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Adolescents' Intentions to Study Science: the Role of Classroom-based Social Support, Task Values, and Self-efficacy

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Abstract
Declining enrolments in senior secondary science have heightened concerns for meeting the demands for more STEM-qualified workers and a scientifically literate society. Students' attitudes to science are formed during schooling, particularly in adolescence when they are exposed to a variety of science topics. Students' perceptions of their ability in science and their subjective task values are well established as predictors of their likelihood of engaging with and continuing their study of science. However, the role of classroom-based social support in supporting ability perceptions and task values is less well understood. In this study, we examined relationships between adolescents' perceived classroom-based social support, task values, and self-efficacy, and how these perceptions and attitudes predicted adolescents' intentions to study the three major science subjects (biology, chemistry, and physics) in senior high school. Participants were 475 adolescents in Grades 8 to 10 recruited from six schools in Sydney, Australia. Structural equation modelling was employed to test the hypothesised model in which social support from science teachers and peers predicted intended science subject selections through science self-efficacy, intrinsic valuing of science, and utility value of science. Results indicate that science teacher and peer support were not directly related to adolescents' intentions to study senior science subjects. Instead, they were indirectly related via their positive relationship with science self-efficacy and task values. Utility value was the strongest predictor of adolescents' intentions to study biology, chemistry, and physics, while self-efficacy and intrinsic value also predicted adolescents' intentions to study chemistry. These results suggest that classroom-based social supports are important for supporting adolescents' attitudes towards science, and that science utility value interventions may be useful in efforts to improve enrolments in senior science subjects.

Keywords Intrinsic value · Utility value · Science education · Self-efficacy · Social support

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During the last two decades, concerns have been raised about the declining numbers of secondary students participating in science, technology, engineering, and mathematics (STEM) subjects (Kennedy et al., 2014; Office of the Chief Scientist, 2016). These concerns are driven by employer demand for STEM graduates with the skills to think critically and solve complex problems (Deloitte Access Economics, 2014; OECD, 2016; PwC, 2015). Alongside predicted shortages of STEM specialists, there are also post-pandemic calls to strengthen the scientific literacy of the general population (Nguyen & Catalan, 2020) as 'we struggle against the denial of scientific knowledge and actively fight misinformation' (UNESCO, 2020, p. 6). It is imperative, therefore, that we investigate ways to make science subjects more attractive to students in secondary school so that they are motivated to enrol in these subjects in their final years of secondary school.

A range of factors have been identified as being related to student participation in science subjects with those with similar prior achievement and motivational profiles tending to pursue STEM studies (Edwards et al., 2023). Expectancy-value theory (EVT) is a commonly used theoretical framework for examining factors relating to STEM participation, with previous research finding that students who are doing well in STEM subjects are more likely to continue to study them in post-compulsory years, and attitudes towards STEM subjects (utility value, self-concept, self-efficacy, enjoyment and interest) are powerful predictors of subsequent subject enrolments (Jeffries et al., 2020; Marsh et al., 2019). There is also evidence that students who receive greater support from parents, peers, and teachers in relation to STEM subjects have more positive attitudes towards science and mathematics (Li et al., 2021; Rice et al., 2013). Questions remain, however, as to whether science classroom-based social supports are directly related to adolescents' science subject selections, or if this relationship is mediated by adolescents' attitudes towards science. Our purpose in this study was to examine these potential relationships.

Social Support in Science Classrooms

Research focusing on social support conceptualises support in three ways: perceived social support, support seeking, and enacted social support (Chu et al., 2010). Perceived support is the perception that support is available if needed, while support seeking refers to the behaviour of turning to others for help. Enacted support focuses on the actual supportive behaviour and can include providing or receiving support. In a meta-analysis of the relationships between social support and wellbeing in children and adolescents, Chu et al. (2010) concluded that perceived social support was the most important type of support for positive wellbeing. In another meta-analysis of studies investigating the relationship between perceived teacher support, student engagement, and academic achievement, Tao et al. (2022) found a positive relationship between students' perceptions of teacher support and student achievement, with a small to medium effect size. This was mediated by student engagement, with students' perceived teacher support positively predicting student engagement, which in turn predicted their academic achievement. These bodies of literature strongly suggest that adolescent perceptions of support are important for academic functioning, wellbeing, and engagement in school.

In the context of learning science at school, there are two key classroom-based social support providers that students may perceive as supportive: science teachers and their peers. Teachers can support learning through their pedagogical practices and in the way that they interact with students (Dietrich et al., 2015). Perceived social support from teachers is generally related to positive outcomes, reflecting the importance of assistance and encouragement from teachers for adolescents (Aldrup et al., 2018). Unsurprisingly, perceived teacher support in science has been found to be positively related to science achievement, engagement, and self-efficacy (Chi et al., 2018; Ganotice & King, 2014; Rice et al., 2013).

On the other hand, peer support can include encouragement, shared interest in science, inclusion in group work, and instrumental or informational assistance (Malecki et al., 2000; Rice et al., 2013). Peers are a fundamental source of support during the adolescent years, reflecting the increased importance adolescents place on peer relationships during this period (Albert et al., 2013). It is therefore unsurprising that perceived support from peers in science is related to higher science self-efficacy, engagement, and achievement (Ganotice & King, 2014; Rice et al., 2013). Peer support may also be particularly critical in science given the importance of collaboration in developing science understanding and literacy (Osborne, 2010), with previous research suggesting students with high social anxiety experience less peer support and poorer achievement in science (Scanlon et al., 2020). Despite the potential importance of peers in science classrooms, there is comparatively less research that focuses on the role of peer support in adolescents' attitudes towards learning in science compared with teacher support.

While teacher and peer support in science is theoretically and empirically linked with positive educational outcomes (Rice et al., 2013), the role of social support in influencing science subject selections is less well-established. Previous research has found that advice from teachers and peers is significantly less important than expectancies and values in adolescents' choices to study science in the senior years of high school (Palmer et al., 2017). However, we were unable to locate any studies that have examined whether perceived social support from teachers and peers has a direct impact on adolescents' decisions to continue studying science. An alternative possibility is that social support influences science attitudes, which in turn may guide subject selections.

Expectancy-value Theory

EVT is widely used in the motivational psychology literature to understand young people's educational choices and performance. The theory posits an individual's motivation to engage in task-directed behaviour is predicted by subjective task values or the value placed on the task by the individual, and ability beliefs or the individual's expected success in the task (Eccles, 2005; Wigfield & Eccles, 2000). Socialisers also play a key role in influencing an individual's attitudes and ability beliefs (Wigfield & Eccles, 2000). While EVT contains many theoretical constructs, among the most frequently used in STEM education research are intrinsic value, utility value, and ability beliefs. Intrinsic value and utility value are subjective task values, while ability beliefs are commonly operationalised as self-efficacy, self-concept, or confidence (Berger et al., 2020).

A significant body of research has used EVT to investigate adolescents' educational and career choices in the STEM disciplines (for example, see Fredricks & Eccles, 2002; Watt et al., 2019). In a recent meta-analysis, Parker et al. (2020) found that gender differences are common, but that the differences vary across the STEM disciplines. Furthermore, Parker et al., (2020) found that when science is operationalised as a single subject, there are inconsistent findings about the relative importance of EVT components for the genders. This inconsistency is likely due to the combination of multiple science domains into a single subject area (Berger et al., 2020). In this paper, we examine the EVT components of intrinsic value, utility value, and self-efficacy in the science domains of biology, chemistry, and physics.

Intrinsic Value

A person's intrinsic value for a task is a measure of their enjoyment and interest in that task (Eccles, 2005). Enjoyment of science is related to young people's intentions to continue studying the subject and aspirations for science-related careers (Ainley & Ainley, 2011a, b; Guo et al., 2017). Enjoyment of science also operates as a mediator between other variables. For instance, science enjoyment mediates the relationship between science knowledge and intentions to study science (Ainley & Ainley, 2011b). In other words, students with strong content knowledge may disengage from science if they do not enjoy learning it. Enjoyment also mediates the relationship between self-concept and science career aspirations (Guo et al., 2017). Students with high science self-concept are less likely to aspire to science careers if their enjoyment of science is low (Guo et al., 2017). Interesting findings emerge from studies which include gender, with some studies showing that girls enjoy science less than boys (Riegle-Crumb et al., 2011), but that intrinsic value is not significantly related to girl's academic achievement in science (DeBacker & Nelson, 1999).

Utility Value

Utility value is a measure of an individual's perceptions of task usefulness (Wigfield & Eccles, 2000). In studies of science, utility value frequently is operationalised as measuring perceived usefulness to future work and lives. Adolescents who value the role of science are more likely to engage in science learning, express aspirations for further study in the sciences, enjoy learning science, and display interest in science (Ainley & Ainley, 2011a). While evidence suggests there are gender differences in science utility value, the overall picture is unclear. For instance, while Else-Quest et al. (2013) reported that adolescent girls valued science *more* than boys, George (2006) reported that girls valued science *less* than boys. Furthermore, George (2006) found that while science utility value increased during secondary school, the increase for girls was smaller than it was for boys.

Self-efficacy

Self-efficacy measures an individual's beliefs about competence and expectations of success in a task (Wigfield & Eccles, 2000). In science, self-efficacy is associated with science career aspirations (Nagengast & Marsh, 2012) and academic achievement (Marsh & Martin, 2011), with a stronger association between self-efficacy and science achievement in comparison to intrinsic and utility values noted in one large international study (Liou, 2017). Self-efficacy has also been found to have a positive association with adolescents' intentions to continue studying science (Mackenzie et al., 2021; Patrick et al., 2010). As with utility value, there are inconsistent findings with regards to gender differences in self-efficacy and the association with other variables and outcomes. Some studies have found that boys have higher science self-efficacy than girls (Sikora & Pokropek, 2012) while others have found no gender differences (Louis & Mistele, 2012). However, the treatment of science as a monolithic domain may be playing a role in these findings, with Jansen et al.

(2015) noting that adolescent boys had higher self-efficacy in physics and chemistry than girls, while there were no differences in biology.

A significant body of research has investigated the extent to which different EVT constructs can be targeted by intervention to improve adolescents' attitudes towards STEM subjects (for reviews, see Rosenzweig et al., 2022; Rosenzweig & Wigfield, 2016). Most of these interventions have been targeted at utility value because it is seen as the most amenable to change (Hulleman et al., 2010). Utility value interventions typically emphasise to students or their parents, or have them reflect on, the usefulness of STEM subjects and content for their personal lives (Harackiewicz et al., 2016). These interventions have been shown to have a variety of positive outcomes for a range of disadvantaged students or those at risk of dropping out of the STEM pipeline (Rosenzweig et al., 2022). In contrast to the significant body of research into utility value interventions, relatively little work has targeted other aspects of EVT which are a focus of this paper, such as intrinsic value.

In sum, previous research examining the role of science values and expectancies in predicting adolescents' participation in science suggests that intrinsic and utility value, as well as self-efficacy are important predictors of adolescents' decisions to continue studying science after it is no longer a compulsory subject. However, the relative importance of these attitudes appears to vary in different populations. EVT provides a wider theoretical framework that can be used to investigate why these differences emerge, which includes the role of socialisers' beliefs and behaviours (and the child's perception of these) in shaping adolescents' expectancies and values for science (Wigfield & Eccles, 2000).

Social Support, Self-efficacy, and Task Values

Classroom-based social supports can provide students with informational resources, feedback, and encouragement (Malecki & Demaray, 2006), laying a solid foundation for adolescents to develop positive attitudes towards learning, and themselves as learners. In support of this, previous research has found that a combination of teacher, peer, and parent support for science is positively related to both science self-efficacy and attitudes towards science for male and female adolescents (Rice et al., 2013). While these findings suggest that perceived support from multiple providers is important for adolescents' science values and self-efficacy, the question remains whether there is variation in the relative importance of support from teachers or peers and whether these supports differ in their importance for studying different science subjects.

Three studies were located that have investigated how perceived support from teachers and peers in science (separately) are related to adolescents' science expectancies and values. In a study of Latino students in Grade 9, perceived support from science teachers was positively related to science self-concept, intrinsic value, and utility value (Hsieh et al., 2019). In the same study, perceived support from friends for science was related to self-concept and utility value, but not intrinsic value. In another study, Chinese high school students' self-efficacy and interest in chemistry was found to be positively predicted by perceived support from both teachers and peers (Huangfu et al., 2023). Finally, Leaper et al. (2012) found that peer support for science was positively related to girls' science motivation (a combined measure of self-concept, intrinsic value, and utility value) in an ethnically diverse sample from North America. Taken together, these studies suggest that teacher and peer support are important for science expectancies and values, but also highlight the relatively limited body of literature which has focused on the role of classroom-based social support in adolescents' science motivation. For example, while teacher support appears to be positively related to self-concept and intrinsic value (Hsieh et al., 2019; Huangfu et al., 2023) only Hsieh et al. (2019) have examined the relationship between teacher support and utility value specifically. There are also conflicting findings regarding the role of peer support, as peer support was not related to intrinsic value of science in one study (Hsieh et al., 2019) but was positively related to interest in chemistry in another (Huangfu et al., 2023). These conflicting findings may be due to measurement or cultural differences, but in any case, point to a need for further examination of the role of classroom-based social supports in science motivation.

The Current Study

The current study sought to address some of the present gaps in understanding about the role that classroom-based social supports play in adolescents' science subject selections. As previous research has shown that adolescents' attitudes can differentially predict their intentions to study each science subject (Jansen et al., 2014; Mackenzie et al., 2021), we considered adolescents' intentions to study biology, chemistry, and physics in the senior years of high school (after science study is no longer compulsory). Specifically, we sought to address the following research questions:

(i) How do classroom-based social supports predict adolescents' intended science (biology, chemistry, physics) subject selections?
(ii) What is the relationship between science classroom-based social supports and adolescents' science task values and self-efficacy?
(iii) How do science task values (utility and intrinsic value) and self-efficacy predict adolescents' intended science subject selections for the three sciences (biology, chemistry, physics)?

Our hypothesised model (see Fig. 1) included social support from science teachers and peers as predictors of intended science (biology, chemistry, and physics) subject selections through science self-efficacy, intrinsic valuing of science, and utility value of science. We

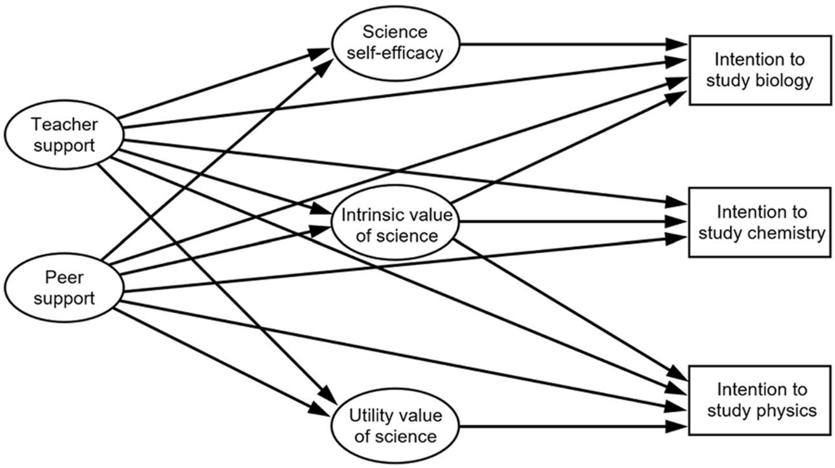

Fig. 1 Hypothesised structural model

also included direct paths between social supports and intended subject selections. Given the potential for gender differences in adolescents' expectancies and values in science (e.g., Else-Quest et al., 2013; Jansen et al., 2014; Riegle-Crumb et al., 2011) we included gender as a covariate in our hypothesised model.

Method

Participants

The study participants were 475 high school students (332 female, 141 male, 2 non-binary) aged between 12 to 16 years ($M = 14.61$, $SD = 0.97$), drawn from six independent high schools located in NSW, Australia. All schools were fee-paying schools, with a mean Index of Community Socio-Educational Advantage approximately one standard deviation above the median for Australian schools (Australian Curriculum, Assessment and Reporting Authority, 2015). Of the six schools, five were single-sex (four girls' schools, one boys' school) and one was co-educational. As a result, females were overrepresented in this study (332 female, 141 male, 2 non-binary). The sample consisted of 180 students in Grade 8 (37.9%), 137 students in Grade 9 (28.9%), and 158 students in Grade 10 (33.2%). These grades represent the second to fourth year of high school in Australia. In terms of social background, 34.3% spoke a language other than English at home, 12% were born in a country other than Australia, and 82.7% had at least one university-educated parent. Aboriginal or Torres Strait Islander students made up 0.6% of participants.

Measures

Classroom-based Social Support

Perceived support from science teachers and peers was measured by adapting the Child and Adolescent Social Support Scale (CASSS; Malecki et al., 2000). The CASSS was developed and validated for middle to late adolescents and enables the measurement of perceived social support from various support providers (Malecki & Demaray, 2002). The teacher support subscale included eight items (sample item: "My science teacher(s) makes it okay to ask questions"). The peer support subscale also included eight items (sample item: "My science classmates give me ideas when I don't know what to do"). Students were asked to identify how often they received the support identified in each item on a scale ranging from 1 (never) to 6 (always). Both subscales demonstrated excellent reliability ($\alpha_{teacher} = 0.94$, $\Omega_{teacher} = 0.94$, $\alpha_{peer} = 0.94$, $\Omega_{peer} = 0.94$).

Intrinsic Value of Science

Intrinsic value of science was measured using the science enjoyment items implemented in the Trends in International Mathematics and Science Study (TIMSS) 2019 Context Questionnaire. This scale demonstrated excellent reliability in the TIMSS 2019 Australian Grade 8 sample ($\alpha = 0.93$) (Yin & Fishbein, 2020). The enjoyment of science subscale included nine items (sample item: "I look forward to learning science in school"). Students were asked to identify the extent to which they agreed with each statement on a scale from 1 (disagree a lot) to 4 (agree a lot). Two items were negatively valanced: "I wish I did not have to study science" and "Science is boring". Responses to these items were reverse coded. The reliability of the intrinsic value of science subscale was excellent, $\alpha = 0.93$, $\Omega = 0.93$.

Utility Value of Science

Utility value of science was measured using the science valuing items implemented in the TIMSS 2019 Context Questionnaire. This scale demonstrated excellent reliability in the TIMSS 2019 Australian Grade 8 sample ($\alpha = 0.94$) (Yin & Fishbein, 2020). The valuing of science subscale also included nine items (sample item: "I need to do well in science to get the job I want"). Students were asked to identify the extent to which they agreed with each statement on a scale from 1 (disagree a lot) to 4 (agree a lot). The reliability of the utility value of science subscale was excellent, $\alpha = 0.93$, $\Omega = 0.93$.

Self-efficacy in Science Subjects

Students' self-efficacy regarding their ability to learn biology, chemistry, and physics were measured using a scale designed for this study, using Bandura's (2006) recommendations for measuring self-efficacy. Each subscale was designed to measure self-efficacy in each of the science subjects separately. Four items for each subject (12 items in total) were presented to students to respond on a scale from 0 (cannot do at all) to 100 (highly certain can do). Sample items include "Rate your degree of confidence to understand the ideas taught in biology" and "Rate your degree of confidence to complete work in chemistry on my own". The three self-efficacy subscales demonstrated excellent reliability ($\alpha_{biology} = 0.94$, $\Omega_{biology} = 0.94$, $\alpha_{chemistry} = 0.95$, $\Omega_{chemistry} = 0.95$, $\alpha_{physics} = 0.95$, $\Omega_{physics} = 0.95$).

Intended Science Subject Selections

Students were asked to rate their intentions to study each of the three science subjects (biology, chemistry, and physics) in Years 11 and 12 on a scale from 1 (very unlikely) to 5 (very likely).

Procedure

The Human Research Ethics Committee (HREC) at Western Sydney University approved this study. Consent for school participation was received from the principal of each school. All students in Grades 8, 9, and 10 were invited to participate and parent/guardian consent for study participation was sought in writing. Student consent was also collected on the day before survey completion. The average response rate across the schools was 15.6%. Participants completed a 25-min online survey administered during class time.

Analysis Strategy

Analyses were conducted using SPSS 29 and MPlus 8.9 (Muthén & Muthén, 2022). Missing data were observed for 17 (3.5%) participants. One case was excluded from the analysis due to missing data for all variables except gender. Varying degrees of missing data were observed for the other 16 participants, which was accounted for using the default full-information maximum likelihood estimator in MPlus. Measurement models were tested for all latent variables and modifications were undertaken to ensure good model fit by examining content validity of items and modification indices. The structural model was then tested to examine hypothesised relationships. Criteria used to determine model fit were comparative fit index (CFI) and Tucker-Lewis index (TLI) greater than 0.95 (acceptable between 0.90 and 0.95), root mean square error of approximation (RMSEA) less than 0.05 (acceptable less than 0.08), and standardised root mean square residual (SRMR) less than 0.08 (Hu & Bentler, 1999).

Measurement Models

A single factor congeneric model was tested for each of the latent variables to be included in the structural model. None of these models provided an acceptable fit using the items originally intended to measure the latent variable. Inspection of face validity of items in conjunction with identification of items with high modification indices was used to determine items for deletion until acceptable model fit was achieved for each latent factor. The items deleted and rationale for their deletion is detailed in the Supplementary Material, as are the individual item factor loadings for each latent factor. Final model fit statistics for each of the measurement models are provided in Table 1.

A full measurement model was tested to examine the factor structure of the latent variables to be included in the structural model. This model fit the data well, RMSEA = 0.05, SRMR = 0.04, TLI = 0.96, CFI = 0.96, $\chi^2 = 797.32$, $df = 356$, $p = 0.00$, AIC = 54880.42, BIC = 55329.37. While self-efficacy in biology, chemistry, and physics was measured separately, we also tested whether these individual science self-efficacy scores were better represented by a higher order science self-efficacy factor, given that students learn science in Australia as a single subject. The full measurement model with a higher order science self-efficacy factor also fit the data well, with very similar fit statistics to the initial measurement model, RMSEA = 0.05, SRMR = 0.04, TLI = 0.96, CFI = 0.96, $\chi^2 = 838.46$, $df = 370$, $p = 0.00$, AIC = 54893.56, BIC = 55284.32.

Table 1 Fit statistics of measurement models and scale reliabilities

Model	RMSEA	SRMR	TLI	CFI	χ^2	*df*	*p*	α	Ω
Self-efficacy in biology	0.09^	0.05	0.99	1.00	4.69	1	0.03	0.94	0.94
Self-efficacy in chemistry	0.04	0.02	0.99	1.00	1.71	1	0.19	0.95	0.95
Self-efficacy in physics	0.06	0.03	1.00	1.00	2.71	1	0.10	0.95	0.95
Intrinsic value in science	0.08	0.02	0.98	0.99	19.40	5	0.00	0.89	0.90
Utility value in science	0.08	0.02	0.98	0.99	20.99	5	0.00	0.90	0.90
PSS science teacher	0.06	0.02	0.99	0.99	24.22	9	0.00	0.92	0.92
PSS science peers	0.06	0.01	0.99	1.00	5.25	2	0.07	0.88	0.88

χ^2 chi-square; *df* Degrees of freedom; *CFI* Comparative Fit and Index; *TLI* Tucker-Lewis Index; *RMSEA* Root Mean Square Error of Approximation; *SRMR* Standardised Root Mean Squared Residual; ^ while the RMSEA is larger than the usual acceptable cut-off, Kenny et al. (2015) suggest that RMSEA should not be interpreted as indicating poor model fit for models with a small degree of freedom

Results

Descriptive Statistics

Descriptive statistics of latent and observed variables are shown in Table 2 and correlations between latent and observed variables are shown in Table 3. Potential gender differences between male and female samples were examined for each variable using a series of independent samples t-tests, with an adjusted alpha of 0.005 to account for multiple comparisons. The only significant gender differences were that female students ($M = 3.62$, $SD = 1.31$) were more likely to intend to study biology than male students ($M = 3.09$, $SD = 1.40$), $t(455) = 3.93$, $p < 0.001$, and that male students ($M = 3.19$, $SD = 1.38$) were more likely to intend to study physics than female students ($M = 2.63$, $SD = 1.31$), $t(455) = 4.20$, $p < 0.001$.

Correlations between the latent and observed variables are shown in Table 3. Intentions to study the three sciences were significantly related to all latent variables, except for perceived social support from science peers (biology and physics). Intentions to study each of the sciences were also correlated with each another, however the correlation between intentions to study biology and physics was only marginally significant ($p = 0.05$).

Structural Model

The hypothesised structural model (Fig. 2), in which perceived science classroom social supports predict science expectancies and values, which in turn predict intended science subject selections, provided a good fit for the data (RMSEA = 0.06, SRMR = 0.08, TLI = 0.93, CFI = 0.94, $\chi^2 = 1271.97$, $df = 467$, $p = 0.00$, AIC = 59127.03, BIC = 59646.65). Gender was also included in the model as a covariate.

Gender was directly related to students' intentions to study biology (favouring girls, $\beta = 0.13$, $p = 0.001$) and physics (favouring boys, $\beta = -0.19$, $p < 0.001$). Boys reported lower perceptions of science teacher support ($\beta = -0.11$, $p = 0.03$), but there were no significant relationships between gender and EVT variables.

Table 2 Descriptive statistics of latent and observed variables

Variables	*M*	*SD*	Range	Skewness	Kurtosis
Self-efficacy in biology	75.24	21.26	99.00	-1.17	1.22
Self-efficacy in chemistry	69.49	23.32	100.00	-0.87	0.26
Self-efficacy in physics	65.75	24.54	100.00	-0.69	-0.14
Science self-efficacy	70.21	20.50	99.67	-0.86	0.60
Intrinsic value in science	3.13	0.76	3.00	-0.73	-0.15
Utility value in science	3.02	0.80	3.00	-0.77	-0.06
PSS science teacher	4.93	1.02	4.50	-0.85	-0.06
PSS science peers	4.70	1.06	5.00	-0.50	-0.56
Intention to study biology	3.45	1.36	4.00	-0.45	-0.98
Intention to study chemistry	3.18	1.37	4.00	-0.20	-1.15
Intention to study physics	2.80	1.35	4.00	0.19	-1.12

M Mean; *SD* Standard deviation; *PSS* Perceived social support

Table 3 Correlations between latent and observed variables

Variables	1	2	3	4	5	6	7	8	9	10
1. Self-efficacy in biology	-									
2. Self-efficacy in chemistry	0.72**	-								
3. Self-efficacy in physics	0.63**	0.73**	-							
4. Science self-efficacy	0.87**	0.92**	0.89**	-						
5. Intrinsic value in science	0.55**	0.58**	0.49**	0.60**	-					
6. Utility value in science	0.52**	0.52**	0.45**	0.55**	0.78**	-				
7. PSS science teacher	0.23**	0.28**	0.29**	0.30**	0.39**	0.28**	-			
8. PSS science peers	0.23**	0.20**	0.23**	0.25**	0.19**	0.18**	0.34**	-		
9. Intention to study biology	0.45**	0.24**	0.16**	0.31**	0.52**	0.55**	0.16**	0.09	-	
10. Intention to study chemistry	0.31**	0.55**	0.37**	0.46**	0.57**	0.58**	0.24**	0.10*	0.44**	-
11. Intention to study physics	0.13**	0.29**	0.45**	0.33**	0.35**	0.40**	0.18**	0.07	0.09*	0.48**

* Significant at the 0.05 level (2 tailed); ** Significant at the 0.01 level (2 tailed)

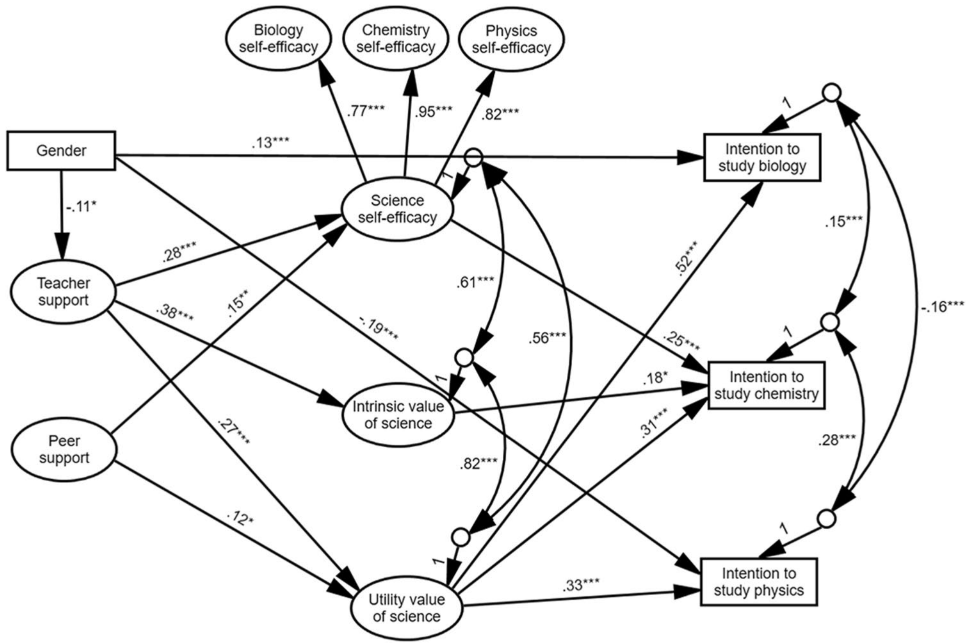

Fig. 2 Structural model including standardised path coefficients for significant paths. Uniquenesses and indicators are omitted for clarity; *significant at the 0.05 level (2-tailed); **significant at the 0.01 level (2-tailed); ***significant at the 0.001 level

When controlling for gender, perceived support from science teachers was positively related to all three EVT variables, which suggests that students who view their science teachers as supportive had higher science self-efficacy (β = 0.28, $p < 0.001$) and held higher intrinsic (β = 0.38, $p < 0.001$) and utility values (β = 0.27, $p < 0.001$) of science. Perceived support from peers in science was positively related to science self-efficacy (β = 0.15, $p = 0.004$) and science utility value (β = 0.12, $p = 0.03$). However, neither of these science classroom-based sources of support was directly related to intentions to study any of the sciences.

Of the three EVT variables, utility value was the most consistent predictor of students' intentions to study the three sciences in the senior years of high school. Utility value had the strongest positive relationship with intentions to study biology (β = 0.52, $p < 0.001$), followed by physics (β = 0.33, $p < 0.001$), and chemistry (β = 0.31, $p < 0.001$). Science self-efficacy (β = 0.25, $p < 0.001$) and intrinsic value of science (β = 0.18, $p = 0.05$) were positively related to students' intentions to study chemistry, but not biology or physics.

An alternate structural model, in which no higher order science self-efficacy factor was included, was also tested. This model did not fit the data well (RMSEA = 0.07, SRMR = 0.16, TLI = 0.89, CFI = 0.91, $\chi^2 = 1612.45$, $df = 448$, $p = 0.00$, AIC = 59505.51, BIC = 60104.11), confirming that the higher order science self-efficacy factor was required to achieve good model fit.

Discussion

The proportion of upper secondary students choosing to study STEM subjects has been declining internationally over the recent decades and in Australia, a National STEM School Education Strategy 2016–2026 (Education Council, 2015) was developed to address the issue. The strategy recognises the need to support student engagement and participation in science through a range of strategies including increasing the perceived relevance of STEM subjects, opportunities for students to work collaboratively in STEM lessons and the capacity of teachers to support student learning in STEM. The strategy also emphasised the need to build a stronger evidence base to improve our understanding of effective STEM education practices. In this study we add to this evidence through an investigation of student perceptions of levels of classroom-based support, science self-efficacy, subjective task values, and their likelihood of studying physics, chemistry, or biology in upper secondary school.

One of our research aims was to examine whether classroom-based social supports directly or indirectly predicted adolescents' intended science subject selections. We did not find any significant direct paths between perceived support from science teachers or peers and intentions to study any of the science subjects. Instead, these classroom-based social supports appear to indirectly influence intentions to study science through their significant and positive relationships with adolescents' science self-efficacy and values. Students who reported higher levels of support from their science teachers also experienced higher levels of science self-efficacy (small effect size, β = 0.28), intrinsic value (medium effect size, β = 0.38), and utility value (small effect size, β = 0.27). In contrast, those who experienced higher levels of peer support reported greater science self-efficacy (small effect size, β = 0.15) and utility value (small effect size, β = 0.12). These findings align with those of previous studies (Hsieh et al., 2019; Rice et al., 2013) and confirm the important role of classroom socialisers in adolescents' science attitudes (Wigfield & Eccles, 2000). They also suggest that teacher support is more important than peer support in predicting adolescents' attitudes in science. Particularly noteworthy was the moderate effect of teacher support on intrinsic value, which highlights the key role that teachers play in supporting students to view science and enjoyable and interesting.

This study was also designed to explore whether science task values and self-efficacy differentially predict adolescents' intended science subject selections. Utility value was the strongest predictor of intentions to study all sciences, with a strong effect on intentions to study biology ($\beta = 0.52$), and moderate effects on intentions to study chemistry ($\beta = 0.31$) and physics ($\beta = 0.33$). This finding suggests that interventions designed to increase adolescents' uptake of senior science subjects should focus on increasing adolescents' perceptions of the relevance and importance of science for their present and future lives. Given that low-cost utility value interventions have a reasonably strong track record of improving outcomes in STEM (Rosenzweig & Wigfield, 2016), we advocate for these strategies to be implemented across all grades in secondary schools. Similarly, there are opportunities for science teacher education programs to educate pre-service teachers about the impact of utility value on adolescents' intended participation in science and examine practical strategies for demonstrating the relevance of science to their students.

As in previous studies, we also found that there were differences in how science attitudes predicted adolescents' intentions to study the three sciences (Jansen et al., 2014; Mackenzie et al., 2021). Our findings indicate that science self-efficacy and intrinsic value played more minor, but still significant, roles in predicting adolescents' intentions to study chemistry. Interestingly, self-efficacy and intrinsic value were not significantly related to intentions to study biology or physics. The lack of significance between science self-efficacy and intentions to study biology and physics was surprising, given that previous research has found that self-efficacy is positively related to intentions to continue studying science (Mackenzie et al., 2021; Patrick et al., 2010). It is likely that this finding was influenced by the fact that the chemistry self-efficacy factor was more strongly related to the higher order science self-efficacy factor than biology or physics self-efficacy factors. However, we note that removing the higher order science self-efficacy factor from the model resulted in poor model fit, supporting the retention of the higher order factor in our final model. As both science self-efficacy and intrinsic value were strongly related to utility value, we argue that both remain important for supporting adolescents' participation in science. It is possible, for example, that self-efficacy and intrinsic value provide longer-term support for science participation, particularly in situations where utility value is difficult to communicate to students. Longitudinal studies will provide opportunities to examine how science task values and self-efficacy change during adolescence and can work towards identifying adaptive trajectories and strategies for supporting these in school contexts.

Our study also sought to investigate the role of gender differences in predicting adolescents' intended science subject selections. Reflecting well-established gender differences in adolescents' actual science subject selections and participation in STEM beyond secondary school (Kennedy et al., 2014; Office of the Chief Scientist, 2016), girls were more likely to intend to study biology, while boys were more likely to intend to study physics. There were no gender differences in adolescents' self-efficacy or task values in science, which aligns with some (Louis & Mistele, 2012) but not all previous research (Else-Quest et al., 2013; Riegle-Crumb et al., 2011; Sikora & Pokropek, 2012). In the final model, being male predicted lower levels of perceived teacher support, but we note that this effect was small. The lack of gender differences in science attitudes can possibly be attributed to our sample, in which female students from single sex schools were overrepresented, however we note that a previous meta-analysis found only trivial differences in outcomes for girls educated in single-sex versus co-educational schools (Pahlke et al., 2014). A small response rate from the coeducational school restricted our ability to conduct a comparative analysis based on school type, but this is a potential area of consideration for future studies.

Limitations

There are several limitations of our study to note. Our outcome variables were adolescents' *intended* science subject selections, rather than their *actual* subject selections. While we note that adolescents' intentions to study science may differ from the subjects that they actually select, we argue that their intentions are a useful indicator of current attitudes towards science. Our cross-sectional research design also does not allow for determination of the direction of effects. Longitudinal studies are needed to expand on these findings by examining developmental changes in science task values and self-efficacy during adolescence. Our sample included a larger proportion of female students and was drawn from schools at relative advantage to other Australian schools. This may limit the generalisability of our findings, and future studies should investigate whether our findings are replicated in other samples. Finally, it was not possible to collect standardised science achievement data, as this would have placed a significant time burden on participants and their schools. However, we recognise that prior achievement likely plays a significant role in adolescents' attitudes towards science, particularly science self-efficacy (Schunk & Pajares, 2002), and recommend that future studies include a measure of prior science achievement where possible.

Conclusion

Adolescents' participation in senior science subjects has declined over the past two decades (Kennedy et al., 2014), despite increased societal needs for STEM workers and a scientifically literate population (Nguyen & Catalan, 2020; OECD, 2016). It is therefore essential that we understand factors that influence adolescents' intentions to study science subjects in the senior years of high school, to enable targeted and effective intervention to increase science enrolments. In this study, we examined the role of perceived social support from science teachers and peers, science self-efficacy, and science task values, in predicting adolescents' intentions to study biology, chemistry, and physics. Our findings suggest that science classroom-based social supports were indirectly related to intentions to study science subjects via their positive relationship with science self-efficacy and task values. Utility value was a particularly important predictor of adolescents' intentions to study biology, chemistry, and physics, while self-efficacy and intrinsic value also predicted intentions to study chemistry. The implications of these findings are that classroom-based social supports are vital for encouraging adolescents' positive attitudes in science, and that science utility value interventions offer significant promise in efforts to improve enrolments in senior science subjects.

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Data Availability The data that support the findings of this study are available on request from the corresponding author.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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