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Exploring Gender Difference in Motivation, Engagement and Enrolment Behaviour of Senior Secondary Physics Students in New South Wales

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Abstract Although substantial gender differences in motivation, engagement and enrolment behaviour are frequently reported in the international physics education literature, the majority of studies focus on students who intend to choose physics for their future study. The present multi-occasional study examines the gender difference in motivation, engagement and enrolment behaviour among senior secondary students from New South Wales schools who have already chosen to study physics. It examines whether the differences reflect differences *of degree* in these dimensions, or differences *of kind* for these students. Fine-grained analyses at module-specific level of the senior secondary physics curriculum indicated that the differences do not represent differences of *kind*. That is, girls' and boys' perceptions of the key facets of motivation, sustained engagement and choice intentions in relation to physics seemed to be qualitatively the same. However, there were differences in the *degree* to which boys and girls are motivated, although the pattern was inconsistent across the four modules of the senior secondary physics curriculum. Girls' motivation, engagement and sustained enrolment plans in relation to physics were found equal to or higher than boys' at various time points through the course. These findings highlight the need to change the existing gender-biased stereotype that students perceive physics as a male domain and that subjective motivation, engagement and enrolment plans will always report higher measures for males. The results have implications for intervention strategies aimed at sustaining student motivation in physics. The potential implications of the findings for practitioners and researchers are discussed.

Keywords Physics education · Gender · Motivation and engagement · Expectancy-value theory · Senior secondary school students

Introduction

In recent decades, there has been a great deal of research reported on the significant gender imbalance that exists in physics classrooms. Studies both nationally and internationally

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indicate that physical science courses, especially physics, are traditionally regarded as 'masculine' subjects and females are greatly underrepresented (e.g. Barmby and Defty 2006; Carlone 2004; Cousins 2007; Enman and Lupart 2000; Häussler and Hoffmann 2000; Lyons and Quinn 2010; Mullis et al. 1988; Speering and Rennie 1996). A substantial body of literature shows that females express significantly lower levels of motivation and engagement with physics than male students (e.g. Seymour and Hewitt 1997; Stumpf and Stanley 1996).

While gender equity and access are critical issues for all subjects, the marked alienation of females from physics has drawn much research interest. Among the traditional sciences (biology, chemistry, physics), physics has the greatest gender differentiation, and various interventions have been conducted to transform this imbalance (e.g. Hollins et al. 2006; Murphy and Whitelegg 2006). Progress of females in science, technology, engineering and mathematics (STEM) careers is metaphorically referred to as a 'leaky pipeline' carrying students from secondary school through university and on to jobs in STEM (Blickenstaff 2005). This pipeline leaks students at various points; however, the majority of the studies on female participation in physics tend to focus on one critical exit point from physics, which is the transition between junior and senior high school. The Australian senior high school structure, where students have a choice to continue or discontinue physics after the first year of senior secondary physics, provides a unique exit point from the pipeline. Little has been explored about females who are already enrolled in this traditionally 'masculine' subject and the motivational patterns of those who retain enrolment intentions. Such analysis may assist in finding explanations to the salient question—whether and why females display lower intentions to stay on in the 'leaky pipeline'? To answer this question, a critical examination of the gender disparity in motivation and engagement with physics and sustained enrolment intentions at senior secondary level is required.

Physics Motivation

This study adopted an expectancy-value (EV) theoretical framework of achievement motivation to identify the major determinants of sustained enrolment intentions in relation to physics. EV theory has been successfully applied to explore achievement-related behaviours in various subject domains, such as mathematics and sciences including physics (e.g. Barnes 1999; DeBacker and Nelson 1999; Greene et al. 1999; Wigfield 1994; Wigfield and Eccles 1992, 2000; Woods 2008). Achievement-related behaviours include behaviours such as the *persistence, choice* and *performance* of an individual in relation to a subject or course (Wigfield 1994). The EV theory proposes that a variety of factors have direct or indirect effects on the achievement behaviours of an individual in any given achievement-oriented situation (Wigfield and Eccles 2000). These factors include the individual's socio-cultural beliefs, perceived beliefs regarding their own abilities to do well on the task, the perceived difficulty of the task, personal goals, past experiences in similar tasks and a variety of socialisation influences emanating from the cultural and social background of the individual (Eccles et al. 1983).

A number of studies by Eccles and her colleagues suggest that students' engagement with learning is linked to their ability beliefs and the high value placed on doing well in the subject (e.g. Eccles 2008). Individuals' desires to engage fully with learning, and their performance, are boosted by increasing the interest value of the learning task (Eccles 2008). Thus, both motivation and engagement are crucial to enhancing learning and persisting in a task, and may be reciprocally related (Eccles 2008; Singh et al. 2002). Therefore, in this study, it is hypothesised that the effects of the EV motivational variables on students' sustained enrolment intentions in physics are mediated by their sustained engagement with the physics course.

Gender Differences in Physics Motivation

An extensive search of studies conducted within the EV theoretical framework indicates that the significant motivational variables that have a direct influence on students' physics enrolment behaviours are the *task values* (specifically *interest value* and *utility value*), *expectancies of success* and *gender role beliefs* students possess towards physics (e.g. Barnes 1999; DeBacker and Nelson 1999; Eccles et al. 1998; Greene et al. 1999; Wigfield and Eccles 2000). Significant gender differences were reported for these variables and for engagement with physics.

Interest Value of Physics Interest value (*interest*) refers to the 'inherent enjoyment or pleasure one gets from engaging in an activity' (Eccles et al. 2005, p. 239). Numerous studies have demonstrated that physics appears to be less interesting to females than to males (e.g. Feder 2002; Ivie and Stowe 2000). According to Hoffmann (2002), interest in physics as a school subject emerges from various personal and environment factors such as '…individual interest in physics, a short-term interest in certain topics of physics produced by the interestingness of physics instruction in the sense of situational interest… and the social climate in physics classes' (p. 448). Variation at an individual level could be expected in relation to the ways in which these factors combine to determine interest in physics as a school subject. For females, this variation can be more pronounced given the gendered expectations within physics classrooms (Hollins et al. 2006) and the 'masculinity' of the standard physics curriculum (Goodrum et al. 2001; Rennie and Parker 1996) probably leading to disinterest in physics.

Performance Perceptions in Physics Students' *expectancies of success* in a subject (referred to as *performance perceptions [perfperc]* in this study) is a major motivational variable which influences their subject choice (Eccles and Wigfield 1995). A number of studies suggest that female students perceive physics to be a difficult subject more frequently than males, and this is a key reason for the marked gender differentiation in physics enrolment (e.g. Häussler and Hoffmann 2000; Lyons and Quinn 2010).

Perceptions of Gender Roles (sexstereo) Physics is portrayed as a 'masculine' domain by society and the media, propagating a gender-stereotyped concept among adolescent students that females are less suited to or capable in physics, inhibiting females from choosing physics. Female students, particularly those from coeducational schools, report this more frequently (Frost et al. 2005; Goodrum et al. 2001; Rennie and Parker 1996; Whitelegg et al. 2007). However, the gender difference in such attitudes is explored in only a few studies. For example, a small group of studies reported that while both boys and girls possessed gender-stereotyped views on sciences, it was generally the boys who rated sciences more frequently as a masculine domain (e.g. Baker and Leary 1995; DeBacker and Nelson 2000; Jones et al. 2000).

Utility Value of Physics Utility value (*utility*) is defined as the 'value a task acquires because it is instrumental in reaching a variety of long-and short-range goals' (Eccles and Wigfield 1995, p. 216), and is suggested as the strongest predictor of academic *choice* in the subject (Eccles 1994; Jozefowicz et al. 1993). Studies report that a marked gender difference exists for the variable whereby females perceive physics as less useful for their personal goals (Barnes et al. 2005; Stokking 2000; Whitelegg et al. 2007).

Sustained Engagement with Physics (engage) Aligning with Willms (2003), student engagement with physics is defined in this study as 'a sense of belonging; a disposition towards learning the subject, working with others and functioning in a social situation (the physics classroom), expressed in students' feelings that they belong to the course and in their participation in its activities' (p. 8). Disengagement, and the largest attrition, occurs in physics education when students pass through the science education program in secondary schools (Whitelegg et al. 2007). This is reported to occur faster in the case of girls, and they begin to drop out of physics at higher rates than males during the senior secondary years (Ivie et al. 2002).

The Present Investigation

In this study, students' sustained intention to choose further programs in physics (*choicein*), which is an achievement-related behaviour, was hypothesised to continue to be influenced by the four EV variables and by sustained engagement (*engage*) with physics when they start studying the subject in senior secondary. Also, since the extant literature offers compelling evidence that male students express higher motivation, engagement and enrolment intentions in physics than female students, it was hypothesised that these differences will continue to exist for male students' favour at the senior secondary level.

Aim of the Study

To explore gender differences in student motivation and engagement in relation to physics, our questions were twofold: If there are gender differences, does the extent to which these differences reflect *differences of degree* in these variables or *differences of kind*, or *both*? According to Martin (2004), 'differences of *degree* would suggest that boys are higher or lower than girls on particular domains: for example, higher or lower in key facets of motivation' (p.133). He interprets differences of *kind* as the qualitative difference between males and females for these variables, for example, 'perceiving key facets of motivation in fundamentally different ways, seeing different factors underlying motivation' (p.133). Are females and males differently motivated (*differences of kind*) or motivated to different levels (*differences of degree*) for physics?

Method

Participants

The participants in this study were senior secondary school physics students in year 11 from nine NSW schools (government and Catholic schools) located in Western and Northern Sydney. There were four data collection points corresponding with the completion of each of the physics modules of the year 11 curriculum. The total sample size across the nine schools varied across the modules (270, 280, 239 and 222 respectively) and was higher for males than females (males—178, 180, 147 and 140; females—92, 100, 92 and 82), reflecting the significantly lower female participation in Australian physics classrooms (Lyons 2006).

Materials and Procedures

The four EV motivational constructs, sustained engagement and enrolment intentions were represented in the Physics Motivation Questionnaire (PMQ). The PMQ comprises 22 items measuring six constructs on a six-point Likert scale (1 = strongly disagree, 6 = strongly agree). Of the six constructs, four were defined under the EV variables (first measurement model), namely: *interest*, *perfperc*, *sexstereo and utility*, and the remaining two were the outcome constructs *engage* and *choicein* (second measurement model). The instrument was validated and the psychometric properties examined (see Appendix). The study explored the extent to which gender differences represent *differences in degree* or *difference in kind* at a fine-grained physics module-specific level, rather than a broader domain-specific level as previous studies have done (e.g. Barnes 1999; Woods 2008). This was possible since the psychometric properties of PMQ were found sound at module-specific levels of the physics curriculum (see Appendix).

In accordance with ethics approval, this study involved four data collection points at the completion of each physics module, participants were asked to complete the PMQ, where the items were made module specific. The order in which the four modules were taken for analysis is the order in which the majority of schools taught the topics in the 2009 academic year: The world communicates (commonly known as the 'waves' module), Electrical energy at home (electricity), Moving about (motion), and The cosmic engine (cosmic engine).

Statistical Analysis

Descriptive Statistics and Confirmatory Factor Analysis In preliminary analysis, we examined the Cronbach's alpha estimate of internal consistency of each *a priori* scale. Next we examined the factor structure of a six-factor model with the 22 items in a confirmatory factor analysis (CFA) for each of the four physics modules and conducted tests of invariance across gender to determine whether there were any differences in *kind.* These tests of invariance would enable us to then compare the means of the latent variables for males and females across each physics module to determine whether differences in *degree* exist.

The procedures for conducting CFA have been described elsewhere (e.g. Byrne 1998; Jöreskog & Sörbom 1996) and are not further detailed here. The CFA was conducted with LISREL 7.2 (Jöreskog and Sörbom 1996). In a CFA study, the parameters typically consist of factor loadings, factor variances and covariances, and measured variable uniquenesses (i.e. measurement errors associated with each item). Based on suggestions from Marsh et al. (1996), the goodness of fit was primarily assessed using the Tucker-Lewis index (TLI, also known as the non-normed fit index, NNFI). However, the chi-square test statistic, the comparative fit index (CFI) and root mean square error of approximation (RMSEA) are also reported. In general, for an acceptable model fit, the values of TLI and CFI should be equal to or greater than 0.90 for an acceptable fit and 0.95 for an excellent fit to the data. For RMSEA, a value of 0.05 indicates a close fit, values near 0.08 indicate a fair fit and values above 0.10 indicate a poor fit (Byrne 1998). Specifically, support for the six-factor model requires (a) acceptable reliability for each scale (i.e. alpha=0.70 or above), (b) an acceptable model fit (i.e. TLI and CFI=0.90 or above and RMSEA <0.08), (c) acceptable factor loadings for the items, loading on the respective factors (>0.30) and (d) acceptable correlations among the latent factors such that they would be distinguishable from each other ($r<0.90$).

Invariance Across Gender Invariance testing proceeded according to Byrne's (1998) recommendation whereby 'sets of parameters are put to the test in a logically ordered and increasingly restrictive fashion' (p. 261). Specifically, verifying measurement invariance involves the testing of five models, where increasing restrictions are set on certain parameters and the five models are assessed across the specified groups (Marsh 1994). These procedures have been described elsewhere (Byrne 1998) and are not further detailed here. Meeting parameter estimates across all five models is considered excessively restrictive. Therefore, consistent with others, in this study, the first three models in the nested model series were considered in determining whether the particular scale was invariant across the two groups (Marsh 1994; Marsh et al. 2009).

To establish the factorial invariance, the change in the goodness of fit indices of these nested models was examined (Cheung and Rensvold 2002; Marsh et al. 2006). Following the guideline set by Cheung and Rensvold (2002), a change of more than 0.01 in the CFI was regarded as an indication of not meeting the invariance criteria. Therefore, across the gender groups, the CFI of the completely free model was compared with that of the other four nested models. Since the PMQ included two measurement models, it was necessary to subject both measurement models to invariance testing across the two groups.

Comparison of Means Mean values of the six constructs across males and females were compared to examine whether there were differences of *degree*. According to Martin (2004), 'if there are mean-level differences, then it can be argued that differences between boys and girls are, at the very least, differences of degree' (p. 135). To determine whether mean-value differences across male and female students were statistically significant or not, the standardised factor correlations of the constructs with gender were analysed (Bodkin-Andrews et al. 2010).

A CFA model of the seven constructs, including the newly created construct *sex*, was conducted, and the fit of the model was assessed. The factor correlations of the six PMQ constructs to the newly constructed latent construct *sex* were examined, provided the fit of the CFA model to the data was shown to be good. The standardised correlations of the six PMQ constructs with *sex* would reveal whether a significant difference exists between males and females for the mean score of each of these constructs. The Wald statistic at an alpha level of 0.05 was used to test the statistical significance of the differences. That is, a z value (estimate/standard error) greater than 1.96 represented significance at the 0.05 level (Goldstein 1995).

The gender of the participants was coded as 1 = male and 2 = female. Positive values (values higher than 0) of the factor correlations with *sex* represent values higher for females than males, while negative values of the factor correlations with *sex* (values less than 0) represent values lower for females than males.

Results

Confirmatory Factor Analysis

The a priori six-factor structure of the PMQ was verified across the physics modules using CFA. The results demonstrated acceptable overall model fit, showing support for the six-factor structure of the PMQ for all modules (Table 1). Therefore, further analyses were undertaken.

Invariance Across Gender

Table 2 represents the CFIs for both measurement models of PMQ in the five nested models series across the four modules.

Examining the variation in the CFI for the nested models, it was identified that invariance across gender was achieved for the factor loading (model 2) and for the factor loading, variance and covariance (model 3). Further invariance testing of the parameters of the

Table 1 Fit indices of six-factor CFA models for the physics modules

Module	χ^2	*df*	χ^2/df	TLI	CFI	RMSEA	Type of fit
Waves	368.55	195	1.89	0.958	0.964	0.058	Fair
Electricity	484.08	195	2.48	0.942	0.951	0.073	Fair
Motion	457.06	195	2.34	0.947	0.956	0.075	Fair
Cosmic engine	567.47	195	2.91	0.928	0.939	0.092	Fair

χ^2 Chi-square, *df* degrees of freedom, *TLI* Tucker-Lewis Index, *CFI* Comparative Fit Index, *RMSEA* root mean square error of approximation

uniqueness (models 4 and 5) achieved invariance in some instances only. However, models 4 and 5 represent overly restrictive practice, and therefore were not considered. These results demonstrate that the differences do not represent differences of *kind*.

Comparison of Means

Since the PMQ was found to be gender invariant, mean score comparisons were possible between male and female groups. Given that parallel wordings were used for indicators that measure the same constructs across the four modules, it was reasonable to assume that the

Table 2 Factorial invariance across gender

Module	Nested models	CFI of measurement models for	
		Predictor variables	Outcome variables
Waves	1	0.966	0.998
	2	0.967	0.999
	3	0.967	1.000
	4	0.960	0.977
	5	0.960	0.981
Electricity	1	0.899	0.999
	2	0.901	1.000
	3	0.899	1.000
	4	0.875	0.967
	5	0.884	0.973
Motion	1	0.903	0.995
	2	0.899	0.986
	3	0.899	0.981
	4	0.869	0.941
	5	0.869	0.929
Cosmic engine	1	0.930	0.997
	2	0.930	0.999
	3	0.929	0.996
	4	0.915	0.965
	5	0.914	0.944

CFI Comparative fit index; *RMSEA* root mean square error of approximation; *1* completely free model; *2* invariant factor loading model; *3* invariant factor loading, variance and covariance model; *4* invariant factor loadings and uniqueness model; *5* completely invariant model scores are comparable. Table 3 shows that participants reported high or near average values (mean of the constructs=3.5) for all variables except for sexstereo across each of the physics modules.

Significance Testing of the Mean Score Differences All CFA models including sex as a latent construct showed acceptable fits to the data (Table 4). Therefore, further analysis of factor correlations was conducted to test the significance of the mean score differences. The standardised factor correlations with the sex construct are given in Table 5.

The results suggest that although there were statistically significant gender differences in some constructs, they did not display a consistent or specific pattern, with the exception of sexstereo. The results revealed gender differences in the value variables (*interest* and *utility*) in relation to some modules studied. Gender role beliefs (*sexstereo*) was the single variable that exhibited gender differentiation consistently across all variables. Females reported significantly lower values for this construct than did males, although males tended to hold low values for this construct too.

Discussion

Difference of Kind

The results suggest that the factor structures of the measurement models for both the predictor and outcome variables of PMQ are consistent across the male and female student sample for all four physics modules. This means that specific facets of the constructs included in the PMQ, or correlations among these facets, did not qualitatively differ between males and females in relation to the physics modules, demonstrating no difference of *kind* (Martin 2004). This finding makes a significant contribution to theory and practice because it is now possible to test difference of *degree* across a full range of physics modules. In practice, this finding suggests that intervention programs designed to boost or sustain girls' physics motivation will also target boys since there is no qualitative difference in their perceptions of motivation, engagement and enrolment intentions for physics. Consequently, practitioners do not need to spend time differentiating the intervention for girls and boys.

Table 3 Mean values of constructs across the four physics modules for males and females

Module	Latent variables											
	interest		perfperc		sexstereo		utility		engage		choicein	
	M	F	M	F	M	F	M	F	M	F	M	F
Waves	3.15	3.58	3.05	3.67	2.45	1.98	3.40	3.60	4.49	4.33	4.84	4.45
Electricity	3.82	3.62	3.82	3.62	2.51	1.71	3.48	3.26	4.44	4.40	4.68	4.56
Motion	3.75	3.68	3.76	3.84	2.47	1.77	3.84	3.45	4.42	4.47	4.47	4.72
Cosmic engine	3.73	3.84	3.75	3.68	2.34	1.76	3.16	3.04	4.53	4.61	4.80	4.62

interest Interest value of the physics module, *perfperc* performance perceptions for the module, *sexstereo* sex-stereotyped attitudes to the module, *utility* utility value of the module, *engage* sustained engagement with the module, *choicein* sustained intention to continue in physics, *M* male, *F* female

Table 4 Fit indices of CFA models including sex as a latent construct across the four physics modules

Module	χ^2	*df*	χ^2/df	TLI	CFI	RMSEA	Type of fit
Waves	388.99	211	1.84	0.956	0.963	0.056	Fair
Electricity	505.73	211	2.39	0.941	0.951	0.071	Fair
Motion	476.79	211	2.25	0.946	0.955	0.073	Fair
Cosmic engine	581.03	211	2.75	0.925	0.937	0.089	Fair

χ^2 Chi-square, *df* degrees of freedom, *TLI* Tucker-Lewis Index, *CFI* comparative fit index, *RMSEA* root mean square error of approximation

Difference of Degree

Our results are mostly inconsistent with previous research. Where there were differences, it was not in males' favour as reported in the relevant literature (e.g. Barnes et al. 2005; Murphy and Whitelegg 2006; Woods 2008). Perhaps the uniqueness of this study's participants, that is, selecting students who have already chosen to study year 11 physics, could explain this variation in results. Since these females have chosen to study what is perceived to be a 'masculine' subject, they most likely possess high motivation and engagement for physics that is on par with their male counterparts. Traditionally, physics studies utilise domain-specific levels of measurement but this study is novel because its measurement is at a module-specific level. The advantage of this approach is the ability to capture more sensitive information in relation to whether patterns of motivation, engagement and future enrolment intentions differ for each of the topics. Results from this sensitive measurement can facilitate the targeting of more effective instructional strategies and interventions that can encourage retention, particularly for female physics students.

Difference of Degree for Interest Value (Interest) The results for interest did not concur with previous research showing that females have lower interest in the topic of electricity than their male counterparts (Angell et al. 2004; Cavas et al. 2010; Woods 2008). While a number of studies suggest that females have less interest in topics related to mechanics (e.g. Hoffmann 2002; Osborne and Collins 2000), in the present study, females did not show any difference in the *degree* of interest for the motion module (equivalent to the mechanics topic referred to in previous studies). This was surprising given that the motion module is governed by mathematical thinking and problem solving, which tends to be preferred by males (e.g. Osborne and Collins 2000).

Table 5 Factor correlations with the sex construct across the four physics modules

Module	interest	perfperc	sexstereo	utility	engage	choicein	sex
Waves	0.228*	−0.064	−0.179*	0.071	−0.109	−0.131*	1.000
Electricity	0.161*	−0.114	−0.225*	−0.106	−0.049	−0.038	1.000
Motion	0.009	−0.096	−0.257*	−0.168*	0.024	0.079	1.000
Cosmic engine	0.095	−0.045	−0.213*	−0.045	0.042	−0.058	1.000

Interest Interest value of the module, *perfperc* performance perceptions for the module, *sexstereo* sex-stereotyped attitudes to the module, *utility* utility value of the module, *engage* sustained engagement with the module, *choicein* sustained intention to choose further physics

*$p<0.05$, significant

Topics in relation to astrophysics (similar to *cosmic engine* in this study) are generally preferred by female students (Angell et al. 2004). It is notable that although females in the present study reported high interest in the cosmic engine, their interest was not higher than that of males. It is speculated that girls express a relatively higher interest in natural phenomena, especially those that are perceived by the senses (Hoffmann 2002), and this may explain the result for the waves module, where females reported higher interest than males.

These findings suggest that for females who have already chosen to study physics, the interest value of the module is independent of the gender stereotype. This finding has major implications for physics educational research, theory and practice. It suggests that once girls are involved in studying physics, their levels of interest could be higher or at least equivalent to the levels of interest shown by their male classmates.

Difference of Degree for Performance Perceptions (perfperc) Relevant literature suggests that females generally report lower expectations for success than males for physics (e.g. Barmby and Defty 2006; Lyons and Quinn 2010). Interestingly, the results from the present study show that no statistically significant differences in *perfperc* exist between males and females for any one of the four modules.

Motion (equivalent to the mechanics topic in relevant literature) is traditionally regarded as a topic in which females are less competent than males (Murphy and Whitelegg 2006). However, the females in the current study did not concur with this observation. They exhibited the same levels of confidence and rated their abilities in physics as equal to that of males, demonstrating that the levels of *perfperc* in specific physics modules do not vary by gender.

This finding has significant implications for educational practitioners. Some studies report that teachers express gender-biased views of students' competence in certain physics topics (Elwood and Comber 1996), but in this study male and female senior secondary students considered themselves to be equally competent. The Pygmalion effect has shown that low teacher expectations can negatively affect students' academic performance (Rosenthal and Jacobson 1968). Therefore, it is important for practitioners to avoid these gender-biased expectancies, especially since girls rated themselves equally as competent as their male counterparts. In support of these studies on module-specific performance perceptions, the current investigation highlights the need for educational practitioners to recognise the equal expectations of success that male and female students have in physics classrooms.

Difference of Degree for Sex-Stereotyped Attitudes (sexstereo) Given the substantial support for previous research findings, that physics is generally perceived as a male domain and that it is unusual for females to succeed in it (e.g. Seymour 1995), the results of this study have implications for researchers and practitioners. Specifically, the results indicate that the participating females demonstrated significantly less *sexstereo* for all physics modules than their male counterparts. They did not conform to gender-stereotyped views of physics, such as males can perform better than females in physics modules, males are more capable of doing physics than females, or males are naturally more interested in physics topics than females. This demonstrated that females already taking part in specialist physics classes do not share the prevailing stereotype of physics education—that they are less suited to studying physics.

It should be noted that the females involved in the current study represent a special group because they have already made a choice to participate in a stereotypically masculine domain, and therefore, different from girls who have participated in the majority of previous research studies. It should also be noted that the results of this study further demonstrate that male students also did not concur with the asserted 'masculinity' of physics across the modules (see Table 3). However, it was females who objected to such views quite vehemently.

Difference of Degree for Utility Value (utility) Students consider physics to be a subject with high utility value for their future careers and study plans, and this utility value has been identified in past studies as the largest predictor of enrolment plans (e.g. Barnes 1999; Hollins et al. 2006; Woods 2008). However, the module-specific utility and gender gap in the perceived value has not been explored in great detail before.

In this investigation, participants reported near- or above-average utility for the four modules and the results did not demonstrate any statistically significant differences in the degree in the module-specific utility for three of the four physics modules. The only exception was the motion module, to which females attached a statistically significantly lower utility for their future study and career plans than males did. This finding is consistent with Osborne and Collins' (2000) study results that girls generally found this particular topic to be less relevant to them. Motion is a module that has high practical relevance in the everyday life of an individual, yet it is evident that females do not perceive this in the classroom. It is notable that females' *perfperc* and *interest* for this module were equal to that of males. Educational practitioners should be alerted to the need to make this module more relevant to female students by elucidating its applications to everyday life and making the learning experiences more personally meaningful and relevant.

Difference of Degree for Sustained Engagement with Physics (engage) Participants reported high levels of engagement (engage) across the four physics modules, and no statistically significant gender differences of degree in the rate of engage level of engagement were reported for any module. Past research on gender differences for sustained engagement with physics is sparse; focus on module-specific engagement is even sparser. From the results of this study, appears that for students who have elected to study physics, levels of engagement with the subject do not represent a gender difference in degree.

Difference of Degree for Sustained Enrolment Intention in Further Physics (choicein) Across the four modules, participants reported high levels of *choicein* for physics. While for three of the four modules (electricity, motion and cosmic engine), gender differences were not found for further enrolment plans in physics, females expressed statistically significantly lower intentions to continue with physics at the completion of the first physics module, namely waves.

The difference of *degree* in female students' intentions to continue with physics at the completion of the waves module was a puzzling finding given the high values for the corresponding precursor variables. With higher *interest* than males for this module, lower *sexstereo* and equal rates of *perfperc* and *utility* to that reported by males, it was expected that females would express equal or even higher intentions than males to continue with physics after this module. Waves were delivered as the first module of the year 11 curricula in the majority of the participating schools. This suggests that female students may have been unsure about continuing with physics in the initial stages of year 11, although they had a high degree of *expectancies* and *values* in relation to the subject. Thus, an issue that requires further exploration is whether girls' entry into this traditionally male domain is accompanied by an initial uncertainty, so that the assurance and interest that appear to come through in later modules are not there at first. Through additional, qualitative study, this could be investigated.

Conclusion

This study extends the current understanding about the gender differences in major motivational constructs and engagement with physics once students commence studying the subject. At a sensitive module-specific level, these differences did not represent a difference of *kind*, but rather a difference in *degree* to which males and females are motivated across the physics modules. These differences were not in favour for males. The findings have substantive implications for educational researchers and practitioners and can prevent teachers from making false evaluations that lead to gender-differentiated expectations and classroom practices.

Appendix

Subscales and items of PMQ

Numerical identifier on PMQ	Item	Coefficient Alpha
Interest value subscale		
6	This module was more interesting to me than other modules	Waves=0.832
11	I have a real desire to study more about this module	Electricity=0.884
16	I look forward to learning more about this module	Motion=0.874
26	I am interested in learning more about this module	Cosmic engine=0.909
31	This was a fun module and I was really into it	
Utility value subscale		
10	This module is a great module for my career interests	Waves=0.842
20	Knowing this module well would be helpful to do well in the course I want to do at Uni/TAFE	Electricity=0.759 Motion=0.785
30	Knowing this module would be very useful if you want to get a good job	Cosmic engine=0.841
Performance perceptions subscale		
3	I know I am able to do well in this module	Waves=0.858
8	I know that my classmates regard me as being capable in this module	Electricity=0.850 Motion=0.887
13	Compared to the majority of students in my class, I found this module easy	Cosmic engine=0.865
18	I was very good at this module	
32	I am happy with my performance in this module	
Sex-stereotyped attitudes subscale		
4	I think this module was more useful for boys than for girls	Waves=0.832
14	I think this was a module for boys	Electricity=0.926 Motion=0.934
19	I think boys can perform better than girls in this module	Cosmic engine=0.934
24	I think this module was more interesting for boys than for girls	
29	The activities associated with this module were more relevant to the life experiences of boys than that of girls	
Sustained engagement subscale		
2	I would like to continue physics to Year 12 if the other modules are similar to this one	Waves=0.745 Electricity=0.702
17	If I have a chance, I would drop physics from my curriculum	Motion=0.770 Cosmic engine=0.718
22	I think I made a wrong decision choosing physics	
Sustained enrolment intentions subscale		
33	I do not want to continue physics to Year 12	0.98**

**Estimated value

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