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PARENTAL VIEWS ABOUT SCIENCE EDUCATION FOR INFORMED CITIZENSHIP

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Abstract

Low post-compulsory science enrolments for secondary students have been a growing concern across the Western world; curriculum reforms to increase scientific literacy levels for civic scientific literacy or informed citizenship and to enhance science participation at secondary level are making little difference.
Much research has examined factors relating to science curricula and students' attitudes about science, but issues relating to parental views of science education remain largely unexplored. This is a critical omission since parents have been demonstrated to be important in influencing their children's perceptions and interpretations of the world around them throughout the schooling years and beyond. Because parents have a strong role in shaping their children's subject selection and career choices, this study explored parental attitudes about science education. Indigenous and non-Indigenous parents of pupils in grades 5-7 in state schools were invited to participate in focus group interviews in a regional Australian city.
Results include a perspective which was empirically demonstrated for the first time: this group of non-Indigenous and Indigenous parents believed geography, history and social studies subjects (under the umbrella of SOSE, study of society and the environment) to be a better preparation than science for informed citizenship. Both sets of parents were unclear as to the nature of scientific literacy, and believed science, as it is currently taught in primary schools, is not relevant to their children's needs and not practical, or "hands-on" enough.
More broadly, parents believed that there are too few employment opportunities for those studying the sciences. They did not know what careers were available to those studying the sciences other than in medical and allied health fields, or which careers required science as a prerequisite. These perceptions were particularly strong among Indigenous parents. Views such as 'science is too difficult for their children' and stereotyped perceptions of scientists were also expressed. Media influences were cited as influential in shaping both groups of parents' perceptions of science careers.
Issues of the importance of science in the curriculum and parents' ability to assist their children with science homework were also explored.
This study sheds new light in an area where there is scope for targeted interventions to impact upon parents' value and support for the study of science. Parents might, in turn, influence their children's engagement with science subjects through secondary and post secondary levels. It also demonstrates the need to explore parental views further using a larger sample drawn from a range of Australian geographic locations.

Introduction

This paper reports findings of a pilot study conducted in regional Queensland. It documents views about science education held by Indigenous and Non-Indigenous parents of students in upper primary school. A regional centre was selected for study because a national Australian survey (Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006) showed that in regional and remote areas student achievement in science is lower than in metropolitan areas, partly due to the unavailability of qualified science teachers in those areas. These results are situated in a context of declining performance in science across Queensland schools over recent decades (Masters, 2009). Coupled with lower performance in science, Masters (2009) reports Queensland 15 year-old students appear to have lower levels of interest in physics, chemistry, biology, astronomy and geology than students in 41 other OECD countries.
In May 2007 a report was released arguing that science education is in crisis in Australia (Tytler, 2007). This crisis in school science, Tytler argued, threatens the future of Australia as a technologically advanced nation. The need to attract more students to science courses and careers is as urgent in Australia as it is overseas (Tytler, Osborne, Williams, Tytler & Cripps Clark, 2008).

Students entering their first secondary school science classes are generally enthusiastic about the subject (Osborne, Simon, & Collins, 2003) but this is short lived. Enrolment trends in post-compulsory science subjects throughout Australia show that they lag behind subjects under the SOSE (Studies of

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Society and Environment) key learning area[1]. In 2006, 54% of students opted for a science subject compared to 65% for one from SOSE, numbers of science enrolments sliding from previous years (for example, 79% in 2000, and 76% in 2001, 56% in 2003, 55% in 2005) (ABS, 2006). The loss of enrolments from science subjects to geography, history and other subjects broadly grouped under the umbrella of studies of society and the environment (SOSE) is evident across Australia (ABS, 2006). A decline in science enrolments is observed in other western countries (e.g., summary in Osborne, Simon & Collins, 2003). In 2001 Dekkers and De Laeter noted that considerable effort had gone into enhancing participation in science courses at the upper secondary level, but little advance was made in science enrolments. Five years later, in 2006, enrolment numbers in science subjects seem to continue to spiral downwards.

The reasons underpinning this trend are many and complex. Carter (2008) contends that students perceive the traditional approach to science education as largely irrelevant to the realities of their world. Indeed many researchers support this view (Dekkers & de Laeter, 2001; Eisenhart, Finkel, & Marion, 1996; Millar & Osborne, 1998; Ogawa, 2001). The Relevance of Science Education (ROSE) Project shows evidence that students across the developed world were disengaged from science education (for details, see the project Web site ROSE Project, 2005; Schreiner & Sj´øberg, 2004). While the causes of this disengagement might not be fully elucidated at this time, science enrolment trends indicate students do not have the motivation necessary to pursue scientific studies beyond the compulsory years.

A decreasing enrolment in science subjects has diverse ramifications; one is centered on economic outcomes (Thomas & Durant, 1987). These are based on the notion that the level of a country's wealth is closely allied to the number of science graduates and specialists who enter the workforce. Although a low number of qualified scientists in any particular country may be ameliorated by importing specialists from other countries, as is currently the case in Australia where there is a dearth of mining engineers, geologists and metallurgists (Young, 2006), there need to be more locally trained specialists to support the country's staff infrastructure.

Parental influences

In order to understand the decrease in science participation, researchers have examined students' views of science education (eg. Osborne & Collins, 2000) including methodological issues concerned with such an examination (Ramsden, 1998). Few have, however, investigated parents' views of science education.
This oversight is critical because a large body of research shows parental views, beliefs and behaviours predict children's career choices, academic outcomes and have influences through to college students' science outcomes (e.g., Alloway, Dalley, Patterson, Walker & Lenoy, 2004; Driessen, Smit, & Sleegers, 2005; Ferry, Fouad, & Smith, 2000; Green, Walker, Hoover-Dempsey & Sandler, 2007; Jacobs, & Harvey, 2005; Lyons, 2006; Neuenschwander, Vida, Garrett, & Eccles, 2007; Ratelle, Larose, Guay, & Senecal, 2005; Tenenbaum & Leaper, 2003; Weishaar, Green, & Craighead, 1981). In Australia, a recent large scale review documents parental expectations and encouragement are among the strongest forces shaping student engagement with science and ultimate career directions. Furthermore, for most students, life aspirations are formed early, before the lower secondary school years (Tytler, Osborne, Williams, Tytler & Cripps Clark, 2008).

When comparing the joint influence of the classroom, home and peer environments, Scantlebury, Boone, Butler Kahle and Fraser (2001) found parental support of students' science education was strongest in predicting student attitudes to science. Similarly, Breakwell and Beardsell (1992) and Simpson and Oliver (1990) provide evidence for a relationship between parental support and attitudes to science. These influences can extend to tertiary level as Fitzpatrick and Silverman (1989) found with female engineers. Authors of recent longitudinal research (Tai, Qi Liu, Maltese & Fan, 2006) using a sample of 3,359 students concluded that to attract students into the sciences or engineering, close attention needs to focus upon children's early exposure to science at the middle and even younger grades, with parental encouragement being a key issue.

An additional layer of influence rests within the cultural context wherein a family is situated (Bronfenbrenner, 1979). Parental socioeconomic status variables such as education, occupation,

[1] This key learning area includes geography, history, society and culture, sociology and futures.

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language background and other attributes underpinning the cultural home environment have also been associated with enrolments in post-compulsory science subjects (Thompson, 2006). Studies examining different cultural groups show stronger links between parental views and career choices for some (Woodrow, 1996), in particular in relation to science career choices (Chen, 2001). In Australia, the student profile of those enrolled in the physical sciences include being male, from a higher socioeconomic (SES) family, and from a language background other than English (Fullerton & Ainley, 2000). Such studies support the notion that student subject enrolment and career choices are determined in part by their family's views and beliefs.

Scientific literacy

In 2007 a large national survey was conducted in Australia to investigate parents' attitudes to schooling (DEST, 2007). It reported less than half of the surveyed parents believe that students leave school with adequate skills in science (46.7%). The study however, did not examine parents' views of post-compulsory science education or their perceptions of science education for civic scientific literacy, an important factor in directing students to persist and engage with science, at least to Grade 10. In view of the importance of parental influences on students' career choices, parental awareness of scientific literacy or a value for such an awareness, needs to be explored.

The value for scientific awareness or scientific literacy is related to the decline in science subject enrolments and has been a matter debated for the last 50 years. Osborne, Simon and Collins (2003) argue that "irrespective of the economic effects, the decline of interest in science remains a serious matter of concern for any society attempting to raise its standards of scientific literacy" (p.1053) because they argue science and technology are integral and distinguishing features of Western societies. Educators agree that general scientific literacy should be an important outcome of schooling.

The concept of "scientific literacy" has played (NRC, 1996) and continues to play (e.g., Millar, & Osborne, 1998; Fensham, 2002) a central role in science education reform efforts in the US, UK and Australia. Its history is succinctly summarized by Turner (2008):

> The 1980s saw two events of significance for the public's evolving engagement with science and technology. The first was the birth of the Public Understanding of Science (PUoS) Movement. That movement consisted of new, vigorous efforts to promote public knowledge of science and to instill confidence and support for the scientific enterprise. As a side effect, the movement stimulated the growth of a new research field organized around measuring the PUoS and analyzing the factors that shape it. The second event was a widespread reassessment of the content and goals of school science teaching and a shift of curricular reform efforts toward the needs of the substantial majority of students who would not pursue scientific and technological careers or post-secondary training in technical subjects. This reform movement mostly went forward under the catchy American slogan, "scientific literacy" (SL) (Turner, 2008, p.55.).

The achievement of scientific literacy is a rationale commonly given for studying science subjects in school (e.g., Bybee, 1997; Brown, Reveles, & Kelly, 2005; OECD, 2003; Shwartz, Ben-Zvi, & Hofstein, 2005), although different interpretations of its meaning abound (DeBoer, 2000; Fensham, 2004; Hodson, 2002; Kolstø, 2001; Laugksch, 2000).

One view of the importance of scientific literacy is articulated by Turner (2008): "the need to create an informed citizenry ready to participate intelligently in the political and social debates over controversial new technologies" (p.59). Earlier, influential educational theorist Robin Millar grouped various reasons proposed for the need of public understanding of science into five overarching themes to defend the teaching of science in schools: (1) the *economic argument:* national economic well-being depends upon a supply of technically and scientifically qualified specialists; (2) the *utility argument:* scientific understanding helps people make informed decisions about diet, health, safety, consumer choices and so on; (3) the *democratic argument:* citizenship requires informed participation in discussion, debate, and decision-making about technological and scientific issues, such as climate change, pollution, drug-testing, stem-cell research; (4) the *social argument*: society needs to understand both "scientific" and "humanistic" perspectives; and (5) the *cultural argument*: science is a major achievement of our culture and we all benefit by being able to understand and appreciate it (Millar, 1996, p.9). More recently, (OECD, 2006) scientific literacy was expanded to include attitudes to science and their influence upon informed citizenship:

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> Scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues; Understanding of the characteristic features of science as a form of human knowledge and enquiry; Awareness of how science and technology shape our material, intellectual, and cultural environments; Willingness to engage in science-related issues and with the ideas of science, as a reflective citizen (OECD, 2006, p.23).

The scientific literacy definitions cited above inform the Queensland science syllabus for years 1-9. They are based on the premise that:

> *"Scientifically literate people are interested in and understand the world around the, engage in the discourses of and about science; are able to identify questions investigate and draw evidence-based conclusions, are skeptical and questioning of claims made by others about scientific matters, and make informed decisions about the environment and their own health and well being" (DETA, 2008, p.81)*

The syllabus further elaborates that "Students should use science as 'a human endeavour, a way of knowing, a way of working, an organized body of knowledge, having ethical dimensions' (DETA, 2008, p.81).

The scientific literacy of Australian students has been assessed to be among the top ten in the OECD partner countries participating in the PISA (2006) study. Therefore, it might be reasonable to assume that secondary school students, at least in the last few years in Australia, are demonstrating acceptable levels of science understanding for informed citizenship or civic scientific literacy. One might also conjecture that given this high level of scientific literacy, post-compulsory science subject enrolment might also reflect rising trends. However this is not the case. Other influences are at play here. Gough (2007) contends that peers and media are implicated. Parental influences are also likely.

Purpose, aims and research methods

The current study began at a time when Australia was preparing for a national election. One of the many issues debated by competing parties was climate change and the role they might play in mitigating its effects. Voting decisions about this issue would presumably be based, among other things, on the scientific literacy of the voters. It was considered pertinent therefore to explore what parents thought of science as an avenue for supporting informed citizenship as well as what they thought of science education for their children. Given the gap left behind by the 2007 DEST research in relation to parental views of science education, it was the aim of this study to provide some data on parents' views of post-compulsory science education and their perceptions of science education for civic scientific literacy.

The study was designed to explore Indigenous and non-Indigenous parents' views about post-compulsory science education. In particular, their ideas about the secondary subjects they thought would assist their children to develop civic scientific literacy for informed citizenship; there is a dearth of empirical studies addressing these issues. The views of Indigenous parents were sought because Indigenous students have a lower participation rate (39.5%) to Year 12 than other Australians and comprise only 1% of all tertiary enrolments (ABS, 2005).
The investigation centered on the following:

- Is secondary science education considered important by parents in preparing their child for informed citizenship?
- What are parents' views of the role of science education?
- Is the study of science subjects (chemistry, physics, biology, marine biology) perceived to be instrumental to a child's future career success?

Parents of students in the final year of primary school were targeted for two reasons: it was considered that they might be thinking about these issues because of the imminent move of their child to secondary school, and the study by Tai et al (2006) highlights the early influence of parents upon their children's engagement with science.

Since the purpose of this research was to seek insight into the experiences, views and beliefs of parents, the data required were essentially qualitative.The approach adopted used qualitative semi-structured focus group interviews to gather parental ideas to inform and refine the questions that would be used for follow up research. This approach follows the rationale that this method will convey the needs of individuals or groups of individuals who are marginalized or underrepresented such as Indigenous parents (Hanson, Creswell, Plano Clark, Petska & Creswell, 2005).

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Interviews were conducted over six months during the last school term of the year and the beginning of the following year. Five[2] state primary schools in diverse areas of a regional Queensland city took part in the study; parents were invited to participate in focus interviews by the school principal. A qualified Indigenous teacher was employed as research assistant throughout the duration of the project in order to conduct focus interviews with Indigenous parents and observe cultural protocols. For consistency, the same research assistant interviewed non-Indigenous parents as well. The focus group interview method was selected because it offers a means of exploring the principal issues of interest in a manner which utilizes the group interaction to challenge, and probe the views of individuals in a non-threatening, relatively naturalized social context, particularly important for Indigenous parents. The group context also offers a degree of support and security and the option not to respond, less available in one-to-one interviews.

Semi-structured questions ***(Appendix 1)*** comprised the protocol for focus group discussions. Questions 1 and 2 were inserted as "ice-breakers" to begin the discussion and encourage parents to articulate their views. Each key question was posed and prompts in relation to each question were only utilized when unstructured discussion of the key question did not result in issues of interest being raised. Focus group interviews were undertaken in a school location determined by each of the schools. The interviews were taped and subsequently transcribed verbatim; they were analysed using content analysis in response to the questions of the interview schedule. Two of us read each transcript independently as an inductive process to discover issues that were raised. Our analysis focused on phrases, explanations, and observations made by participants that illustrated the themes under study. We then compared our results until agreement for the responses was reached.

Group size determines the number of lines of communication and the time for any one individual to contribute. With n participants the number of lines of communication is simply $n\,(n-1)/2$. With ten people, there are forty-five possible channels with a danger of destabilising the group dynamics. For this reason, a group size of six to eight is often considered optimal (Folch-Lyon & Trost, 1981) though as few as four and as many as twelve in a group can also be satisfactory. In this study the average group size was four.

Findings

Eight Indigenous parents agreed to participate from one school and sixteen non-Indigenous parents from three different schools; all parents were mothers. Parents' response to the invitation for focus interviews was very disappointing, but the principals of the participating schools assured us that this was "the norm" rather than the exception. Reasons for this might be the work commitments of parents, parents' socioeconomic status and their perceptions of university personnel, the topic under discussion (science education), the lack of reporting of science achievement as a separate subject to parents (Hackling & Prain, 2005) or a combination of factors. Nonetheless a high degree of data saturation was obtained from the five focus interviews.

The questions of interest were questions 3 to 10, ***(Appendix 1)*** with the question on mathematics being included by way of a comparison framework.

As expected, both sets of parents[3] endorsed English, mathematics and science as the most **important subjects for their children**, with Indigenous parents placing great stress on English because for most Indigenous (I) people it is a second or third language:

> (I)*Because English is mainstream mainland, you have to have English. That's the bottom line. You have to be able to read. Read and write and be able to understand mainstream to live, to, you know, work. I mean to get a good job, you have to have English.*

Throughout the interview it became clear that Indigenous parents' primary focus was that their children were receiving an education; it appeared from their comments that science as a particular area of education was not given specific consideration.

> (I) *I got thinking about it since you talked to me last week[4]; until you brought this up, science was left at school, a subject that we did at school and when I left high school that was it.*

[2] Parents from only four schools eventually took part in focus interviews.
[3] Indigenous parents are referred to as (I); non-Indigenous parents (NI); non-Indigenous science trained parents (NIS).

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There were several comments from parents to indicate that **science was difficult**, for particularly able students, and remote:

(I) *A lot of them kids they think, science, they think dissecting, too much work, you gotta be really smart, you know. It's the stigma that's attached to it you know, people think of scientist, what they see on the TV or whatever, the white coats, the laboratory and all of the that sort of stuff and they think, whoa! This is where nerds go, you know people that are really, really smart and clever.*

Non- Indigenous parents had a variety of **perceptions about science**:

(NI) *I believe there is a common misconception that studying math and science involves high level knowledge of 'dry' facts only. I believe that parents, in general, don't appreciate the investigative and problem solving component of math/science education and the value of children developing such skills. It (science) provides a general approach to all sorts of problem solving in general.*

Non-Indigenous parents also saw science as particularly remote and disconnected from everyday life. **Relevance of science** became a central issue particularly for those parents, the majority, not trained in science.

(NI) *Study should focus on more on how to apply science to real life and the world around. I believe it would be more interesting and engaging for students. Get some enthusiasm back into the teaching of science. Get rid of the teachers who state up front that the subject is boring but we have to do it. Only allow those who are passionate about science to teach it. Get away from the textbook. Make it relevant – link it back to real life, contextualise it.*

Indigenous parents saw strong links between maths and science and expressed positive **value for the study of science** at school, placing strong emphases on the applied nature of the various strands of science and citing examples of this relevance, in particular biology:

(I) *Biology's really, really important, especially when you've got kids playing sport and kids that are developing. When you're looking at high school and they're doing these subjects in grade 11 and 12 and not doing any before that because biology comes into their life at 15 and then they're talking about reproduction, having sex and all that kind of stuff, having babies and the males growing and changing and stuff, so it's all very , very relevant to them personally ….that change of their bodies and going through puberty, so high school is just a pool of puberty. Physics blows people up! oh well when you're looking at driving cars, kids going to… driving cars best to know bit more about physics, about how long its going to take to stop, you know, how fast you can turn corners, stuff like that. Medication, I don't know, oh drugs, the pill, drugs, alcohol and drugs, vanilla essence, we know that lemon essence is flammable! I learnt that kids mix "red bull" and vodka... Chemistry taught you that it's toxic, poison.*

However, these perceptions of science were limited to personal experiences and did not encompass the broader applications of the various science strands which the non-Indigenous parents isolated:

(NI) *When I look at chemistry I think laboratory chemistry and biochemistry*

and

(NI) *So when I think of science I think of engineering, agriculture, everything basically, medical and marine, yeah, everything. So it's hard to sort of confine to specific things especially since the technology boom as well*

As far as what was the **most relevant science subject** for their children's education non-Indigenous (NI) parents reserved judgment based upon their children's emerging talents:

(NI) *Science is critical in Years 6-9 +. Further persistence of these subjects becomes more conditional upon the emerging skills and talents of the child.*

Indigenous parents endorsed all of them but perhaps this was due to short-term, immediate perspectives, rather than future career ideas:

(I) *A lot of parents don't realise that science is in everything*

But there was also **confusion between science and social science**:

(I) *Social science for starters, J---- has, had no idea of what anything was or how it functioned or anything. Social science, their living... how you function yourself in society, things like that.*

This **unexpected perception of social science** was prominent in response to "which subject would help your child to make informed decisions about socio-scientific issues such as climate change, genetic engineering, nuclear power, water quality":

(I) *Well SOSE! (The study of the societies and environment)*

Non-Indigenous parents also endorsed this unexpected view, including one science trained non-Indigenous mother:

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[4] Comment in response to the invitation to participate in focus interviews.

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(NIS) *I'm not sure which ones, like they've changed it, it's SOSE now isn't it, studies of societies and environment. Probably the one that covers politics and things like that.*

Views about the **expense of science training** and the **perceived dearth of science job** opportunities converged in the two focus groups.

(I) *I think less people are studying them (science) at university because it's too God---- expensive at uni, how you can expect people to send their children to uni*?

(NI) *We are led to believe that a (science) university education leads to higher paying jobs - This is rubbish! It leads to years of no pay while studying and a high HECS/HEL*[5] *debt.*

(NI) *I don't know how many of those students that go through uni actually get jobs in it (science). I've certainly seen quite a few go back there and do teaching or working somewhere else.*

Nonetheless, Indigenous parents maintained they would encourage their children to take up science careers if they were guaranteed a well paying job.

When parents were asked whether they would be able to **help their children with homework in science** there were some differences among the two focus groups with Indigenous parents feeling less confident than non-Indigenous parents; both groups felt they were not sufficiently competent in science to help their children with science homework:

(I) *It would be helpful if teachers could help the children with their homework. We need a homework centre. It was very helpful*

(NI) *Parents today in the 35+ age group are mostly unable to assist their child with science and maths as it has changed considerably since we were at school*

(NIS)*We help them with everything; I mean we're not particularly fazed by anything*

The term **science literacy** emerged in the conversation in relation to Education department drives to improve numeracy, literacy and scientific literacy. Parents were not sure what this meant. A science trained non-Indigenous mother made the following comment:

(NI) *I've heard of the studies saying how poor the literacy is for science students at university, that's really changed in the last probably 10 years or so, certainly wasn't that bad when we were there.*

Another, younger, mother joked: (I) "*Scientific literacy? A nerd meter"*

Both comments reflect misconceptions about scientific literacy, and lack of awareness of the drive to improve it in our students. Such misconceptions do not appear as often when speaking of mathematical or English literacy. Perceptions might be the result of low levels of communication to parents of the importance of scientific literacy, compounded by teachers' lack of confidence with science teaching (Masters, 2009; Tytler, 2007) and the low proportion of qualified science teachers in rural/regional areas (Lyons et al, 2006). However, given the lack of consensus about what it means to be scientifically literate and the primacy given until recently to numeracy and literacy by education specialists and the media, perhaps this is not unexpected.

Knowledge about science careers was the last question explored. Most parents believed they knew what these were and entailed; one parent made a pertinent comment, highlighting the need for scientists to showcase their work more widely:

(NIS) *I think that science specialists, bacteriologists for example like me, should go into schools before students have to decide what subjects to enroll in senior and show them what they do, grow some bacteria or whatever, in Year 8, so they see a range of science specialists. They know what a doctor does, a dentist, a physiotherapist because they have personal experience of them but what does a metallurgist do?*

Most parents in both Indigenous and non-Indigenous groups reported university aspirations for their children. This suggests that parents in this pilot study are supportive of their children's post-compulsory education.

Discussion

Although it is acknowledged that there is always the possibility of a gulf existing between reported attitudes and beliefs and ultimate actions (Ajzen & Fishbein 1980), results reported here provide valuable new empirical evidence about a range of Indigenous and Non-Indigenous parental conceptions and attitudes to science education and the importance they place upon it for preparing their children for informed citizenship. Prior research findings have confirmed that parents influence and guide their children's career choices so their views must be considered in any examination of post-compulsory

[5] HECS/HEL refers to the student debt accumulated if they chose to pay their university fees after completing their degree.

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science participation trends. Parental influences are instrumental for both Indigenous and Non-Indigenous students (Parente, Craven, Munns & Marder, 2003).

Results of this study highlight some unexpected notions about science and its role in developing informed citizenship. Since parents hoped their child would go on to university one may assume that they would support post-compulsory education for their children and therefore critically engage with the subjects offered at secondary level for their children's future.
A major finding was parental endorsement of geography, history, social studies or SOSE as better preparation for their children to develop informed citizenship than science for issues such as climate change, nuclear power and genetic cloning. This perspective, demonstrated for the first time, needs to be heeded by science curriculum reformers and teachers. Is science viewed as redundant, a subject needed only by those wishing to specialize?

Theorists have long recognized that the science curriculum has failed to address relevant scientific issues playing out in the public arena (e.g., Fensham, 2004; Solomon, 1999). Whilst both Indigenous and Non-Indigenous parents recognized the usefulness of science for developing thinking skills, many parents complained that it was not relevant enough or contextualized. SOSE was not perceived this way. The SOSE subject rationale states:

> Students use their knowledge about the complex interactions between people, and between people and their environments, to investigate social, political, economic, environmental and cultural ideas and issues. They clarify their personal values and acknowledge others' values and world views in a range of contexts and settings. They develop their capacity for effective community participation and meaningful responses to social and environmental issues. (DETA, 2007, p.1)

Perhaps teachers of SOSE have been more successful than science teachers in communicating this rationale to children and their parents. SOSE contains topics that are not part of any science syllabus such as civics, legal and justice system and government structures and processes. Furthermore, within the "Place and Space" strand of SOSE, environmental issues are also taught (under "human and physical interactions and sustainable practices"). Some examples include overgrazing and erosion; overuse of fossil fuels and carbon dioxide emissions; resource use and its environmental impact; logging and the survival of small communities dependent on that industry. In other parts of Australia these matters are covered in geography.

What parents did not seem to be aware of is that these topics were also taught and investigated in science, thus contextualising scientific content. Perhaps this was not known by most parents as it was not reported back or internalised by students, or not sufficiently publicized by schools, not emphasised by science teachers. Or perhaps due to the prevalent conception of science as "dry, clinical and remote" which is so pervasive that facts are ignored and old experiences and ideas persist. One parent's comment illustrates this possibility:

> *(NI) I believe there is a common misconception that studying science involves high level knowledge of 'dry' facts only. I believe that parents, in general, don't appreciate the investigative and problem solving component of science education and the value of children developing such skills*

Parents were not clear about scientific literacy in the way they understood mathematical or English literacy. This is not an unexpected view since there appears to be a lack of consensus about what it means to be scientifically literate. Moreover, primacy has not been given to scientific literacy by education specialists or the media, leading to confusion about the role of science in curricula. This might be anticipated given the changes in science curricula since the 80s in an effort to make "science for all" (Fensham, 2002).

Findings highlight an urgent need for parents to be better informed about current science curricula. Given the low responses generated by the focus interview invitations, greater parental engagement and involvement might be difficult to foster, it is however, necessary. As one parent said when asked why she thought students were not studying science: "*I don't think they* (parents) *realise how good it is, and the pay certainly in the engineering side is massive now*" (NI).

There are clearly cultural variables at play as well, since the majority of those studying the physical sciences in Australia, as in the UK, tend to have a language background other than English (Thompson, 2006). It may be that, for example, Asian ethnic groups still perceive science and a science career (not limited to health sciences) as more prestigious than a career in commerce or banking, areas that have drawn large numbers of student enrolments in Australia (ABS, 2007a).

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Parental views in this study echoed Australia-wide parental views in ranking science below mathematics and English in importance (DEST, 2007). Parents believe success in mathematics is more important than success in science for their child's future; an attitude also expressed by US parents (Kadlec, Friedman & Ott, 2007). Therefore, they would perhaps be more likely to muster support for their children when they experience difficulties in mathematics than if they were struggling with science. If this is the case, students are themselves less likely to be engaged and motivated to succeed in science.

Two further interesting findings were the perceived lack of employment prospects for science graduates and the notion that university training was expensive, both reasonable practical considerations for parents thinking about supporting their children's career choices. These views appear to be also evident in US parents (Bhattacharjee, 2009). While science employment opportunities are publicised in specialist magazines such as New Scientist, or national papers, they are often not advertised in the more popular local and regional publications that parents might habitually read. This might give the impression to parents that there are few employment opportunities for science graduates. Moreover, the cost of university training in Australia is higher than in European countries and may underline different graduation rates (for example, in the UK 37% of the population graduate from university compared with about 25% in Australia (ABS, 2007a).

Such practical contingencies lend strong support to the notion that parental awareness and knowledge of science and scientists' work must be increased and updated if the number of students studying science in the future is to be raised. This perspective is already endorsed by a group in the US who have began an advertising campaign to increase parental engagement with and awareness of science and mathematics education; this was administered by the Board of Regents of the University System of Georgia initiated by the Partnership for Reform in Science and Mathematics (PRISM). School level intervention engaging students and parents is helping in this. Studies conducted in Australia investigating interventions at primary level strongly suggest that outcomes for students' science engagement and achievement are increased (Hackling & Prain, 2005). About half of all primary teachers in this large scale, Australia wide, study had no science training beyond high school and most had low self-efficacy for science. As a result of the intervention program, their competence for teaching science increased and this had flow on effects upon student learning, scientific literacy, scientific achievement and the status of science in the participating schools. The program linked science with literacy; used cooperative learning and followed and used an investigative teaching process. The impact this program had on parental perceptions of science has not yet been reported. It appears clear, however, that what Tytler (2007) has reported with regard to science teacher quality and the shortages of suitably qualified science teachers has and will have an impact upon the teaching of science and, consequently, the image of science.

While parents have repeatedly complained of the lack of relevance of science, they also resist, along with academics and policy makers, any attempt to contextualise science teaching (Tytler, 2007; Ash, 2008). In the UK, the context-based approach pioneered by the Salters Project of the 1990s was successful in attracting a large proportion of students to study 'A' level sciences. In Australia, contextualisation has begun to be used by Victorian, New South Wales and Queensland courses to varying degrees. Implementation is, however, difficult, because not only do teachers need a deep understanding of the contexts and scientific concepts and their interrelationships, they, along with many parents and academics, hold traditional views of the nature of science, and are often conservative in their support of change, if it is seen to transgress notions of academic rigor attached to traditional conceptual knowledge. This reticence opposes the very changes which are advocated by some parents and educational experts and which research suggests need to be made. The influence of traditional conceptions of science held by non-science curriculum policy makers also blocks the timely implementation of contextualized science teaching according to Tytler (2007).

Since such difficulties exist in the teaching and learning of science, it is hardly surprising that science is not perceived by parents to provide a strong vehicle for developing their children's appreciation for socio-scientific issues: their civic scientific literacy. Teachers appear not to be promoting science for a range of reasons; policy makers oppose change to assist student engagement with science; and, university level academics are suspicious of changes to traditional science curricula, while some parents themselves are ambivalent about the contextualization of science teaching, fearing the loss of academic rigor (Tytler, 2007). One way forward is the promotion and encouragement, by way of

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incentives, of more well-qualified scientists into the teaching profession, a step taken by the new Australian federal government. Interventions in the primary years to increase pupil engagement and parental participation, using practical applications in investigative methods to grapple with real issues, are also likely to help.

The media and popular press also need to be convinced to make programs that promote science. Phenomena such as climate change, the search for alternative energy sources and less polluting renewable materials, forensic science are all matters of popular interest, which could be packaged with a pro-scientific perspective to draw attention to the usefulness of the study of science. The history of science, the ways people have discovered things are further ways of awakening scientific interest and should be popularised by way of programs and articles. Showcasing Indigenous scientific knowledge is also timely to enhance both Indigenous and non-Indigenous parents' appreciation of the role science plays in making human lives richer and of a higher quality. Conversely, it is should be pointed out that it is through scientific endeavour that the human misuse of science knowledge becomes highlighted and issues of sustainability come to the fore.

Parents had the opportunity to make detailed comments but often these were negatively slanted, restricted to the lack of perceived relevance of science, rather than the facilitative role of science education. No-one made any suggestions about where greater emphases should be placed in the teaching of science. Only one science trained Non-Indigenous parent commented that science had lost its "*hands-on approach*".

Research needs to be conducted to extend findings in other larger groups and cultural and geographic contexts where contingency factors might be different. For example, employment opportunities for 15-19 year olds might provide viable alternatives and influence post-compulsory education. Among other issues, further research needs to investigate questions like:

a) do science graduates have significantly more science trained parents than other graduates?
b) what sorts of parental behaviours predict a science career in their offspring?
c) what sorts of prevalent cultural influences and media images enhance the appeal of a scientific career or detract from it?

In the immediate future, however, parents of primary age children need to be better informed about the nature of current science curricula, the range of possible employment opportunities for science graduates and the benefits of science education for civic scientific literacy and informed citizenship. Schools might have to be more creative in their communication methods as the letter home often proves an inefficient mode of communication and may, in some cases, be unable to be read if English is a second language for some parents. Primary school interventions to raise the level of confidence of their teachers for science teaching are likely to be the most efficacious first step in this regard. In addition, teacher training institutions need to ensure that all prospective primary teachers complete a number of units covering science content and effective pedagogies.

Conclusions

Parental influences upon their children's career trajectories have been well documented. If we are to redress the dearth of science graduates, we must increase the number of students studying science at post-compulsory levels and enhance their engagement with science early on in primary school. To do this, we need to provide parents with more pertinent information to allow them to make informed decisions to encourage their children's career trajectories.

Clearer and simpler information about the nature of current school science curricula, the range of possible employment opportunities for science graduates and the benefits of science education for civic scientific literacy and informed citizenship need to be emphasized to parents at strategic transition points as their children progress through school. There is a need also to highlight to parents that science is needed and is relevant for those children who are aiming to pursue vocational education pathways, for example to be electricians, automotive mechanics and so on.

Providing interventions at primary school, continuing professional development to raise the level of confidence of teachers for science teaching, ensuring teacher training institutions support prospective primary teachers with a range of compulsory units covering science content and effective pedagogies could help change the current parental perceptions of school science.

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Appendix 1
Interview protocol

1. How do you feel about your child's move to secondary school next year?
2. Is your child a boy or girl?
3. Tell me which subjects you think are the most important for your child's education?
4. Tell me how important or relevant do you think the study of **mathematics** will for your child.
5. Tell me how important or relevant do you think the study of **science** will be for your child.
6. Which subjects will be most important for your child's future job options?
7. If you had to help your child with homework, which subjects would you feel most confident about helping your child with? Which the least confident about?
8. Which school subjects do you think will be most useful in helping your child understand socio-scientific issues such as those being debated currently in politics?
9. Tell me what you think about the various science strands (biology, physics and chemistry, marine science)? Which is the most relevant or important for your child's future do you think?
10. What would you like to know about studying science and the careers it can lead to that might help you encourage your child to put in extra effort with science at school?

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