Exploring Sex Differences in Science Enrolment Intentions: An Application of the General Model of Academic Choice

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Abstract

In many countries there remain substantial sex differences in enrolments in elective science courses, despite concerted efforts in recent years to alleviate them. This paper explores the reasons for these differences by comparing models of male and female enrolment intentions in elective courses in biology, chemistry and physics. The models are based on responses from approximately 450 students from 5 Australian high schools.

First, a theoretical model, the Science Enrolment Model, was derived from Eccles and colleagues' General Model of Academic Choice. Students' responses were then used to develop empirical models of enrolment intentions in the three elective courses. Analyses for the models were conducted using the LISREL 'mean structures' extension. Sex differences in the dependent variables in the models were then attributed to the relevant sets of independent variables.

Substantial sex differences were identified in measures of perceived career value, interest and performance expectations in all three models which explained between 70% and 82% of the sex differences in enrolment intentions.

For several decades science educators in developed countries have expressed concerns about continuing sex differences in enrolments in elective science courses, with males predominating in the physical sciences and females in the biological sciences. These concerns have been motivated by both economic and philosophical considerations. First, it is argued that the economic well-being of a society is inextricably linked to the state of its science and technology (e.g. National Board of Employment, Education and Training 1994, National Science and Technology Analysis Group 1987) and that it is important that all members of a society with the potential to contribute to its scientific and technological development, whether they be male or female, should be encouraged to do so. Second, it is argued that, because of the alienation of women from the physical sciences, developed societies should be concerned about 'the outcomes of technology deprived of the human values associated with the female' (Harding, Hilderbrand and Klainin 1988).

In many countries education authorities have devoted substantial resources to alleviating these differences with limited success. Where improvements have been achieved they have often been the result of reductions in the proportions of males enrolling in the physical sciences and females enrolling in the biological sciences (Barnes 1999). If strategies aimed at reducing these sex differences are to be effective they need to be based on a more detailed understanding of what motivates students to enrol in elective science courses. Are females less likely to enrol in physics and chemistry and males in biology because they find them less interesting and if so why? Do they have less confidence in their abilities in these domains? Are enrolment decisions influenced by sex-stereotypical attitudes towards the different domains? What other psychological constructs influence students' enrolment decisions and how do all of these interact with each other?

There have been a number of studies exploring sex differences in science enrolments in recent decades (e.g. Johnson and Bell 1987, Kelly 1988), however the bulk of this work has been limited to largely atheoretical attempts to assess differences in the factors assumed to influence enrolment. Efforts to develop comprehensive models of enrolment behaviour and to explore sex differences in the relationships between the model constructs have been limited. The present investigation explores the causes of sex differences in enrolments by comparing comprehensive male and female models of enrolment behaviour – models which have been developed with the guidance of the wealth of achievement motivation literature presently available.

Eccles and colleagues observed that a situation similar to that which exists with science enrolment research existed with regard to mathematics in the early eighties. They noted that '... field studies on academic achievement have been designed without the guidance of a broad based, integrative, theoretical orientation. Applied researchers have tended to proceed piecemeal, each researcher investigating a subset of the possible causes' (Eccles et al. 1983, p.135). As a consequence, they developed the General Model of Academic Choice (GMAC), a theoretical framework for exploring student enrolment behaviour in mathematics (Eccles et al. 1983). A particular focus of their research was the sex differences evident in mathematics enrolments (Eccles 1984, Eccles, Adler and Meece 1984, Meece, Parsons, Kaczala, Goff and Futterman 1982).

The present study explores sex differences in enrolments in elective science courses by adapting the GMAC to the specific issue of science enrolment. A theoretical model of enrolment behaviour, the Science Enrolment Model, was developed by fitting the specific constructs which have been shown to influence enrolment in elective science courses into the structure of the GMAC. The Science Enrolment Model, therefore, is provided with a strong theoretical and empirical base which is not evident in the majority of studies examining the issue of science enrolment. A questionnaire was then developed and administered to approximately 450 students to obtain measures of the constructs included in the Science Enrolment Model. These data were used to construct empirical models of enrolment intentions in elective courses in biology, chemistry and physics.

In order to understand sex differences in enrolment behaviour it is important to consider both the differences in the relevant student attitudes and the differences in the importance which is placed on these attitudes when making enrolment choices. For example, males may find biology more interesting but may not place as much importance on 'interest' when making enrolment decisions – the utility value of the course may be more important. The present study involves the simultaneous consideration of both the differences in attitudes – as indicated by differences in construct *means*, and the relative importance of these attitudes – as indicated by differences in *path coefficients*. This is achieved by carrying out the analyses for the path models using the 'mean structures' extension of the LISREL structural equation modelling program. The simultaneous determination of means and path coefficients then enables the determination of the relative contributions of the expectancy and value constructs to the differences in enrolment behaviour.

Development of the Science Enrolment Model

The General Model of Academic Choice (GMAC – See Figure1) has been developed within the expectancy/value perspective which has a long tradition in achievement motivation research. It assumes that the ultimate influences on an achievement behaviour are the value which the behaviour has and performance expectations in relation to it. These values and expectations mediate the influence of a range of other

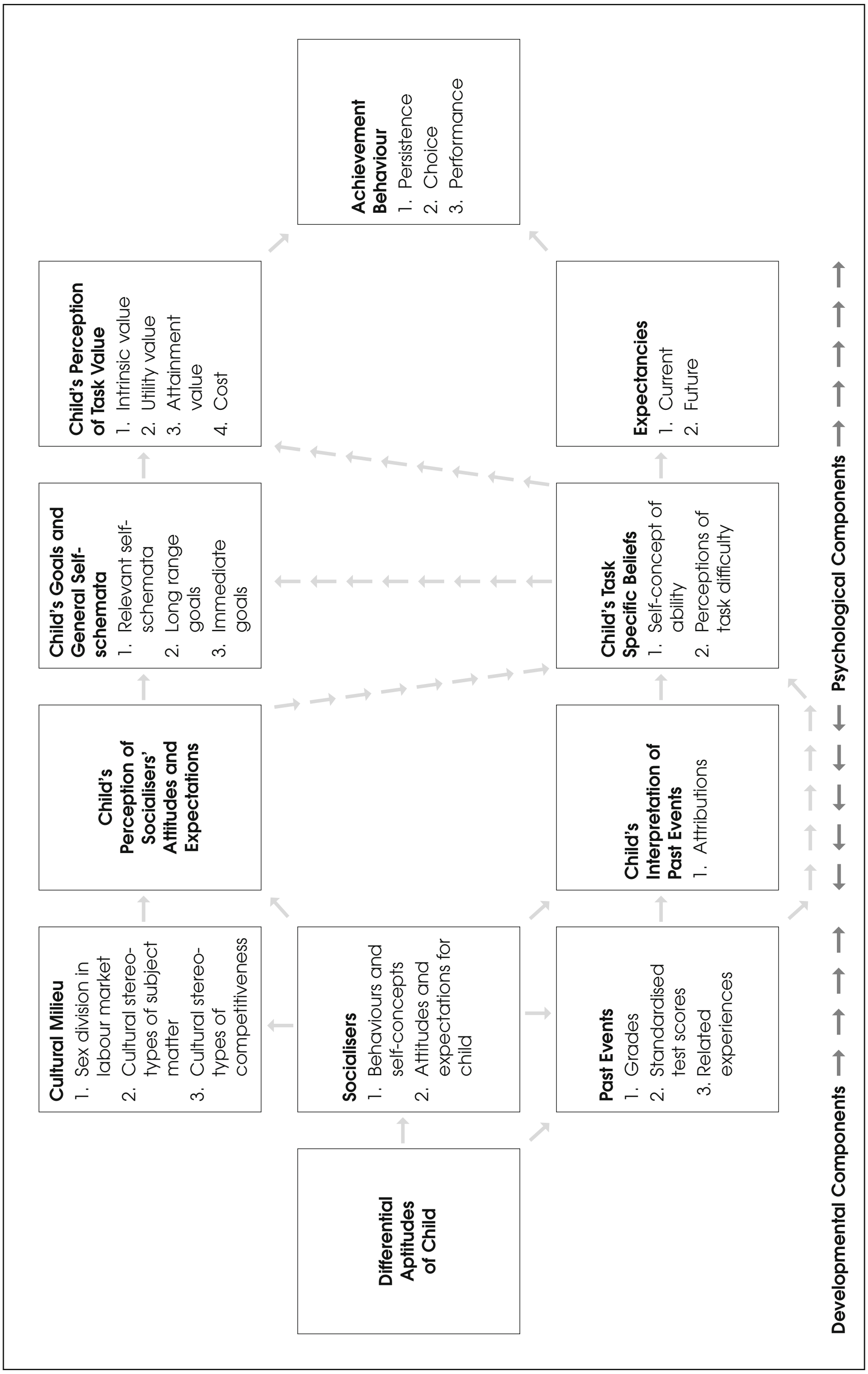

Figure 1: The General Model of Academic Choice

'psychological components' which, in turn, are influenced by a range of 'developmental components'. Since Eccles and colleagues developed the GMAC in the 1980s it has been used as the framework for many studies and its structure has been well supported (e.g. Deeter 1989, 1990, Etherington 1991).

In the present study the major attitudinal influences on students' decisions to enrol in elective science courses were identified through a review of the science enrolment literature. These specific constructs were then fitted into the general framework of the GMAC to obtain the Science Enrolment Model (see Figure 2). As has been pointed out on numerous occasions, demonstrating the existence of relationships between variables is not, in itself, evidence of causation. This must be argued independently. By adopting the framework of the GMAC, which is firmly embedded in the achievement motivation literature and has been supported empirically in numerous studies, a theoretical justification is provided for the structure of the Science Enrolment Model. Note that the Science Enrolment Model is derived from the 'Psychological Components' section of the GMAC only. As with the GMAC, the Science Enrolment Model assumes that the influence of developmental factors such as socio-cultural environment is mediated by the psychological variables.

Expectancy/value variables

The three expectancy-value variables which have been identified in the research literature as influences on students' enrolment decisions are 'Interest value', 'Career value', and 'Self-concept/ performance expectations'. 'Self-concept' and 'Performance expectations' have both been shown to influence enrolment decisions and measures of both constructs were included in a preliminary version of the Science Enrolment Model. However, the constructs could not be distinguished empirically in the data sets collected so they have been condensed into one.

The interest value of a course has consistently been identified as a dominant influence on enrolment intentions in elective science courses and sex differences in interest levels have usually been evident. For example, Cameron (1989) found that 66% of females gave 'interest' as the main reason for choosing biology, 17% for physics and 27% for chemistry. Comparable figures for males were 43% for biology, 29% for physics and 39% for chemistry. The value of a course as preparation for a science oriented career or tertiary studies in science has also been identified consistently as an influence on enrolment with the influence being greater in the physical sciences than in the biological sciences. Sex differences have also often been evident. For example, Kelly (1988) found that 51% of boys and 48% of girls cited career considerations as a reason for doing physics compared with 20% and 29% for biology.

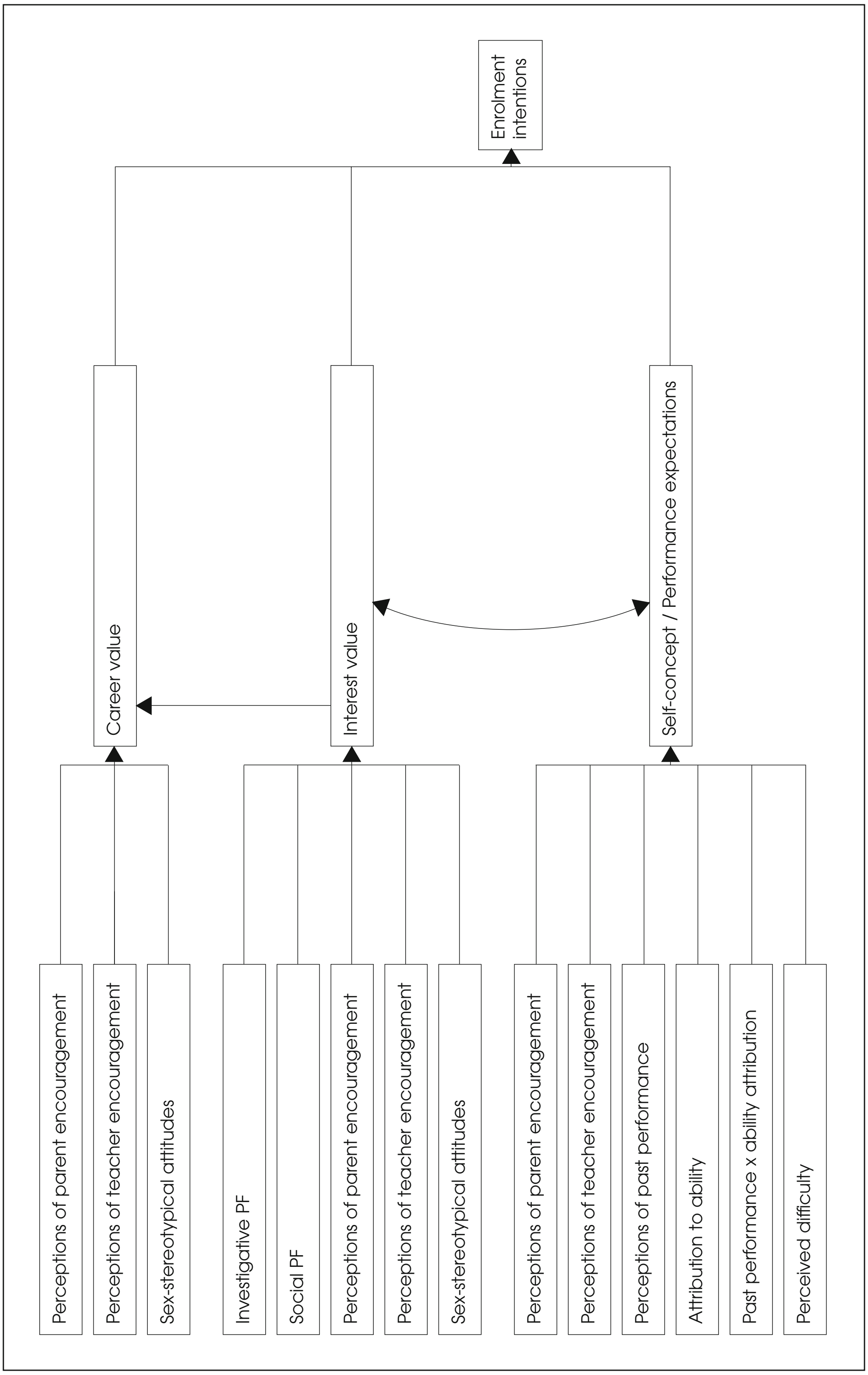

Figure 2: Science Enrolment Model

The Science Enrolment Model proposes a causal link between 'Interest value' and 'Career value'. While there does not appear to be any research directly exploring this link within the context of enrolment behaviour research, studies examining the predictive validity of vocational guidance instruments such as Holland's RIASEC (Realistic, Investigative, Artistic, Social, Enterprising, Conventional) typology (Holland 1985) provide indirect evidence for such a link (e.g. Dumenci 1995, Sheffey, Bingham and Walsh 1986). The relationship between interest and career choice is fundamental to the use of such instruments.

Self-concept and expectations for success have long been recognized as influences on achievement related decisions and there is an abundance of evidence demonstrating their importance. For example, in a study involving a large number of students across a wide range of schools in North Carolina, Simpson and Oliver (1990) found that 'Science self concept at the tenth grade level is a good predictor of both number and type of science a student will take during high school' (p.13). Similarly, DeBoer (1987) found that 34% of the variance in the continuing enrolment intentions of college chemistry students was explained by performance expectations.

A number of researchers have also identified significant differences in the self-concepts of boys and girls in relation to science subjects. Tamir (1988), for example, using data extracted from the Second International Science Study (SISS), found that boys in Israel perceived themselves as higher achievers in science and mathematics than girls. Such differences have been detected even when the performance of boys has been shown to be no better than that of girls and in some cases has even been inferior (eg. Khoury and Voss 1985).

The Science Enrolment Model assumes that 'Interest value' and Self-concept/ performance expectations' mutually influence each other. Intuitively it is reasonable to assume that there is a positive relationship between these two constructs. People are generally more inclined to be interested in tasks about which they feel confident and are inclined to show little interest in tasks which they feel are beyond them. However, there is insufficient research evidence to support an assumption of causality in one direction or the other so the Science Enrolment Model assumes a mutually causal relationship between them. The LISREL analysis provides a measure of the partial correlation between the two constructs, a measure of the variance which they share when the influence of the independent variables is removed, which can be interpreted as a measure of the strength of this relationship.

'Penultimate' variables

The three expectancy-value variables included in the Science Enrolment Model mediate the influence of a range of other psychological constructs. These 'penultimate' influences identified in the literature as having a substantial impact on enrolment behaviour are 'Perceptions of parent encouragement', 'Perceptions of teacher encouragement', 'Sex-stereotypical attitudes', personality factors, 'Perceptions of past performance', the degree to which past performance is attributed to ability and the 'Perceived difficulty' of the subject.

There have been a number of studies demonstrating a relationship between student self-concept and expectations on the one hand, and parent and teacher attitudes on the other. Barnett, Sink and Hixon (1993), for example, examined relationships between student perceptions of academic competence and parent and teacher ratings of academic competence for a sample of 62 sixth-grade children. They found significant correlations among parent, teacher and student perceptions which, they argued, 'are consistent with the social interactionist view, where individuals construct their self-images based on feedback from significant others' (p.7). The Science Enrolment Model suggests that parents and teachers are also likely to express attitudes which could conceivably influence achievement behaviours through their impact on 'Career value' and 'Interest value' although this relationship does not appear to have been explored in previous research.

There have been many studies examining gender differences in attitudes concerning the relative abilities of males and females in the different scientific domains and the gender appropriateness of these domains as areas of study and work. Weinburgh (1995) conducted a meta-analysis of studies published between 1970 and 1991 which examined gender differences in these sex-stereotypical attitudes and the relationship between these differences and achievement. She identified 18 studies which she considered appropriate for inclusion which provided 31 independent effect sizes relating to attitudes towards science. Of these, 81% indicated more positive attitudes by boys and 19% indicated more positive attitudes by girls. Unfortunately, such studies have not usually explored the relationship between attitudes and enrolment. Thus, while there is ample evidence of the existence of gender differences in attitudes towards science, there is little direct evidence of the influence of such attitudes on enrolment behaviour. Because 'Sex-stereotypical attitudes' are assumed to influence attitudes concerning the appropriateness of both academic domains and related careers the construct is assumed to influence both 'Interest value' and 'Career value'.

A number of studies have demonstrated the link between personality factor measures and enrolment choice (e.g. Bradley 1981, Clark 1986, Collings and Smithers 1983, 1984, Saville and Blinkhorn 1976). The Science Enrolment Model, in line with the General Model of Academic Choice, assumes that the influence of these personality factors is mediated by the task value constructs. In the interests of parsimony, the Model uses Holland's RIASEC typology (Holland 1985) as an integrative framework to condense the many personality variables shown to influence enrolment into a more manageable number. This framework has the advantage of being constructed specifically with a view to understanding the relationship between personality and academic specialisation. Holland argues that vocational, educational and recreational preferences are an expression of underlying personality traits and has developed a six factor typology based on such preferences. His six personality dimensions are the Realistic, Investigative, Artistic, Social, Enterprising and Conventional (RIASEC). On the basis of previous research (e.g. Bradley 1981, Clark 1986) it was hypothesized that scores on two of Holland's six dimensions, the Investigative and Social, would be likely to influence interest, and therefore enrolment, in one or more of the science courses being considered.

Many studies have demonstrated that past performances in science related subjects are strongly related to intentions to enrol in science elective courses. Khoury and Voss (1985) found that a measure of academic achievement was the strongest influence on enrolment decisions for males and the second strongest influence for females while Gardner and Tamir (1989) found that achievement in Year 10 biology was the most important factor influencing a sample of Israeli students to enrol in biology in Year 11. As measures of past performance were not available to this study, students' perceptions of their past performances were used as a convenient alternative.

Eccles et al. (1983) point out that 'According to several theorists, it is not success or failure per se but the causal attributions one makes for these outcomes that influence one's future expectations' (p.86). Attribution theorists argue that future performance expectations are a function not so much of students' past performances, but the extent to which they attribute these to stable factors such as their own ability or unstable factors such as the amount of effort expended, luck, etc. (e.g. Weiner 1974, 1984). In recent decades there has been a substantial body of research confirming the importance of students' attributions in shaping future expectations.

It was hypothesized that the attribution process would influence self-concept primarily through the interaction of 'Perceptions of past performance' and 'Attribution to ability'. If past performances are attributed mainly to ability they will have a much greater influence on self-concept than if they are attributed to other factors such as effort, luck, etc. The extent to which past performances influence self-concept will be determined by the extent to which they are attributed to ability. In other words, it is the interaction between the two constructs which should influence self-concept. Accordingly, the 'Perceptions of past performance' x 'Attribution to ability' cross-product was included in the Model. This cross-product is an addition to the GMAC.

Exploring the influence of 'Perceived difficulty' has been problematic because of the individual/normative nature of the construct. A capable student might not find physics difficult but still regard it as being more difficult than other subjects. Not surprisingly, therefore, studies which have examined the influence of the perceived difficulty of a subject on enrolment intentions have produced mixed results. For example, in a Canadian study involving about 300 Year 11 and 12 students Toews (1988) found 'difficulty' to be the most important reason cited by students for not doing physics. On the other hand DeBoer (1984) found that, for college students who rated their performance as successful, task ease was negatively related to decisions to continue. Results concerning gender differences are also mixed. For example, Kelly (1988) concluded that girls were more likely than boys to consider the difficulty of a subject an important factor in deciding whether to take it while Crawley and Coe (1990) reached the opposite conclusion.

The Science Enrolment Model, then, applies the GMAC to the specific issue of enrolment in elective science courses and, by so doing, provides a theoretically strong, empirically supported framework for examining this issue. In essence, the Science Enrolment Model enables the following questions to be addressed:

- Are there differences in males and females perceptions of the 'Career value' and 'Interest value' of elective science courses and their 'Self-concept/performance expectations' in relation to these (as indicated by differences in construct means); and are there differences in the importance placed on these perceptions when making enrolment decisions (as indicated by differences in path coefficients)?
- What are the relative contributions of 'Career value', 'Interest value' and 'Self-concept/performance expectations' to the differences in male and female enrolment behaviour?
- Are there sex differences in the constructs which, in turn, influence the value and performance perceptions (as indicated by differences in construct means); and are there differences in the way in which they influence them (as indicated by differences in path coefficients)?

Methodology

Participants

In the New South Wales education system all students in Years 7-10 (approximately 12-16 years of age) complete a general science course containing material drawn from the major science disciplines. At the end of Year 10 students select a minimum of six subjects which they study for the next two years, culminating in the Higher School Certificate examination at the end of their secondary schooling. Elective courses in biology, chemistry and physics are the most common science courses in which students enrol. At the time that the data were collected students could choose to study none, one or two of these courses. The Science Enrolment Model was used as a framework to construct empirical models of enrolment intentions in these three courses.

The enrolment models were based on the responses of 449 Year 10 students attending 5 high schools in Sydney, Australia (223 males and 226 females). The schools were selected to ensure a study sample which was representative of New South Wales secondary students. The five schools were coeducational, academically comprehensive and catered for a wide socioeconomic spectrum. Three of the schools were government schools and two were non-government.

The Science Enrolment Questionnaire

Early in the latter half of the school year, the participants completed the Science Enrolment Questionnaire, an instrument designed to measure the constructs of the Science Enrolment Model. Students were asked how likely they were to enrol in each of the three elective courses in the following year. 'Enrolment intentions' was used as the dependent variable rather than actual enrolment primarily because a student's final course selection can also be influenced by school organisational requirements. The three expectancy/value constructs were measured with multiple items; 'Career value' and 'Interest value' with three items and 'Self-concept/performance expectations' with five. All of the 'penultimate' constructs, except for the two personality factors, were measured with a single item. Students were asked to respond to each of these items three times, once for each of the three elective courses. The two personality factors were each measured with eighteen items which were summed to provide a single measure. This measure was used for each of the three models.

The personality factor items were measured on a three-point scale. All other items, except one item eliciting information about the students' sex, were answered on a five-point Likert scale. The personality factor component of the questionnaire was derived from Holland's Self Directed Search (SDS) instrument (Holland 1985).

Analyses

The analyses for the construction of the models were performed using the 'mean structures' extension of the LISREL structural equation modelling program (Joreskog and Sorbom 1988). This procedure enabled sex differences in construct means to be determined as well as the path coefficients. The sex difference in each of the dependent variables in the models is the sum of the differences induced by the relevant set of independent variables plus the intercept difference – the unexplained difference induced by factors not included in the model. For example, the sex difference in enrolment intentions is the sum of the differences induced by 'Interest value', 'Career value' and 'Self-concept/performance expectations' plus a component which is not explained by these three variables. The component of the difference which can be attributed to each independent variable is calculated by multiplying the sex difference in that variable by the female path coefficient. (A detailed description of these analyses is presented in Barnes 1999).

Variable	**Biology**	**Chemistry**	**Physics**
Enrolment intentions			
Career value	.16	-.09	-.28
Interest value	.21	-.04	-.01
Self-concept/expectations	.00	-.08	-.16
Unexplained	.08	-.09	-.13
Total	.45	-.30	-.58
Career value			
Interest value	.28	-.14	-.32
Parental encouragement	.06	-.02	-.07
Teacher encouragement	.04	.01	-.00
Unexplained	.04	.00	-.09
Total	.42	-.15	-.48
Interest value			
Investigative P.F.	-.13	-.30	-.39
Social P.F.	-.05	.02	-.10
Parental encouragement	.09	-.04	-.04
Teacher encouragement	.04	.00	-.01
Unexplained	.53	.07	-.03
Total	.48	-.25	-.57
Self-concept/expectations			
Parental encouragement	-.02	-.06	-.06
Teacher encouragement	-.01	-.06	-.06
Perc. Of past perf.	.01	.01	.01
Attribution to ability	.00	-.01	.00
Past perf. x atttrib.	.01	.02	-.02
Perceived difficulty	-.01	-.06	-.05
Unexplained	.10	-.16	-.27
Total	.08	-.31	-.45

Table 1
Attribution of Sex Differences in Variable Means

Results

The pairs of male and female path coefficients (in brackets) and the differences in the construct means (without brackets) for the biology, chemistry and physics models are presented in Figures 3, 4 and 5. Means and path coefficients for 'Sex-stereotypical attitudes' are not included. This construct was omitted from the LISREL analyses after initial examination revealed that there was insufficient variation in the distributions of the responses to the items used to measure it. The attributions of the sex differences in the dependent variables to the relevant sets of independent variables are presented in Table 1.

The differences in the three 'Enrolment intentions' means are generally well explained with the unexplained component being a relatively small proportion of the total. The differences in the 'Career value' means are also well explained, however this is not always the case for the other two dependent variables.

Physical Science Models

There were many similarities in the two physical science models, so it is convenient to consider them together. Males had significantly higher enrolment intentions than females in both models (differences of -.30 standard deviations in Chemistry and -.58 in Physics). These differences were well explained by the enrolment models with the three explanatory variables accounting for 70% of the difference in Chemistry (-.09 of the -.30 difference was unexplained) and 78% in Physics (-.13 of the -.58 difference was unexplained). There were substantial differences favouring males in the three expectancy/value variables. Males were more likely to consider careers related to the physical sciences (differences of -.15 and -.48), find them more interesting (differences of -.25 and -.57) and think they were more capable at them (differences of -.31 and -.45). Because career considerations and performance expectations had a greater direct influence on enrolment behaviour (the path coefficients were much larger) it was these two constructs which were the main direct causes of the differences in enrolment intentions. Career considerations accounted for -.09 (30%) of the difference in chemistry and -.28 (48%) in physics while performance expectations accounted for -.08 (27%) in Chemistry and -.16 (22%) in Physics (see Table 1). Interest had a substantial influence on enrolment, however, this influence was predominantly indirect, mediated by 'Career value'.

The differences in 'Career value' in the two models (-.15 standard deviations for chemistry and -.48 for physics) can be attributed mainly to the differences in interest levels and the strong influence which interest has on 'Career value'. 'Interest value' accounted for -.14 and -.32 of these differences respectively (see Table 1). Parent encouragement also contributed substantially in the Physics model (-.07). This was

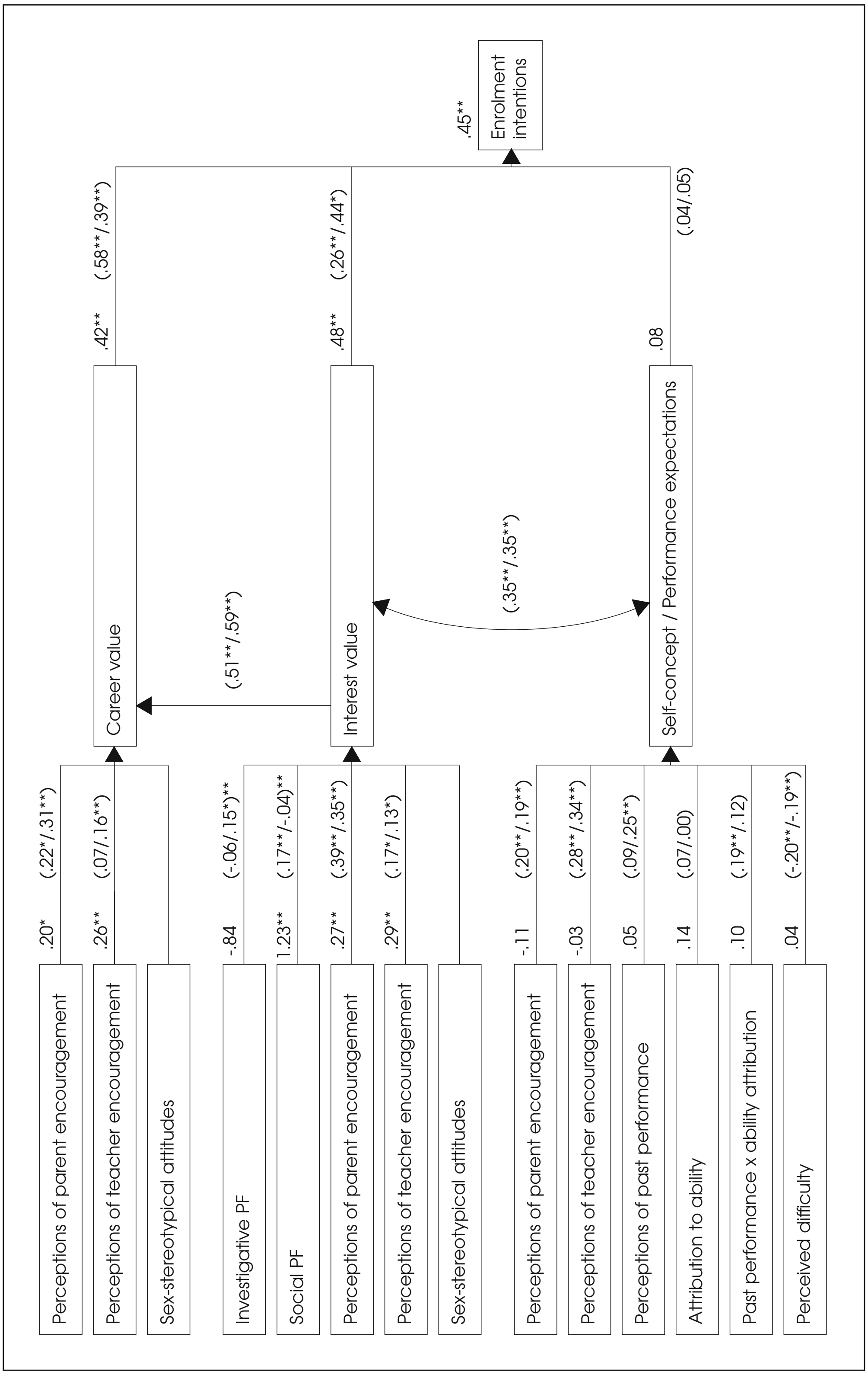

Figure 3: Biology Enrolment Model

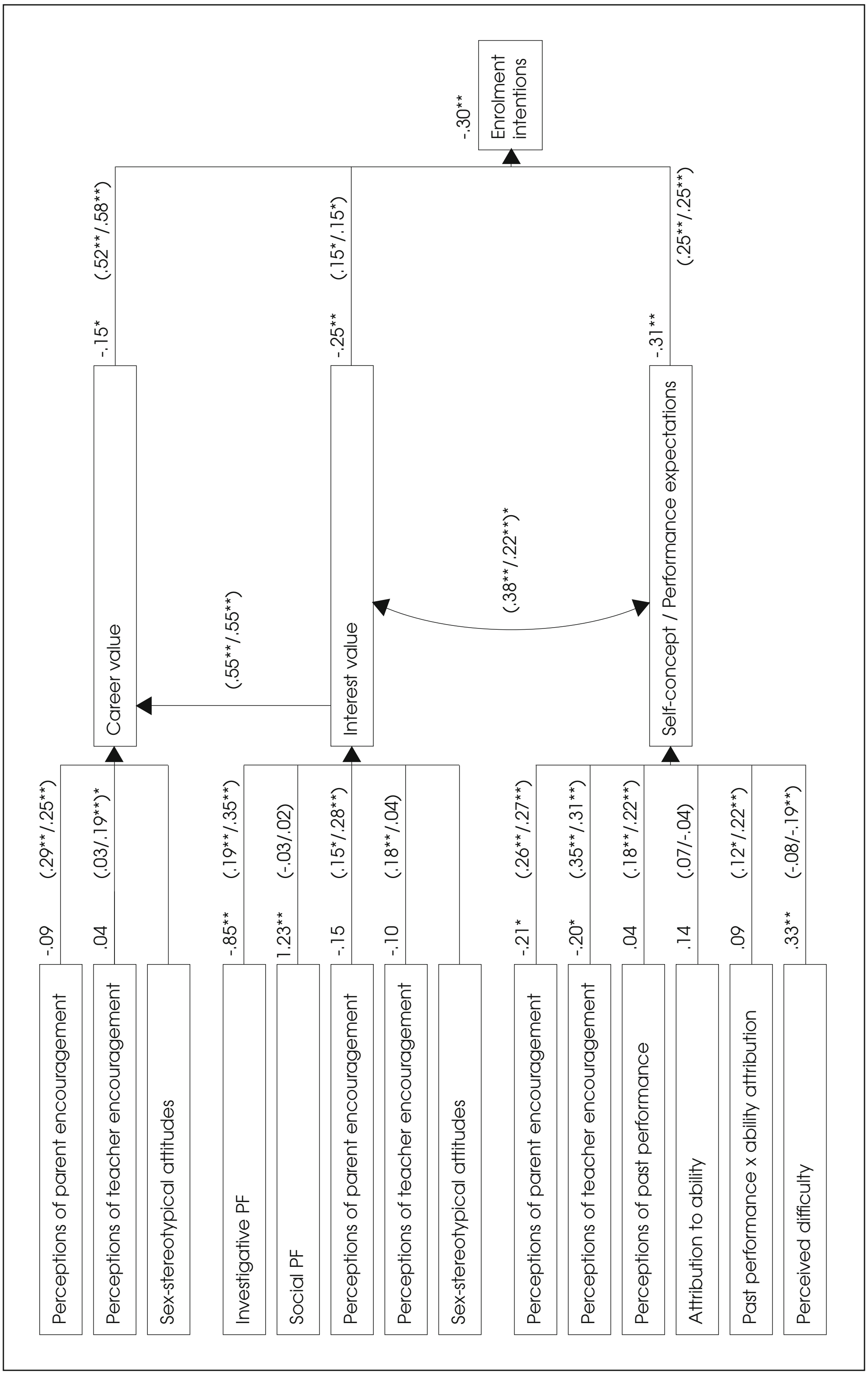

Figure 4: Chemistry Enrolment Model

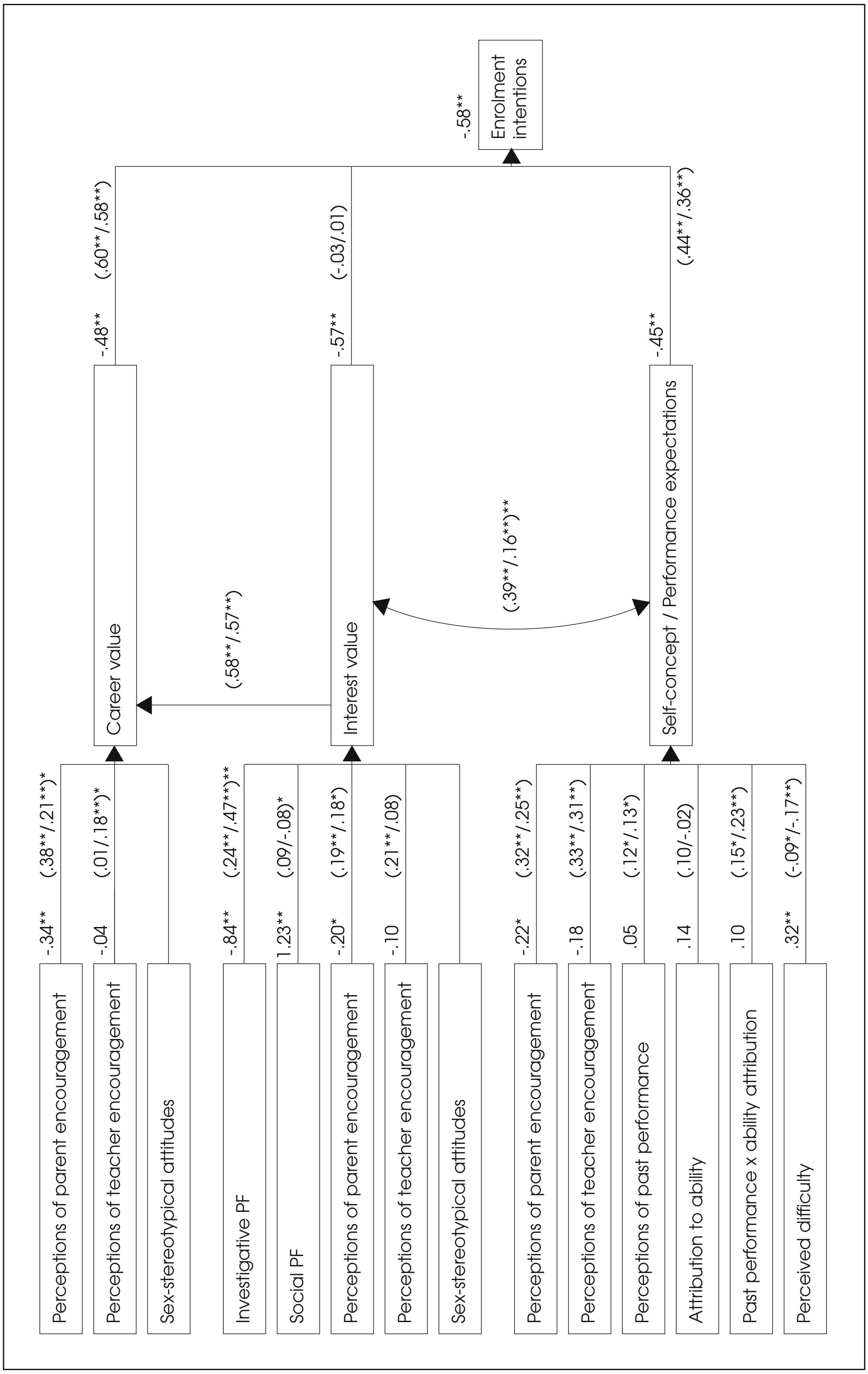

Figure 5: Physics Enrolment Model

Notes to Enrolment Models

*** p < .05 , ** p < .01.**

Means:

A positive difference indicates a higher mean for females. Differences are expressed in standard scores based on combined groups. T-values associated with the female means were used to assess the statistical significance of the differences. The means of the endogenous variables and associated t-values are not provided in the LISREL output. The means are readily determined from the other parameters. T-values for the sex differences in the value and expectation constructs were obtained by treating them as exogenous variables and using the measurement sub-model. Because each of the 'Enrolment intentions' variables was measured with a single item the significance of the sex differences in them was assessed with t-tests.

Path coefficients:

Coefficients are standardized to a common metric for males and females. The first coefficient of each bracketed pair is for males and the second is for females. The asterisks inside the brackets indicate whether the individual parameters are significantly different from zero. The asterisks outside the brackets indicate the statistical significance of the difference between the path coefficients. LISREL does not provide a measure of the statistical significance of the difference in path coefficients. This was assessed by dividing the difference between the unstandardised path coefficients by the standard error of their difference. The standard error of the difference was determined by taking the square root of the sum of the squares of the standard errors of the individual coefficients. T-tables were used to assess the statistical significance of the quotient.

not only because males were more likely to perceive their parents as encouraging them to pursue careers in Physics (difference in means of -.34) but also because they were significantly more likely to be influenced by these perceptions (path coefficient of .38 for boys compared with .21 for girls).

The strong influence of 'Interest value' on 'Career value' meant that 'Interest value' also exerted a substantial indirect influence on 'Enrolment intentions'. The magnitude of this influence can be readily determined by multiplying the proportion of the difference in 'Career value' induced by 'Interest value' by the proportion of the difference in 'Enrolment intentions' induced by 'Career value'. Accordingly, it can be calculated that the indirect effect of 'Interest value' accounted for 28% of the difference in 'Enrolment intentions' in Chemistry and 32% in Physics.

The Investigative personality factor was the main contributor to the difference in interest levels in the two physical science models. Although the path coefficients for this factor were greater for females, this difference being statistically significant in the Physics model, males generally had higher scores (difference in means of -.84

standard deviations). A closer examination of the data sets revealed that the reason for the differences in path coefficients was that females with low or medium scores were less likely than their male counterparts to find the physical sciences interesting while females with high scores were as likely to do so as their male counterparts, hence, as scores on the Investigative P.F. increased, the likelihood of enrolling increased more rapidly for females than for males.

Parental and teacher encouragement and 'Perceived difficulty' were the main causes of the differences in 'Self-concept/performance expectations' in the two models. However neither model was particularly effective in explaining this difference, with a large proportion remaining unexplained.

Of particular interest are the sex differences in the correlations between the 'Interest value' and 'Self-concept/performance expectations' constructs. In what are considered to be traditional male domains, males were more likely than females to be interested in these courses if they considered themselves to be capable at them, or alternatively, they were more likely to consider themselves capable at them if they were interested in them.

Biology Model

Females indicated significantly higher enrolment intentions in biology than males, a difference of .45 standard deviations, with the three explanatory variables accounting for all but .08 (18%) of this difference. The female means for the three expectancy/value constructs were all significantly higher. However, the difference in enrolment intentions can be attributed primarily to the 'Career value' and 'Interest value' constructs which accounted for .16 (35%) and .21 (47%) of the difference respectively (see Table 1). These contributions were mainly due to the higher female means. It is noteworthy, however, that the differential influence of 'Interest value' was magnified by the greater importance placed on interest by females when deciding whether or not to enrol in biology, although the difference in the path coefficients did not reach statistical significance at $p < .05$. By the logic outlined above it can be determined that the indirect effect of 'Interest value' accounts for 23% of the difference in 'Enrolment intentions'.

As with the two physical science models the major cause of the difference in 'Career value' means was 'Interest value', accounting for about two-thirds of the difference. Perceptions of parent and teacher encouragement also contributed substantially to the difference, with females being more likely than males to perceive both their parents and their teachers as encouraging them to pursue careers in the biological sciences. The models were not effective in explaining the sex differences in interest in biology while the differences in 'Self-concept/performance expectations' were minimal.

Discussion

The first of the three central questions to be addressed through the construction and comparison of the male and female enrolment models was whether there are differences in the value which males and females place on participation in elective science courses and their performance expectations in such courses, and whether there are differences in the importance placed on these values and expectations when making enrolment decisions. The findings in relation to this central question are clear and consistent across the three models. The substantial differences in 'Enrolment intentions' identified can be attributed almost entirely to sex differences in values and performance expectations, as indicated by differences in means, with very little difference in the importance placed on these constructs, as indicated by path coefficients. Sex differences in enrolment behaviour can be attributed almost entirely to differences in the perceived career value of the courses, differences in how interesting males and females expect to find them and differences in how well they expect to perform. Interestingly, the study provides no support for the findings of some previous research that females tend to be more intrinsically motivated and males tend to be more extrinsically motivated, that is, that females are more likely to pursue what they are interested in and males are more likely to pursue what will provide advantage.

Findings in relation to the third central question – whether there are sex differences in the 'penultimate' psychological constructs which influence the value and performance perceptions and differences in the way in which they influence them – are less clear cut. Although the sex differences in the three expectancy/value constructs are primarily a result of differences in these perceptions and attitudes (differences in means) there are also significant differences in the way in which the influence of these constructs operate (differences in path coefficients).

'Career value' is the largest contributor to the differences in enrolment behaviour in the physical sciences and the second largest contributor to the difference in biology. This is a result of the substantial sex differences in the 'Career value' means for the three courses and the strong influence which 'Career value' has on enrolment behaviour for both males and females. In NSW, as in education systems in many developed countries, specialist science courses, particularly physical science courses, have been structured and marketed primarily as 'career preparation' courses. They have traditionally provided a curriculum which is focused on preparing students for entrance to university science and technology courses, although this has been changing somewhat in recent years. It is not surprising, therefore, that career considerations have such a strong influence on students' enrolment decisions. Sex differences in enrolments might be substantially reduced by broadening the narrow 'career preparation' focus which elective science courses have traditionally had.

The combined direct and indirect effects of 'Interest value' also contribute substantially to the sex differences in enrolment behaviour in all three courses, mainly because females tend to find the physical sciences less interesting and the biological sciences more interesting (differences in construct means). Differences in interest levels in the physical sciences are primarily the result of the differential influence of the Investigative personality factor with males generally having higher scores on this factor (difference in construct means of -.84). In other words, the physical science elective courses, as they are presently structured and taught, are more likely to appeal to people who resemble a particular academic 'type' and males are more likely to resemble this 'type' than females. This raises the question of whether the material which is selected for inclusion in senior secondary physics and chemistry courses could be broadened to include material which is of interest to a wider clientele, perhaps by providing a greater range of options within courses. Physics courses, for example, have traditionally focused on more 'practical' topics such as mechanics and electrodynamics, and have often emphasised the development of 'computational' skills, reflecting the fact that students are being trained as potential science/engineering practitioners. There has been less emphasis on topics such as astronomy which can have broader appeal, although there has also been significant change in this area in recent years.

Sex differences in self-concept account for more than a quarter of the difference in 'Enrolment intentions' in chemistry and physics. These differences are intriguing given that there are virtually no sex differences in students' perceptions of their performance in their junior science course. To some degree this anomaly can be explained by the fact that the junior science course is a composite of material drawn from all branches of science, not just physics and chemistry. It seems unlikely, however, that this could account for all of the differences. It is feasible that these differences could be attributable, at least in part, to the differential influence of interest on self-concept. The models indicate that self-concept and interest are more closely linked for males than for females in the physical sciences. The Science Enrolment Model did not assume causality in either direction between these two constructs as there was insufficient evidence in the research literature to justify doing so. If it is assumed, however, that interest has some causal effect on self-concept then this could account for some of the sex difference in self-concepts in the physical sciences. As females' interest in the physical sciences increase their self-concepts do not increase at the same rate as that of males. Hence, females who are interested in the physical sciences are less likely to have high self-concepts than their male counterparts.

The present study set out to address what was perceived to be a major short-coming in much of the research into sex differences in science enrolments, namely the employment of a sound theoretical framework to guide the collection, analysis and interpretation of data. This study brings together strong theoretical underpinnings, provided by the General Model of Academic Choice, rigorous measurement practices and sophisticated analytic techniques. The success of the study in explaining large proportions of the sex differences in students' enrolment intentions in elective courses in biology, chemistry and physics highlights the benefits of such an approach. The study also provides strong support for the use of an expectancy/value framework for exploring student enrolment behaviour.

The results suggest that strategies aimed at reducing sex differences in enrolments in elective science courses would benefit from focusing on alleviating sex differences in students' interest, career and performance considerations. It is differences in these three constructs which are largely responsible for the differences in enrolment behaviour.

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