fact about half the sample agreed that science jobs were both easy to get and well paid, and only about 15% disagreed with these propositions (Lyons & Quinn, 2010). This is noteworthy given concerns about job insecurity and remuneration in science discussed above (Giles, et al., 2009; Graduate Careers Australia, 2009). Only a third of students (about 35%) agreed that school science had opened their eyes to new and exciting jobs (Lyons & Quinn 2010), and no sex difference was apparent in responses to this item.

Table 1. Mean responses to items and scales relating to students' career interest in science, perceptions of science careers, self-rated ability and enjoyment of science

	Mean		S.D.	
Item	girls	boys	girls	boys
It is likely I will choose a science-related university course when I leave school	2.90	2.99	1.41	1.37
Career interest 10-item TOSRA scale $\alpha = 0.89$	2.85	2.90	0.83	0.81
I think science careers are well paid	3.48	3.40	0.89	1.02
I think it is fairly easy for a person with a university science degree to get a job in science	3.43	3.44	0.94	0.99
School science has opened my eyes to new and exciting jobs (ROSE 5-point item)	2.87	2.98	1.33	1.37
How would you rate your own academic ability in science this year compared to others in your class	**3.35**[a]	**3.60**	0.96	1.01
Enjoyment of Science 10-item TOSRA scale $\alpha = 0.91$	**3.09**[b]	**3.18**	.87	.86
I like school science better than most other school subjects (ROSE 5-point item)	**2.56**[c]	**2.90**	1.26	1.33

Notes: **Bolded** means significantly different at $p<0.001$ (α of 0.001 because of large sample size) a: Cohen's d = 0.25, b: Cohen's d = 0.1, c: Cohen's d = 0.26

Science self-concept

Boys rated their ability in science compared to others in their class more highly than did girls, and this represents a meaningful but small difference (Table 1). This is consistent with gender differences in self-concept found by previous research, including for Australian students in PISA (OECD, 2007a) and Hassan (2008). It is also consistent with the gender differences in responses of English High School students to the ROSE item " School science is rather easy for me to learn" (Jenkins & Pell, 2006).

There is some evidence though, of a relational aspect to students' perceptions of their abilities across different subject domains. For example, it has been suggested that from an internal frame of reference, girls' science-related self-concept might actually be negatively affected by the breadth of their abilities and interests in comparison to boys', for example; "I am better at English than science" (Beier & Rittmayer, 2008, p. 3). The findings reported by Eccles (1989) that high school girls underestimated their mathematics ability while becoming more confident about English ability over time could also be interpreted from this perspective. The possible influence of students' perceptions of their ability in one domain on their perceived ability in another is potentially fruitful ground for further exploration, particularly given the relational nature of other science beliefs and choices (Jacobs, 2005; Simpkins, et al., 2006).

Enjoyment of school science

Although the mean response for boys on the Enjoyment of Science scale was significantly higher than for girls, the effect size was trivial, suggesting very little meaningful difference between boys and girls' overall enjoyment of science. This is consistent with the finding of Hassan (2008), which was also in an Australian context and used items from the same TOSRA scale. It is also not dissimilar to the small gender difference in enjoyment of science found in the PISA study. Despite the very small difference apparent in boys' and girls' overall enjoyment of science, boys tended to agree significantly more than girls with the item "I like science better than most other school subjects", and there was a reasonable effect size. The gender differences we found reflect similar results obtained from the ROSE project in comparable countries (Schreiner & Sjøberg, 2007).

Considered together, these findings highlight the importance of the relational aspect of students' enjoyment of science: that in this study while Australian boys and girls enjoy science to a similar extent, or boys may enjoy science slightly more, boys certainly seem to enjoy it more *in relation to other subjects* than do girls. This may reflect girls' greater relative enjoyment of humanities relative to boys, as has been suggested by Jovanic and King (1998) and found empirically in a comparison of boys and girls' self-concept of ability in mathematics and English (Eccles, 1989). Perhaps girls in this study did not enjoy science less than boys, rather they enjoyed other subjects more. This interpretation would be consistent with the suggestion of previous research (Eccles, 1989, 2005; Jacobs, 2005) that it is the students' perceptions of science relative to other subjects that is particularly relevant to their choices - it is the *relative* personal value that counts.

Relationships between enjoyment, self-concept, instrumental perceptions and intentions towards tertiary science studies

We explored the association between five possible predictor variables and students' responses to the item "It is likely I will choose a science-related university course when I leave school" for both girls and boys in the *Choosing Science* sample, using hierarchical regression. Although the two TOSRA scales had the highest correlations with the criterion item they were excluded to avoid multicollinearity. Reflecting the order of causal influences on behavioural choices outlined by Eccles (2009, p. 80), students' self-rated ability was entered first, followed by all the other items as a single block. Results are shown in Table 2.

Table 2. Summary of hierarchical regression analysis for variables predicting responses to the criterion item "It is likely I will choose a science-related university course when I leave school"

		girls		boys	
Step	Item	β	part corr'n	β	part corr'n
1	How would you rate your own academic ability in science this year	0.37^*	0.37	0.36^*	0.36
	Adjusted R^2	**0.14**		**0.13**	
2	How would you rate your own academic ability in science this year	0.09^*	0.08	0.13^*	0.11
	I like school science better than most other school subjects	0.33^*	0.24	0.28^*	0.22
	School science has opened my eyes to new and exciting jobs	0.26^*	0.22	0.27^*	0.23
	I think science careers are well paid	0.08^*	0.07	0.13^*	0.12
	I think it is fairly easy for a person with a university science degree to get a job in science	0.06	0.05	0.09^*	0.08
	Adjusted R^2	**0.36**		**0.37**	
	ΔR^2	**0.22^***		**0.25^***	

Note * contribution to the regression model is significant at $p \leq 0.001$

As indicated by Table 2, for both girls and boys, self-rated ability on its own accounted for about 14% of the variance in the model. However, its contribution to the regression was dramatically diminished when other variables were included, especially for girls. The model as a whole accounted for about 37% of the variance, and after controlling for self-rated ability the other items explained an additional 22% (girls) and 25% (boys) of the variance.

The items contributing most to the solution for both girls and boys are the students' liking for school science and awareness from school science of new and exciting jobs, followed by their perceived self-ability, which accounts for much less variability. The relative contribution of these predictors was very similar for both sexes although self-rated ability was a stronger predictor of boys' intentions to study at university compared to girls.

The items relating to science career pay and ease of getting a job contributed very little to the solution, despite the fact that about half the students thought that that science jobs are both easy to get and well paid. In addition, these items contributed more to the solution for boys than girls. This suggests that these instrumental considerations were more related to intentions to study science at university for boys, which is consistent with the 'breadwinner' gender role experienced by males (Eccles, 2005, 2009).

Discussion and implications

The issues outlined above reinforce much previous research showing poorer science self-concepts and less relative enjoyment of science as potential barriers for high school girls considering university science. As outlined in the work of Eccles (e.g., 2009) both of these constructs are inextricably linked to the students' developing identities, and over the past two decades much has been done in science classrooms and by science teachers to ameliorate these interrelated problems. As summarised and reviewed by Brotman and Moore (2008) these interventions have to date predominantly focused on reducing inequities in science classrooms (e.g., by ensuring both girls and boys manipulate equipment, reducing sex-bias in teaching materials), and adopting more gender-inclusive curriculum and pedagogy (e.g., by using more cooperative learning strategies, incorporating topics of interest to girls, facilitating deep learning, providing authentic inquiry-oriented learning mastery experiences, highlighting socio-scientific aspects etc.). Many of these characteristics of gender inclusivity are, as mentioned by Brotman and Moore (2008), essentially characteristics of good teaching in general, which can improve science education for all students. But despite the findings of some qualitative studies, there is little evidence in larger scale quantitative studies of particular benefits of these measures to girls (Brotman & Moore, 2008), and consequently, as noted by Jacobs (2005), after 25 years of research effort, girls are still 'leaking out of the science pipeline' at a far greater rate than boys.

This is perhaps not surprising given that the formation of students' science self-concept and identity is related to such a wide range of factors in their 'distal cultural milieu' (Eccles, 2009). These factors include social role systems and gender stereotypes related to abilities and roles, and reactions to key socialisers, family characteristics and previous experiences. Many of these interrelated distal influences are likely to be more powerful and pervasive than students' limited experiences in science classrooms, which is perhaps one reason why decades of interventions in science classrooms have not greatly impacted on gender disparity in some science fields. To 'use the classroom to counteract years of socialization' as suggested by Eccles (1989) seems to be necessary but not sufficient to reduce the underrepresentation of women in science careers.

As an example, one commonly recommended classroom strategy aimed at re-socialisation of girls (e.g., Britner & Pajares, 2006), is providing girls with female role models, preferably those with some characteristics with which adolescent girls can identify. Certainly role models have an important role in countering gender stereotypes of science as a male activity (see e.g., Farenga & Joyce, 1999) and enhancing girls' science-related identity. However from this wider perspective of girls' identity formation there is evidence that role models in the classroom may not be enough to make a discernible difference on their own. For example, Hazari, Sonnert, Sadler, and Shanahan (2010) found that female guest speakers, and female scientist examples had no significant effect on high school girls' physics "identity" and concluded that they were not sufficient to 'encourage' girls into physics. Further studies cited by Hazari et al. (2010) showed that students' science identities in 10^{th} grade were not affected by the percentage of female teachers they encountered in their school learning context. More broadly, Blickenstaff (2005) was not enthusiastic about the potential of role models to ameliorate the problem of under-representation of girls in science. These are not arguments against using role models, but underline the need for additional strategies to foster girls' enjoyment of science and science-related self-concepts and identities.

Additional potentially fruitful measures to help ameliorate low self-efficacy of girls in science center around personal and individualised interactions between teachers and their students. These measures include teachers specifically and accurately praising students' abilities and achievements in science, and encouraging them (as appropriate to their ability) to feel that they will be able to master difficult science tasks (Britner & Pajares, 2006). Teachers can also enhance students' science self-efficacy by being alert to their anxieties about new or difficult science tasks and teaching them how to deal with this (Britner & Pajares, 2006). As argued by Eccles (1989), teachers have a potentially powerful role in countering the tendency of girls to attribute success to reasons other than ability, and can also harness the socialising power of parents by providing them with direct feedback about girls' abilities (as distinct from performance). This sort of encouragement has been shown to critically important to high school students' confidence in science (Stake, 2006). It is important for these interactions to occur at primary and early secondary school when the socialising role of parents and teachers is still relatively strong, and given the strong influence of early career intentions on later career decisions (Tai, et al., 2006). The real challenges to this posed by other demands on teachers related to cultural and socio-economic diversity, and time, curriculum and bureaucratic pressures must be acknowledged.

The measures of the kind outlined above have been criticised in critical feminist literature as inadequate in redressing gender disparity in science, because of the persistent underlying problem of the fundamentally masculine rational and objective portrayal or nature of science. For this reason several researchers call for science teachers to adopt a more critical perspective in the science classroom or suggest that 'we must overturn current ideas about scientific knowledge and practice' (Brotman & Moore, 2008, p. 988) in order to reduce barriers to girls in science. Some support for this general approach has been found in a recent study where explicit classroom discussion of gender differences in science did influence developing identities whereas role models did not (Hazari et al. 2010). Full discussion of this issue is beyond the scope of this paper but it is possible that measures such as this in the science classroom might lead girls to invest valuable personal resources in venturing a bit further along the 'science pipeline', only to opt out later on encountering the masculine world of science in practice. It is also problematic in this regard that the 'masculine' end of science such as engineering is more highly valued, as indicated by better and more highly remunerated employment prospects than many other science disciplines, with the notable exception of medicine. Ultimately from this perspective the wider socio-scientific values that interact with identity and career choices need also to be addressed beyond the science classroom –a much more difficult proposition.

Although many of the students in our study held fairly sanguine views of employment prospects and remuneration in science, these were not strong predictors of intentions to study science at university for girls, but were somewhat more important for boys. Knowing about "new and exciting jobs" from school science, though, was the second highest predictor of intentions to study science at university, for both girls and boys. These results underscore the need for girls' and boys' choices to be more thoroughly informed by knowledge of the employment prospects in science– both the exciting array of opportunities in a vast range of fields as well as some of the current employment limitations.

Programs such as “Scientists in Schools” which connect school students with professionals in science and allied science fields have much to offer in this regard by involving students in current, authentic science and helping them to see how school science relates to exciting new science jobs. Such experiential learning in science helps high school students with difficult career decisions (Guenette, Marshall, & Morley, 2007). There is a risk though, that these programs might also reinforce the narrow and stereotypical views that are held by many high school students about what careers are related to science (as discussed by Cleaves, 2005) which may be particularly problematic for girls given their interest in ‘helping’ and ‘people-oriented’ careers (Eccles, 2005). As argued by Osborne (2008), students also need to see how school science relates directly to social contexts and to the gamut of wider careers such as the allied health professions, food technology, eco- and environmental areas. This points to the need for a greater nexus between science and careers specialists in helping high school students with complex career and study decisions.

The issues discussed in this paper point to some difficulties associated with the common rhetoric of actively ‘encouraging’ girls into science using strategically targeted interventions. Apart from the overtones of passivity and malleability implicit in this discourse, it is ethically questionable for educators to actively steer school students, whether boys or girls, into science or any other career for that matter. This is especially so given the uncertain employment prospects in some areas of science which our study suggests are unknown to many secondary students. Our findings also highlight the potentially limited effectiveness of classroom-based interventions aimed at reducing barriers to participation in science as critical for girls, given the relational nature of students’ perceptions and choices and the extent and power of societal influences beyond the classroom doors.

Nonetheless we also suggest that there are measures that can be adopted in science classrooms to improve girls’ enjoyment of science and science self-concepts, and although their individual impacts might be small, their interaction may well reduce some of the barriers to science for some girls who would otherwise consider science as a possible career. Reducing constraints to girls’ developing personal and collective identities, subject choices and career horizons has potential benefits to individual girls and also to the practice and communication of science, which can only benefit from the more diverse perspectives and contributions of both sexes.

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