CHAPTER EIGHT

CONCLUSIONS AND IMPLICATIONS

THE FOCUS OF THE STUDY

This research was initially motivated by the declines in senior high school science enrolments which have been in evidence throughout Australia, and in NSW in particular, over the last two decades (Dekkers & De Laeter 1997, 2001). This trend has been of concern to science educators because of its implications for the quality of the scientific endeavour in Australia, and because of the important social benefits associated with cultivating a scientifically literate society (Fleming 1989; Leach 1996). In exploring decisions about enrolling in science courses, this study focused on Year 10 students progressing to senior high school who had achieved at the highest levels in their compulsory science course.

Quantitative investigations of high school science enrolment patterns had identified a range of factors, including gender, academic achievement, socioeconomic status, parental education and ethnic background, associated with enrolment in senior science courses. These findings formed the basis of a conceptual framework which recognised the need to focus on the sociocultural domain when investigating influences on science enrolment decisions.

The present study explored the influences on students' decisions using an innovative model, based upon the 'multiple worlds' model developed by Phelan, Davidson and Cao (1991), and first used in the science education field by Costa (1995). This model was adapted to better suit the aims and context of the present study. It conceptualised students' sociocultural domains in terms of four worlds: school science, peers, family and the mass media, each comprising various cultural constructs having the potential to influence students' perceptions and responses. The explorations within and between worlds produced a number of findings, the most significant of which are reviewed below. In summarising the findings relating to each thematic research question, the review first addresses the specific questions, before providing a synopsis of the broader conclusions.

MAJOR FINDINGS

Question 1a

> What are science teachers' perceptions concerning the influences on science proficient students' decisions to forgo senior science?

The opinions of science teachers regarding their students' enrolment decisions were sought in order to provide a triangulation of perspectives. A large majority of these teachers,

including five science coordinators, observed that fewer science proficient Year 10 students in their schools had been enrolling in senior science courses over recent years. Most teachers believed these declines to have been influenced by students' perceptions of the poor employment prospects and relatively low pay and social status of science careers. The teachers saw alternative subjects, including 'soft options', and more attractive career paths, as drawing students away from potential science careers and, consequently, senior high school science courses. For the most part, these opinions reflected anecdotal evidence in the literature about the assumptions of science teachers (Louis & Page 1998; Ridd & Heron 1998; Werry 1998), though the lack of rigorous research into the views of Australian science teachers about students' enrolment motivations was noted.

Question 1b

> What explanations do science proficient students give for their decisions about enrolling in senior science courses?

The extrinsic/intrinsic dichotomy noticed by other researchers (Ainley et al. 1994; Woolnough 1994) investigating the explanations of students choosing physical science and biology/other science courses was also evident among these science proficient students. Those choosing physical science subjects cited university and career requirements as their primary motivations, while biology/other science students explained their decisions in terms of self-efficacy and their interest in, and enjoyment of, life science topics. Most students choosing to forgo senior science study maintained that there was little need for them to take science courses, given their post-school intentions. However, timetable clashes, uninspiring experiences of school science and low levels of self-efficacy also contributed to the decisions of some of these students.

The importance placed on post-secondary considerations by many students choosing physical science, or no science, appeared on the surface to support the opinions of their science teachers. However, the career ideas of these Year 10 students were in general quite rudimentary. Far from considering science careers to be low in pay and status, most students supposed them to be well regarded and financially rewarding, though in general they knew little about specific science careers. Thus, the primary assumption of science teachers was not supported by the views of their students. This was one of a number of inconsistencies found between the opinions of science teachers and the explanations of their students, revealing the need for greater research into the nature and origin of teachers' beliefs about students' enrolment decisions.

Conclusions Regarding the First Thematic Research Question

> What are the influences on science proficient students' decisions about enrolling in senior high school science courses?

While the perceptions of science teachers, and the explanations of their students, provided some directions for investigation, it was students' descriptions of their worlds that revealed the most substantial influences on their enrolment decisions. These influences are summarised in Figure 8.1.

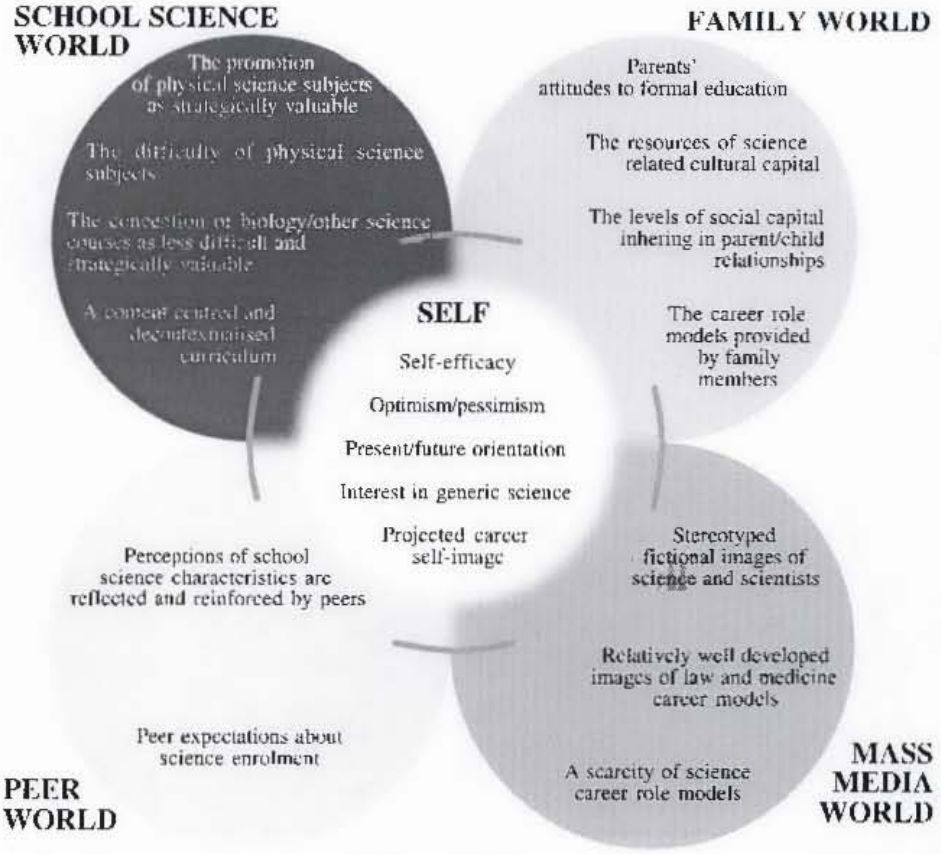

Figure 8.1 Summary of the characteristics of the four worlds which were negotiated by many science proficient students in their deliberations about enrolling in senior science courses. Characteristics of students influencing their enrolment decisions are shown in SELF.

Influences within school science worlds

Four potential influences on science enrolment decisions were found within students' school science worlds. In general, the interview respondents did not paint a very flattering picture of their school science experiences. While reports of decontextualised curricula and teacher-centred learning experiences are unfortunately all too common in many schools (cf. Goodrum et al. 2001; Osborne & Collins 2001), it was surprising to find such descriptions prevalent among students who had achieved at the highest levels in the subject. However, the fact that such characteristics were described by students in all three choice categories indicated that different enrolment decisions were not necessarily related to different school science experiences, but to students' responses to these experiences. This suggested that influences outside the world of school science were of critical importance in shaping these responses.

Influences within family worlds

Of the four influential characteristics of the family world shown in Figure 8.1, the first three were identified as being strongly associated with enrolment decisions. Students choosing physical science subjects often described their parents as emphasising the strategic importance of formal education, through comments, actions or personal histories. In contrast,

most students choosing biology/other science described their parents as being more concerned with intrinsic benefits, such as their child's enjoyment of, or present satisfaction with, particular subjects. The students deciding to take no science courses did not fit either pattern, with equal numbers describing the two parental attitudes above. Differences between the choice categories were also found with regard to the resources of science related cultural capital students described as being provided by parents. Family worlds rich in this form of capital, which was represented by positive attitudes towards science, and embodied in science related books and materials (Bourdieu & Passeron 1977), were more often described by students choosing physical science subjects than by those making alternative decisions.

The most substantial contribution of the present study in this area was the discovery of how the levels of social capital (Coleman 1988) students felt inhered in their relationships with particular parents, mediated the influence on enrolment decisions of their parents' aspirations or attitudes to science. With the exception of one case, which could not be determined, all of the students choosing physical science subjects enjoyed positive, supportive relationships with a parent whose attitudes to education, or science, favoured such a choice. In contrast, decisions by a number of science proficient students to forgo enrolment in physical science courses were related to the problematic relationships swith parents. The dimension of interpersonal dynamics, which to date has been overlooked in the research on subject choice, was therefore found to play a crucial part in the deliberations of some science proficient students considering demanding science courses. Furthermore, the quality of parent/child relationships was implicated in the levels of confidence and academic self-efficacy of students, and in some cases affected the role modelling dynamics within families.

Influences within peer worlds

It was concluded that peer worlds were not greatly influential in the science enrolment decisions of interview participants. Nevertheless, this was still a significant finding because it is also valuable to identify aspects of the lives of science proficient students have little influence on their decisions about science enrolment. While students were aware of peer expectations regarding the subjects they should take, those taking both physical science courses, and those taking no science courses, often made their decisions contrary to these expectations. This finding was inconsistent with that of Costa (1995), who found that the peers of 'potential scientists' generally also took science courses, while the peer worlds of 'other smart kids' were incongruent with the world of science. This inconsistency may be due to the different educational contexts of the studies, a point that has implications for comparisons between international studies.

Influences within mass media worlds

The exploration of the mass media worlds of students in this study found few differences across choice categories, and little indication that enrolment decisions had been influenced by engagement with the mass media. Images of fictional scientists, other than doctors and forensic pathologists, were generally naive and stereotyped, with few students able to recall seeing any real scientists in the mass media. In contrast, positive fictional images of lawyers were described by a number of students who were contemplating careers in law, suggesting that media images may have some influence on career aspirations. While no general

associations were found between science enrolment decisions and students' engagement with the mass media, individual cases nevertheless indicated that the influence of mass media images on career ideas and aspirations is a potentially fruitful area of research.

Students' self-efficacy

Another critical influence, not situated within any particular world, was a student's sense of self-efficacy. The general importance of this issue was illustrated initially by the rationales of students choosing biology/other science, for whom this choice was a compromise between taking physical science subjects, which were considered too difficult, and taking no science at all. About half of the interview respondents choosing no science were also influenced by the perceived difficulty of physical science subjects.

The most interesting finding regarding self-efficacy was the differential roles it played in the decisions of students choosing physical science subjects. Female students enrolling in these subjects generally saw themselves as being less academically able in science than did male students. They also tended to rely more than males on various sources of advice, and to consult more widely than either males choosing these subjects or females in other choice categories. The most compelling interpretation of these findings, supported by research from other contexts, was that, despite having achieved at the highest levels in Year 10 science, female students contemplating enrolment in physical science subjects required a greater level of confidence than their male counterparts.

Question 2a

> Is cultural congruence influential in decisions by science proficient students to enrol in senior science courses?

Enrolment by science proficient students in physical science subjects was strongly related to congruence between family and school science characteristics. The particular combinations of characteristics are detailed in the next section. Again, however, this congruence was only influential where students enjoyed positive, supportive relationships with the family member(s) embodying or promoting these characteristics. The effect of congruence between students' school science worlds and their peer or mass media worlds was less compelling. While there were a number of potential influences in individual cases, no general conclusions could be drawn linking these influences to science enrolment decisions.

Question 2b

> Is cultural incongruence influential in decisions by science proficient students to forgo further science study?

The decision to take no science courses was not clearly associated with incongruence between characteristics of students' different worlds. Despite many examples of incongruence, it was often more difficult to determine just how influential it had been in the enrolment decisions of science proficient students, since the effects of incongruence could not always be distinguished from those of other, more intrinsic, considerations. On the one hand, the influence of congruent characteristics was often noticeable, since many students who were not

drawn to physical science courses for intrinsic reasons nevertheless took these subjects. On the other hand, however, less influence was required in order to drop science altogether, since physics and chemistry courses were seen as only benefiting those wishing to maximise their post-school options, or contemplating a career in science. Without such imperatives, there was little to recommend these subjects based upon the descriptions of school science provided by most of these students.

Conclusions Regarding the Second Thematic Research Question

> Does cultural congruence or incongruence between the different worlds of science proficient students play a part in their science enrolment decisions?

While a number of characteristics of students' worlds contributed to their decisions, the study concluded that no one characteristic, or single world, was solely accountable for these decisions. Rather, combinations of characteristics, found predominantly within school science and family worlds, were most closely associated with the enrolment decisions of interview participants. Students' deliberations about taking science courses were recognised as processes of referencing, negotiating and reconciling the structural, attitudinal and dynamic features of their worlds. The observation made by Phelan et al. (1991, p. 227), that the multiple worlds model can illustrate how 'meanings drawn from each of these worlds combine to influence students' actions', was clearly applicable to the context of science enrolment decisions. As a consequence, this study supported the contention of other advocates for this model (Aikenhead 1996, 1997, 2001; Costa 1995) that only a framework facilitating the holistic exploration of students' sociocultural domains, and recognising the significance of congruent or incongruent influences, can be expected to reflect the complexity of interactions between these influences.

THEORETICAL IMPLICATIONS

Implications for the Multiple Worlds Model

The multiple worlds model proved to be a valuable and flexible research framework, accentuating the differential influence of students' various worlds. The findings in this study confirmed that the model does indeed transcend ethnic and gender categories, as claimed by Phelan et al. (1991), since it focuses on the sociocultural influences negotiated by individual students, rather than on characteristics associated with particular ethnic or gender groups. Thus, while male and female students of different backgrounds may have 'perceived boundaries very differently, and used various adaptation strategies' (1991, p. 228), they nevertheless all constructed personal meaning from the cultural cues in their different worlds.

The generic nature of the original model allows it to be applied to a variety of research contexts, in which the specific influences related to those contexts could emerge from explorations within the worlds. In the context of enrolment decisions by science proficient Year 10 students, this flexibility allowed the general model with which this study began (Figure 2.5), to be refined into three specific models illustrating the influences on each of the different science enrolment decisions. Since these models are based upon the deliberations of

the relatively small number of science proficient students in this study, they are offered as frameworks for future research in this area, rather than as explanatory models applicable to larger populations.

Physical science enrolment model

The first model, Figure 8.2, is both the most clearly defined and the most pertinent for science proficient students choosing physical science subjects. First, the model suggests that science proficient students are more likely to choose physical science courses when the importance attributed to science by teachers is congruent with the advocacy for science of a significant, and supportive, family member. This value is embodied in the attitudes and materials constituting the science related cultural capital provided within the family.

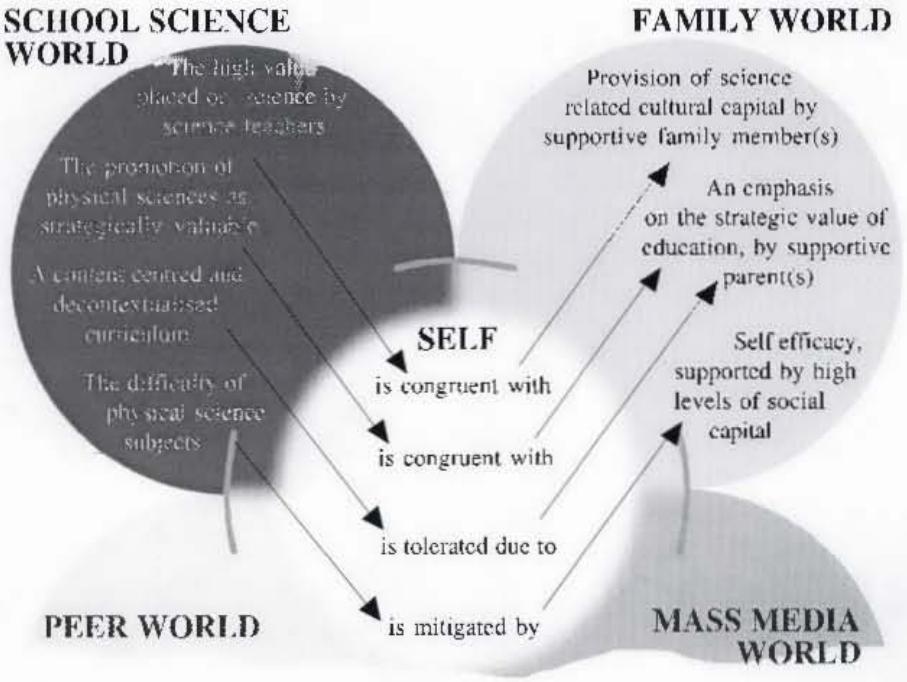

Figure 8.2 A model illustrating the congruence between characteristics of family and school science worlds found among science proficient students choosing physical science subjects

Second, enrolment in physical science subjects is more likely where the perception that they are primarily of strategic value resonates with students' recognition that such a quality is highly valued within the family. The strategic orientation towards education of some parents is also a type of cultural capital, typical of, though not limited to, families of high socioeconomic status (Bourdieu & Passeron 1977). This aspect of the model is, therefore, supported obliquely by the strong statistical correlations found between enrolment in the physical sciences, and high levels of parental education and socioeconomic status (Ainley et al. 1994; Fullarton & Ainley 2000; Woolnough 1994).

Third, for some students, the perception that school science is a content-centred subject presented in a transmissive mode may also resonate with their parents' perceptions of school education as primarily involving the assimilation of content, and of success as measured in terms of examination results. However, the findings in this study showed that the content-centredness of school science was not generally viewed as an attractive characteristic, even among those who did choose physical science subjects. Nevertheless, the model above acknowledges that the disadvantages of the dominant pedagogy are, for some students, offset by the strategic value offered by physics and chemistry. Likewise, some students may be willing to tolerate the decontextualised and personally irrelevant content anticipated within these subjects for the benefits they offer in the long term. Such a reconciliation is consistent with the priority given by parents to strategic values over intrinsic ones.

Fourth, the perception that physics and chemistry are the most difficult of science courses may be less daunting for some students due to the levels of confidence, optimism and self-efficacy they possess. Such qualities are associated with the high levels of social capital inhering in their relationships with one or more significant family members, usually a parent. The quality of a parent/child relationship is particularly influential where the parent also emphasises the importance of a strategic orientation, and expresses confidence in their child's ability to take on challenging subjects.

Biology/other science enrolment model

In contrast to the model proposed above, there were a number of models which could conceivably be constructed to describe decisions by science proficient students to take biology/other science courses. This was because incongruence between *any* of the salient features of family and school science worlds in Figure 8.2 could result in a student forgoing enrolment in physical science subjects in favour of biology/other science courses. For example, in one possible model parents may support their child's science interests, but advise him or her to choose subjects s/he enjoys and with which s/he feels comfortable. Without the strategic imperative, the choice of physical science becomes less attractive. In a second possible model, the student may not have sufficient investment in the values of a parent advocating a strategic orientation, and may therefore choose a more intrinsically attractive subject. A further possibility is that a student may feel there is inadequate academic support within the family to risk undertaking demanding science subjects.

Figure 8.3 represents one attempt to highlight the wider range of possible combinations which favour the choice of biology/other science by science proficient students. Again, this model does not describe all of the influences on decisions to choose biology/other science. The contrast between the number of permutations which can lead to the choice of biology/other science courses, and the quite restricted combinations found among physical science students (Figure 8.2) is discussed at the end of this section.

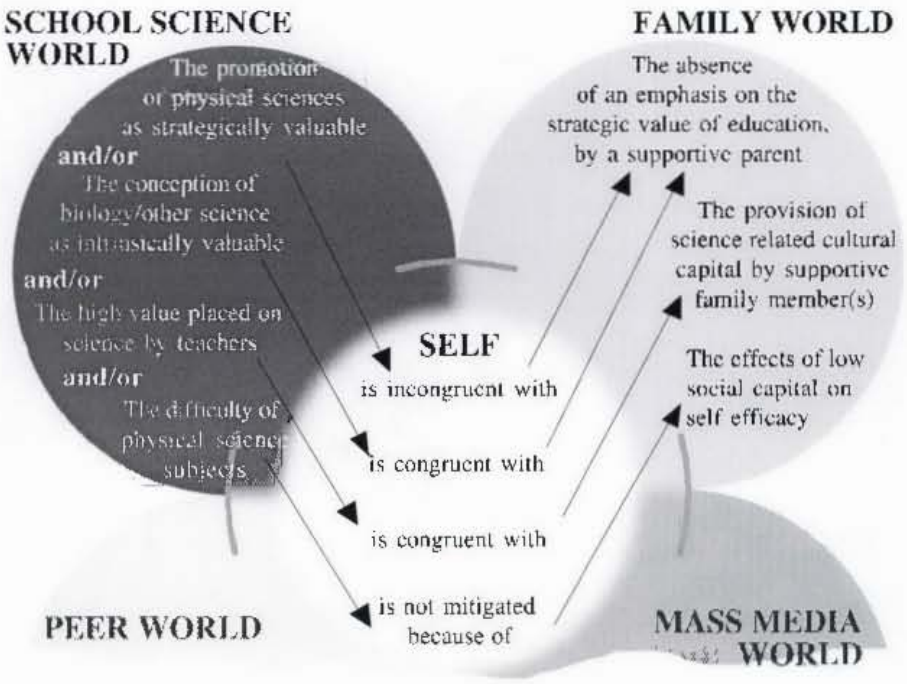

Figure 8.3 A model illustrating the congruence and incongruence between characteristics of family and school science worlds found among science proficient students choosing biology/other science subjects

A model describing decisions to choose no science courses

As with the previous model, attempts to summarise the influence of incongruencies and other issues on decisions to forgo senior science resulted in a model (Figure 8.4) less well defined and comprehensive than Figure 8.2, in that it does not describe the deliberations of *all* interview participants choosing no science courses. Nevertheless, it does describe the influences on most of these decisions, where incongruence between any of the salient characteristics could lead to a science proficient student deciding against taking senior science courses. For example, the perception that physical science subjects are primarily of strategic value may make them less attractive to students who do not see this quality as being particularly valued within their families. Even where students recognise congruence between strategic imperatives within their school science and family worlds, the relatively low value of science in their family worlds may influence the student to take other strategically valuable subjects, such as higher mathematics, English or economics courses. Alternately, it may be the case that students feel they do not enjoy sufficient reserves of social capital to support them in undertaking a demanding subject profile.

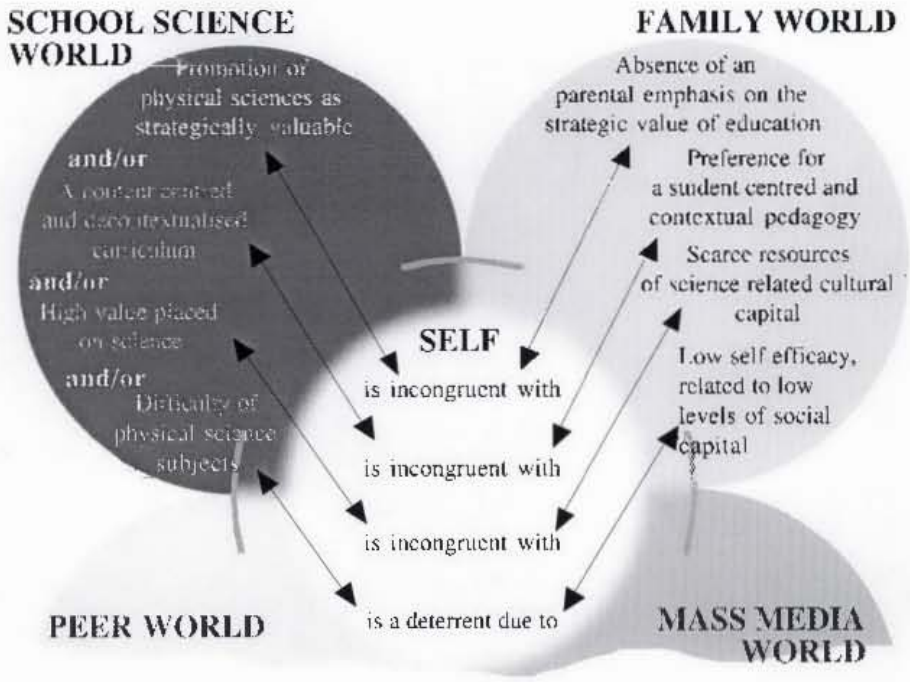

Figure 8.4 A model illustrating the congruence and incongruence between characteristics of family and school science worlds found among science proficient students choosing no science subjects

Reflections on the three models

There was an element of irony in the discovery that this study was, in the end, more clearly able to describe the decision to choose physical science than the decision to forgo science, given that tendencies towards the latter option originally motivated the research. This realisation was cause for some reflection about the assumptions of many science educators, including teachers in this study, concerning the whole phenomenon of high school science enrolment decisions. The proposition that science proficient students' deliberations about taking senior science begin at a neutral point on some hypothetical scale, from which the balance may be shifted towards, or away from, the choice of science courses by personal or external considerations, is an incorrect assumption. Given the generally unengaging descriptions of school science outlined in Chapter Five, which are supported by other studies (Goodrum et al. 2001; Osborne & Collins 2001) the starting point in subject deliberations is, for many science proficient students, already tipped away from the choice of senior science courses, particularly the physical sciences. A substantial influence, such as congruence between characteristics of family and school science worlds, is therefore required to overcome this initial bias.

For those choosing not to take science, however, it was not the case that any dissuasive influences needed to be substantial. In many cases the default decision favoured no science, unless students were sufficiently convinced that undertaking science courses would be worthwhile. Arguments for taking physical science subjects centre on their strategic importance and status, as promoted by teachers and university prerequisites. The argument

about balance and bias, which may shed some light on the declines in science enrolment, is taken up in the section on implications for policy and practice. The point to be noted at this juncture is that conclusions about the effect of incongruence on decisions to take no science courses were far more tentative than those concerning the influence of congruence.

Implications for the Conceptual Framework

The decision to explore students' sociocultural domains was influenced by the literature showing science enrolment patterns to be statistically associated with a range of background factors. These associations informed the conceptual framework (Figure 2.3) guiding this study. As noted in Chapter Two, however, few of these studies attempted to explain how such factors actually influenced students' decisions. In reflecting on the findings of the present study in the light of other theoretical positions (Bourdieu & Passeron 1977; Coleman 1988), it is argued that factors such as parental occupations or education credentials are only indicators, or outward manifestations, of the more directly influential characteristics of students' sociocultural domains, such as the types and amounts of cultural capital made available to students by their families.

It is therefore more meaningful to discuss intentions to enrol in particular subjects in terms of parental attitudes to formal education, or to science, rather than in terms of socioeconomic status or ethnic background. This argument helps to explain why, in this study and others (Ainley et al. 1994; Myhill et al. 1994), the tendency for the children of migrants to enrol in physical science subjects was an exception to the otherwise strong correlation between high socioeconomic status and enrolment in these subjects. What many working class, or lower middle class, NESB parents have in common with parents who have higher occupational or educational status, are high educational aspirations for their children (Hartley & Maas 1987; Mak & Chan 1995; Ninnes 1997b; Parr & Mok 1995).

The tendency for quantitative studies to highlight relationships between students' enrolment decisions and factors such as parental occupation and academic qualification possibly has more to do with the relative ease of measuring such factors. Cultural capital, on the other hand, is a more difficult, though not impossible, construct to measure (Bourdieu 1979; Keeves 1975, 1988; Marjoribanks 1994), while measuring social capital is also problematic (Coleman 1988; Furstenberg & Hughes 1995). Likewise, although 'sex' is a convenient statistical factor, this study has shown that self-efficacy was an important aspect of the gender differences in deliberation behaviour and enrolment outcomes. It may well be the case that self-efficacy is simply one element of gender which, along with teachers' and parents' expectations (Eccles 1989; Harding 1996; Jones et al. 2000; Kahle 1988) may be more closely related to enrolment intentions than the commonly used factor, 'sex'. Certainly there was sufficient evidence in this study to warrant further investigation of this relationship.

In view of these considerations, the background factors acknowledged in Figure 2.3 have been replaced in Figure 8.5 by influences shown by this study to have greater explanatory power, and to be better articulated with the explanations provided by students for their decisions.

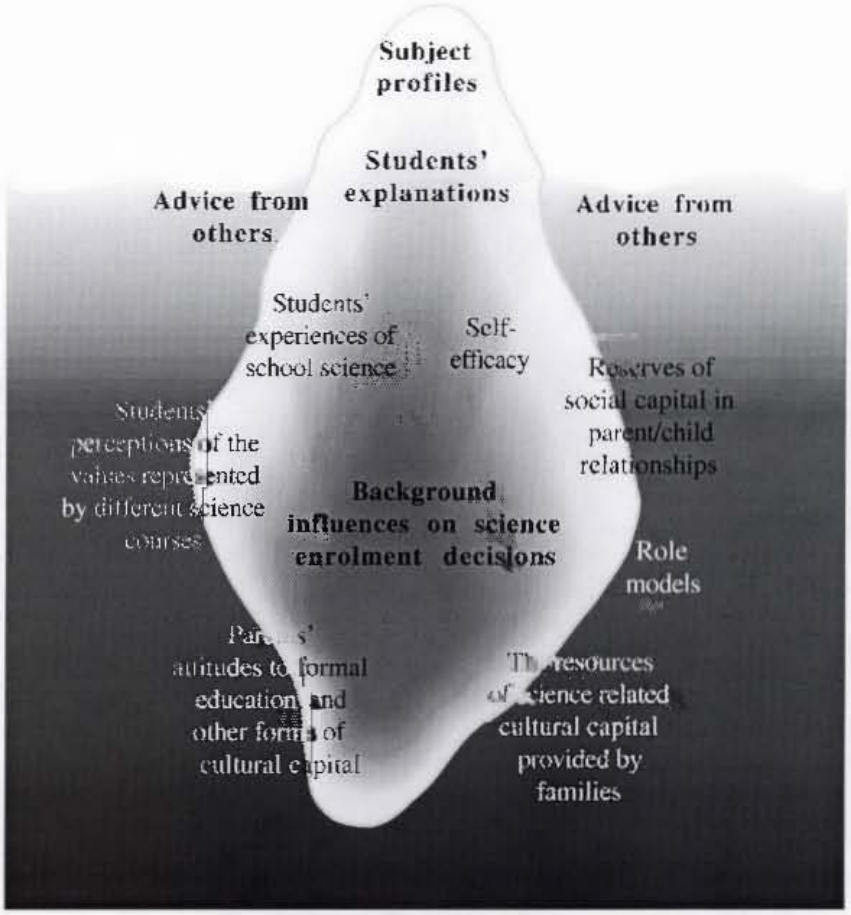

Figure 8.5 The conceptual framework, modified in the light of major findings from this study.

The contribution of social capital to the framework

Most of the background influences in Figure 8.5 can be seen as replacing, or respecifying, the sociocultural factors from Figure 2.3. However, the addition of social capital (Coleman 1988) to this framework represents a new and important contribution to the literature on science enrolment decisions, since associations between parental attitudes and decisions about senior science in this study were much more robust when the social capital inherent in parent/child relationships was considered.

A related addition to Figure 8.5 was the influence of self-efficacy. Although this was more evident in the case of female students, and even more so among females choosing physical science, self-efficacy was also implicated in the decisions of a number of male students. From their experiences of school science and the opinions of teachers, most students in this study conceptualised the senior sciences in terms of levels of relative difficulty, and many consciously or unconsciously referenced their levels of self-efficacy against the resources of social capital and support upon which they felt they could rely. Thus, an important finding of this study concerned the relationship between social capital and self-efficacy, and the role of both in deciding about enrolment in academically challenging subjects.

The contribution of cultural capital to the framework

The concept of cultural capital contributed significantly to this study by providing a theoretical basis for understanding the influence of parents' attitudes and aspirations on those of their children. While Bourdieu and Passeron (1977) were concerned with cultural reproduction on a large scale, the framework they developed for explaining the transmission of parental dispositions and attitudes regarding education was clearly relevant to this study, which sought an explanation for the link between the sociocultural characteristics of families and the enrolment decisions of students. Indeed, the theoretical perspectives of Bourdieu and Passeron (1977) are in many ways an appropriate complement to large scale surveys, which provide valuable descriptive data (e.g. Ainley et al. 1994), but which do little to help us understand how and why such patterns exist.

The concept of cultural capital has not been fully developed in this thesis, since its role in science enrolment deliberations was only recognised in the process of interpreting the narrative data. Like social capital, cultural capital was not an *a priori* consideration in the framework of the thesis. In particular, there has been no discussion of Bourdieu's concept of *habitus* (Bourdieu 1977, 1979), or of its sometimes controversial role in students' educational decisions[1], as this level of detail falls outside the scope of the thesis. Nevertheless, the concept of cultural capital now arguably has a foothold in the context of science enrolment deliberations, and deserves further investigation.

IMPLICATIONS FOR POLICY AND PRACTICE

The major contribution of this study to the field of science education is the way it describes and interprets the complex enrolment deliberations of science proficient Year 10 students. These interpretations point to the need for a change of perspective regarding declines in science enrolments; a change having implications for policy and practice. Common to much of the research in this area has been the assumption, articulated by the science teachers in this study and by others in the literature (e.g. Louis & Page 1998; Ridd & Heron 1998; Werry 1998; Woolnough 1993), that the decline in enrolments over the last two decades has been due primarily to external issues acting to draw students away from science courses, which have themselves changed little over that period. From this perspective, enrolment in senior science courses, and particularly the physical sciences, is assumed to be the default choice of any science proficient student, as it has been in the past. This perspective has been supported by both the customary status of science in the school curriculum and its widespread inclusion among university prerequisites (Fensham 1988). In being propped up, as it were, by educational structures, it may be the case that school science has come to rely too heavily upon, and to reflect too closely, these external supports, to the detriment of its intrinsic benefit to students.

Over the course of this research, it became increasingly obvious that the most cogent single force acting against the choice of senior science was not external, but rather the culture of the subject itself. While emphasising its status and strategic utility, school science to Year 10

[1] see Nash 1999; Reay 1995; Tooley & Darby 1998 for details of this discussion

level had fewer intrinsically satisfying characteristics than it might have, even for many students who had achieved well in the subject. Thus, in speculating about the overall decline in science enrolments, it is suggested that the combination of a devaluation in the subjects' strategic usefulness on the one hand, and the lack of intrinsic motivations on the other, is most closely associated with decisions to forgo senior science subjects, particularly physics and chemistry. In defining itself, by its culture if not by its curriculum, as a subject area which fulfills a strategic need, school science may have discovered this foundation to have been eroded by a number of recent developments. These include the increasing variety and legitimacy of newer HSC subjects, the devaluing of physics and chemistry as university prerequisites for some courses, and an increase in demand for graduates in other science fields, such as psychology and computing science.

Science educators looking to stabilise, or even reverse, the declines in science subjects need to recognise that the source of the problem lies as much, if not more, within the science classroom than outside. The often unflattering descriptions of school science provided by students in this study clearly has substantial implications for the teaching and learning of school science. Students' depictions of their school science worlds suggest that much needs to be done to address the quality of the learning experience so that, for greater numbers of students, the extrinsic 'need' to take science might be complemented by an intrinsic 'want' to continue with this subject. In particular, there is clearly a need for elements of the junior secondary science curriculum to be presented in contexts providing personal relevance and interest. While this study involved students who were high achievers in science, it is reasonable to presume, and suggested by the literature (Goodrum et al. 2001; Osborne & Collins 2001), that the experiences of students achieving at lower levels would not have been more positive than those described here.

In making recommendations about the contextualisation of content, it is noted that a new junior secondary science syllabus was phased in by the NSW Board of Studies in the period following the data collection for this study. Fortunately, the new syllabus emphasises the need for contextualisation of content, in order to increase motivation, conceptual meaning, confidence and levels of literacy (BoS 1999b, p. 62). Recommendations about addressing the particular science curriculum experienced by students in this study were, to some extent, made redundant by this development, and it remains to be seen whether experiences with the new curriculum will improve students' attitudes to the subject. Nevertheless, the new syllabus document leaves the contextualisation of content to the individual science teacher, so it is to science teachers that the following recommendations are addressed. While some of these have been made in other studies (e.g. Aikenhead 1996; Costa 1994; Goodrum et al 2001), the fact that this study comes from a different research context, and yet draws many of the same conclusions, only serves to emphasise the need for their implementation.

The most positive learning experiences of many students in this study occurred where science content had been made personally meaningful, either through relevant context or student centred pedagogy. The first recommendation is that when implementing the new syllabus, teachers situate the content and skills as much as possible in contexts that are engaging to the majority of students. This means making the students, rather than the curriculum content, the

starting point for learning, and focusing on the diversity of their interests. A second recommendation concerns the prevalence of 'chalk and talk' pedagogy in science classrooms. The comments of many students in this study highlighted the importance of appreciating that the medium is the message, and that aspects of the learning process, such as teacher enthusiasm, encouragement and innovation, were more influential in shaping students' attitudes than the subject content. Consideration of the variety of learning modes among students should itself suggest the appropriateness of using a variety of teaching approaches. This issue has been raised often in the science education literature and many recommendations have been made for enhancing the quality of the science learning experience (see among others, Driver & Bell 1986; Gunstone 1988; Hofstein & Walberg 1995), so it was disappointing to find the lecture-based/content-focused approach still predominant in the schools involved in this study.

A third recommendation involves enhancing the image of science and scientists in the eyes of Year 10 students. The lack of science role models could be addressed by inviting working scientists, or university science students, into classrooms. These scientists could be welcomed as guest speakers to discuss their careers, aspirations or positive experiences of university science, or involved more closely with syllabus topics. The internet has facilitated greater access to scientists, with some education sites even providing real time online access to working scientists for problem solving. Talks by young women undertaking university science courses may also help address the generally lower self-efficacy of science proficient Year 10 female students.

The introduction of real scientists into the curriculum at Year 10 level might also challenge the stereotypical images of scientists prevailing in the mass media. Other ways of broadening students' perceptions of scientists and science careers could be to set projects on science related careers, to establish work experience relationships with science faculties or industry, or even to include the study of media stereotypes of scientists as part of a unit. Such projects would present students with images to which they can refer in their subject deliberations.

The issue of self-efficacy could be addressed in other ways. While most teachers appreciate that not all students enjoy a nurturing home environment, they may not make the connections between family dynamics and a student's self-efficacy, optimism and science enrolment decision. The effects of encouragement, support and personal interest from science teachers emerged as a significant influence on some students' confidence about engaging with school science. Even these high achieving students considered personal encouragement by teachers to have had a significant impact on their attitude towards school science, a fact possibly not appreciated by all teachers. Teachers should also make a point of reassuring proficient female students of their potential, and encouraging those they consider capable of more challenging senior subjects to undertake these. Given the substantial efforts of many female students in consulting senior students who had undertaken physics and chemistry previously, a closer relationship between senior and junior students, perhaps in the form of mentoring, might be advantageous.

Finally, serious consideration needs to be given to the predominant conceptions about senior science courses held by the most academically proficient science students. In particular, the characterisation of physical science subjects almost exclusively in terms of their strategic attributes should be of concern. To conceive and promote physical science subjects in this way is to devalue the importance of the scientific endeavour, the excitement of discovery, and the awe and wonder of the natural world. It also diminishes the vital role science has played, and is playing, in human history. It was disconcerting to find that the aims set out by the NSW Board of Studies for what can be achieved in taking physics, for example, were not reflected in the reasons students gave for choosing this subject. This highlights an incongruity of conceptions. On the one hand the syllabus documents, both those applicable at the time of data collection (BoS 1994) and those replacing them (BoS 1999c), emphasise the intrinsic benefits of the study of physics - the appreciation of patterns and laws, the investigative skills, and the relationship between science and society. For most students in this study, however, physics, and to some extent chemistry, were seen as hurdles intended to distinguish the more academic students from the general student population and which, if successfully negotiated, could considerably enhance post-school prospects. If this is the conception science teachers and curriculum developers wish to propagate, then it has certainly been successful. If not, they need to recognise the disparity between the ideal culture of school science, as set out in curriculum documents, and the perceptions students have of the subject area, and reconcile this dual and contradictory identity.

FURTHER RESEARCH

One of the most exciting outcomes of this research was the array of potential avenues for further research produced. The exploratory nature of the study meant that these avenues radiated in a number of directions. The first line of research, however, should be to verify the conclusions of this study. Confirmative research could focus on specific conclusions, using more focused strategies and larger samples of science proficient students. For example, a large scale examination of the relationship between the enrolment decisions of science proficient students and the types of cultural capital in their families, would make an interesting and valuable follow-up study. If findings from this or other research verified those of the present study, investigations could be undertaken to examine the transferability of these results to a wider population of science students. It is also important to refine, or challenge, aspects of the three enrolment models put forward in this chapter.

The recognition that social capital was strongly implicated in the degree to which many students' invested in the values and advice of others, suggests a promising new direction for research in the context of high school science enrolment. The decline of family social capital, and the implications of this decline for a range of educational outcomes, are currently an issue of contention in the sociology of education literature (Fukuyama 1999; Winter 2000). While this thesis is hesitant to link declines in science enrolments to trends in larger social phenomena, such as changes in parenting structures, the narratives of several students did implicate poor quality relationships with fathers as being influential in their enrolment decisions. In a number of these cases, fathers were potential science career role models. The

rapidly increasing proportion of Australian families in which fathers are on the periphery (ABS 2002)[2], suggests that the quality of parent/child relationships, and paternal relationships in particular, might also be an interesting direction of further research on enrolment influences. Related issues such as self-efficacy, optimism and role modelling, could also be explored in this research. The importance of paternal relationships in this context may be more pertinent than relationships with mothers, given the traditional tendency for males to take more science at the secondary and tertiary levels, and to be involved in science related careers.

Another area of research interest concerns the belief by science teachers that the perceived status and employment prospects of science careers contributed significantly to Year 10 students' decisions to forgo science enrolment. While this was not confirmed by the narratives of the students in this study, the strength of the opinion did suggest that, somewhere between Year 10 and Year 12, students do become aware of these issues. It would, therefore, be of interest to both teachers and researchers if a longitudinal study was commissioned to record the changes in students' perceptions of these issues over their final three years of school. It would also be of interest to investigate how science teachers develop their beliefs about the influences on students' decisions.

The implementation of the new junior science curriculum in NSW provides an opportunity for future researchers to investigate whether attempts to contextualise science content have an impact on science enrolment profiles, thus determining to some extent the degree to which perceptions of irrelevance and decontextualisation of content relate to enrolment. This type of research is particularly important in the light of findings that students' descriptions of school science culture had little in common with the aims of the science syllabus.

It was revealed in Chapter Six that, to date, there has been little research into the influence of media images on students' responses to science. The findings from that chapter indicated that media images did at least have the potential to influence students' perceptions of particular careers, and that such images were more numerous and attractive in some career areas than in others. The findings also suggested that whereas students' images of scientists did not often evolve beyond the stereotypes of childhood, their images of business people, lawyers, doctors, designers and so on, did develop over time, and that this was in some way linked to exposure to television programs. This is unexplored and potentially fertile territory for research which may lay the foundation for the reconstruction of students' conceptions of science, and perhaps therefore school science, as an attractive, relevant and rewarding field of interest.

The findings of this study also have a number of implications for researchers wishing to undertake further study in this area. First, it was noted earlier that whereas studies such as Fullarton and Ainley (2000), Ainley et al. (1994) and Haeusler and Kay (1997) recognised the motivational and background differences between students choosing physical science and those taking biology, other researchers investigating subject choice simply classified all science students as a single group. The present study re-emphasises the importance of

[2] The percentage of Australian children living in single parent families has risen from 13.6 per cent in 1991, to 19.6 percent in 2001 (ABS 2002).

making distinctions between choice categories when researching in this field, since projects failing to do so could arrive at questionable conclusions regarding students' decisions.

Second, the important role of social capital in students' deliberations also has implications for future research methodologies. Questionnaire based studies which have attempted to correlate variables such as parental aspirations, occupational status or education level with children's attitude or achievement variables have often neglected the quality of the dynamic between parent and child. The conclusions from this study emphasise the importance of considering this issue in designing such research and in interpreting the results of past studies.

A final methodological implication of this research concerns the capacity of the qualitative approach to plumb below surface phenomena and explore the meaning behind students' responses. The richness and depth of the narrative data highlighted the appropriateness of the interview process for exploring deliberations. For instance, it was evident that issues such as social capital, cultural capital and the importance of self-efficacy, could not have emerged from a purely quantitative study. Moreover, conclusions about meaning, or cause and effect, which were revealed in many of the cases here, could not have been drawn using quantitative strategies such as factor analysis. That said, the fact that a number of findings were in accord with, and guided by, those of statistical studies, underlines the complementarity of different approaches in building a credible picture of the enrolment decisions of science proficient high school students.

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