

SCIENCE CHOICE AT SCHOOL: GENDER AND THE RELATIVE IMPORTANCE OF FACTORS STUDENTS CONSIDER WHEN SELECTING SUBJECTS

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Science study at school has been linked to the provision of a scientifically capable workforce and a scientifically literate society. Concern has been expressed by educators, academics and policymakers that too few students are choosing post-compulsory science at school. Gender-based preferences for some science subjects has been cited as an important factor affecting choice of science at school. A Best-Worst Scaling survey was used to measure the relative importance of 21 factors that male and female students consider when choosing and rejecting subjects. Results from 333 Year 10 (age 14–17) students suggest that male and female students choose and reject subjects in a similar manner but there are differences in the degree of importance students place on some factors. Girls considered their interest, enjoyment, past ability and type of classwork as being relatively more important than boys did when choosing subjects. Girls considered their past ability and difficulty of a subject as more important than boys did when rejecting subjects. This research indicates that overall girls and boys rank the factors for choosing and rejecting subjects in a similar manner but there are differences in the importance they place on individual factors.

Keywords: gender subject choice

INTRODUCTION

Scientifically trained individuals are needed by our society to expand our knowledge, create new and improved technologies, and investigate solutions to pressing world problems (Goodrum, Druhan, & Abbs, 2012). The study of science in the final years of school is critical in the process of training these individuals as the subject selection decisions that teenagers make influence their potential career paths (Thomson, 2005). However, when given the opportunity to choose subjects for their final years of schooling many students choose not to continue with science. For example, in Australia almost half of Year 10 (typically age 15–16) students do not choose a science subject for their final two years of schooling (Lyons & Quinn, 2010).

Extensive research has been conducted into the factors influencing students' choice of science when it becomes elective at school (e.g. Ainley, Kos, & Nicholas, 2008; Henriksen, Dillon, & Ryder, 2015; Lyons & Quinn, 2010, Regan & DeWitt, 2015). The factors commonly cited are: students' engagement in previous school science, their perceptions of science and its usefulness, socio-economic factors, the decreased relative popularity of science as a school subject and, gender preferences for some science subjects.

Understanding how students choose their subjects for their final years of school is an important step in discovering how science is valued relative to the other subjects that students can choose. This paper presents gender based findings from a broader study that aims to create new strategies to improve the uptake of science through improved understanding of how students value science and make their subject selection decisions. It addresses the research question, "What is the relative importance of the factors that male and female

students consider in choosing their subjects for their final years of school?” through analysis of gender segregated data from a Best-Worst Scaling (BWS) survey conducted with 333 Year 10 (age 14–17) students who had recently chosen their subjects for their final years of school. Further background to the results or method presented in this paper can be found in Palmer et al. (2017).

The remainder of this paper is organised into four sections. The first is a brief review of the research of gender-based choice of science at school. The second section describes the list of factors students consider when choosing their subjects used in this study and the Best-Worst Scaling (BWS) task used to quantify the relative importance of these factors. The results for the survey are then presented followed by a discussion of these results.

BACKGROUND

Gender-based preferences for some science subjects has been suggested as an important factor affecting choice of science at school (Ceci & Williams, 2007; Dobson, 2006; Kessels & Taconis, 2012). Within Australia, male and female students have differing subject choice preferences with respect to science (Ainley, Kos, & Nicholas, 2008; Kennedy, Lyons, & Quinn, 2014; Thompson, 2005). Male students appear to have a slight preference for chemistry and female students show preference for biology. With respect to physics, the gender bias towards males is significant. Further, boys consistently show more positive attitudes to school science than girls (Regan & DeWitt, 2015). Rebalancing the gender mix in some science subjects has been posed as a strategy to improve the numbers of students taking science (Quinn & Lyons, 2011).

The quest to explain why there is gender heterogeneity in students’ choice of science has made this topic the subject of many scholarly papers and books particularly with respect to the underrepresentation of girls in science. According to Regan and DeWitt (2015), important factors contributing to fewer girls choosing science are that girls consistently show less positive attitudes to science than boys and display lower self-efficacy in it. In addition they state that girls may identify science as being a “masculine” pursuit. Blickenstaff’s (2005) review of 30 years of research into the underrepresentation of women in STEM suggests that the problem is multifaceted and unsolved and he argues that genetic differences between the sexes are not the reason. He suggests that female participation may be increased by improvements in the teaching of science.

Other research has suggested that gender bias for science subjects is due to basic differences in preferences held by boys and girls rather than a specific result of teaching practices (Thomson, 2005). Females appear to prefer to work in areas that will self-evidently help people (e.g. biology and health) rather than in the enabling sciences (physics and chemistry) that are perceived as leading to non-traditional roles for women (Dobson, 2006). Wang and Degol’s (2013) review of literature on gender differences in STEM choices found that intellectual aptitudes and motivational beliefs are strong predictors of science choice at school. They noted that as girls achieve on average higher grades in mathematics and science at school and have higher verbal skills that intellectual aptitude may not be a factor in girls not choosing science. They suggest that girls’ higher verbal skill may mean that girls may choose career paths that need these skills.

A meta-analysis study on gender and science research conducted by the European Commission on gender segregation in research careers stated that a change in culture of science and research was required to encourage more women to study science (Caprile, 2012). The reasons for gender preferences for certain science subjects remains unclear and continues to be a main area of interest in science education.

METHODOLOGY

To determine the relative importance of the factors that students consider in choosing or rejecting a subject at school, a BWS survey was completed by students who were considering their subjects for their final years of schooling.

The BWS method is a well-validated technique that allows factors identified as impacting a decision-making process to be ranked according to their importance (Louviere, Finn, & Marley, 2015). The online BWS survey used in this study presented students with sets of factors believed to influence their subject selection decisions.

To generate the list of factors believed to impact subject choice, prior research was conducted in four schools in metropolitan Sydney, Australia. This included: 10 focus groups each with five upper-secondary students; interviews with 15 adult subject-selection stakeholders within schools; observations of seven subject-selection events; and a review of the literature relating to subject choice (Palmer, 2015; Palmer, Burke, & Aubusson, 2017). A list of 21 factors that students considered in their subject selection process was created and verified at a conference of science education researchers.

Consistent with the work of Shafir (1993) on choosing and rejecting choices, students in focus groups were found to use different reasoning when explaining how they chose subjects versus rejected subjects for future study. Therefore, the 21 factors for choice were presented to students in two formats relating to the differing viewpoints of choosing a subject (BWS-Choose) and rejecting a subject (BWS-Reject). Table 1 shows the list of factors and the two versions of attribute statements presented to students in the survey.

Table 1. BWS-Choose and BWS-Reject subject selection attribute statement pairs.

Grouping	Factor #	Factor title	Attribute statement for BWS-Choose	Attribute statement for BWS-Reject
Advice	1	Parent advice	My parent(s) suggested doing the subject	My parent(s) suggested not to do the subject
	2	Older peer advice	Older students or sibling suggested doing the subject	Older students or siblings suggested not to do the subject
	3	Peer advice	A friend in my year suggested doing the subject	A friend in my year suggested not doing subject
	4	Teacher advice	My teacher suggested doing the subject	My teacher suggested not to do the subject
Enjoyment and Interest	5	Interest expectation	I will find the subject interesting	I will find the subject boring
	6	Enjoyment experience	I enjoyed the subject (or similar subject) in middle school	I did not enjoy the subject (or similar subjects) in middle school
Logistics	7	Number of units ¹	I needed extra units	I had too many units
	8	Timetable fit	The subject fitted with my timetable	The subject did not fit my timetable
	9	Information	I had plenty of information about the subject	I did not have enough information about the subject
Ability (marks)	10	Ability	I got good marks in the subject (or similar subject) in middle school	I got poor marks in the subject (or similar subject) in middle school
	11	ATAR ² scaling	The subject will scale well for my ATAR	The subject will not scale well for my ATAR
	12	Mark expectation	I think I can get good marks in the subject	I think it will be hard to get good marks in the subject
Subject characteristics	13	Assessment type	I like the type of assessment	I do not like the type of assessment
	14	Classwork style	I will enjoy the classwork for this subject	I won't enjoy the classwork for this subject

	15	Difficulty	I will find the subject easy	I will find the subject difficult
Teaching	16	Teacher quality	I think the subject's teachers can help me get a good mark	I don't think the subject's teachers can help me get a good mark
	17	Teaching style	I like how the subject is taught	I do not like how the subject is taught
	18	Teacher like/dislike	I like a teacher or teachers I might get	I dislike a teacher or teachers I might get
Usefulness	19	Need for future study	I probably need the subject for my future study	I probably do not need the subject for my future study
	20	Need for personal life	The subject will be useful in my personal life	The subject will not be useful for my personal life
	21	Need for career	The subject could be useful for my career	The subject is unlikely to be useful for my career

¹Subjects for the final two years of school study in NSW Australia are offered in 'units' and most subjects are worth two units. Students must choose at least 12 units in Year 11.

²ATAR is the Australian Tertiary Admission Rank, the primary measure for undergraduate entry into university in Australia.

The BWS survey presented either the BWS-Choose or the BWS-Reject factors as attribute statements to students in sets. Students saw sets of factors multiple times in different combinations according to a statistical model. The BWS task asked students to choose only the best and worst option from the sets of factors presented. By comparing the choices respondents made within each set, a ranking of the average relative importance of all 21 factors was created. It is important to note that BWS scores are relative so that factors with lower scores are not necessarily unimportant for students when choosing subjects.

To determine which factors to show in which set in the BWS task, a Balanced Incomplete Block Design (BIBD) was used (Street & Burgess, 2007). The BIBD allowed the 21 attribute statements to be arranged into the minimum number of sets so that each statement appeared the same number of times and was assessed against every other statement an equal number of times. This statistical design resulted in 21 sets that each contained five attribute statements. Students saw each of the 21 statements five times in the survey and each factor co-appeared once with every other factor.

BWS analysis (or 'MaxDiff' analysis) was used to calculate a score of relative importance for each of the factors that impact the subject choice decision process (Marley & Louviere, 2005). When a student chose a factor as most important (best) the factor received a score of 1. Where a factor was chosen as least important (worst) it received a score of -1. The survey displayed each factor five times so the scores range from a minimum of -5 (where a factor was always chosen as worst) to a maximum of 5 (where a factor was always chosen as best). Scores are calculated for each individual and then averaged to produce a BWS-Score.

Students were randomly shown either the BWS-Choose or the BWS-Reject factors but not both. For the BWS-Choose survey, the instructions to students read: "Please think about how you chose your subjects for Year 11. For each of the sets of features below, please choose the feature that you find most important and least important in choosing a subject to study." The BWS-Reject version replaced the word *choosing* with *rejecting*. Figure 1 shows an example of a set of statements presented to students from the BWS-Choose survey. Students were asked to click the button next to the statement that was most important to them and the one that was least important to them in each set.

Most important		Least important
<input type="radio"/>	Older students or sibling suggested doing the subject	<input type="radio"/>
<input type="radio"/>	I received good marks in this subject (or a similar subject) in middle school	<input type="radio"/>
<input type="radio"/>	I enjoyed the subject (or similar subject) in middle school	<input type="radio"/>
<input type="radio"/>	I like a teacher or teachers I might get	<input type="radio"/>
<input type="radio"/>	I will enjoy the classwork for this subject	<input type="radio"/>

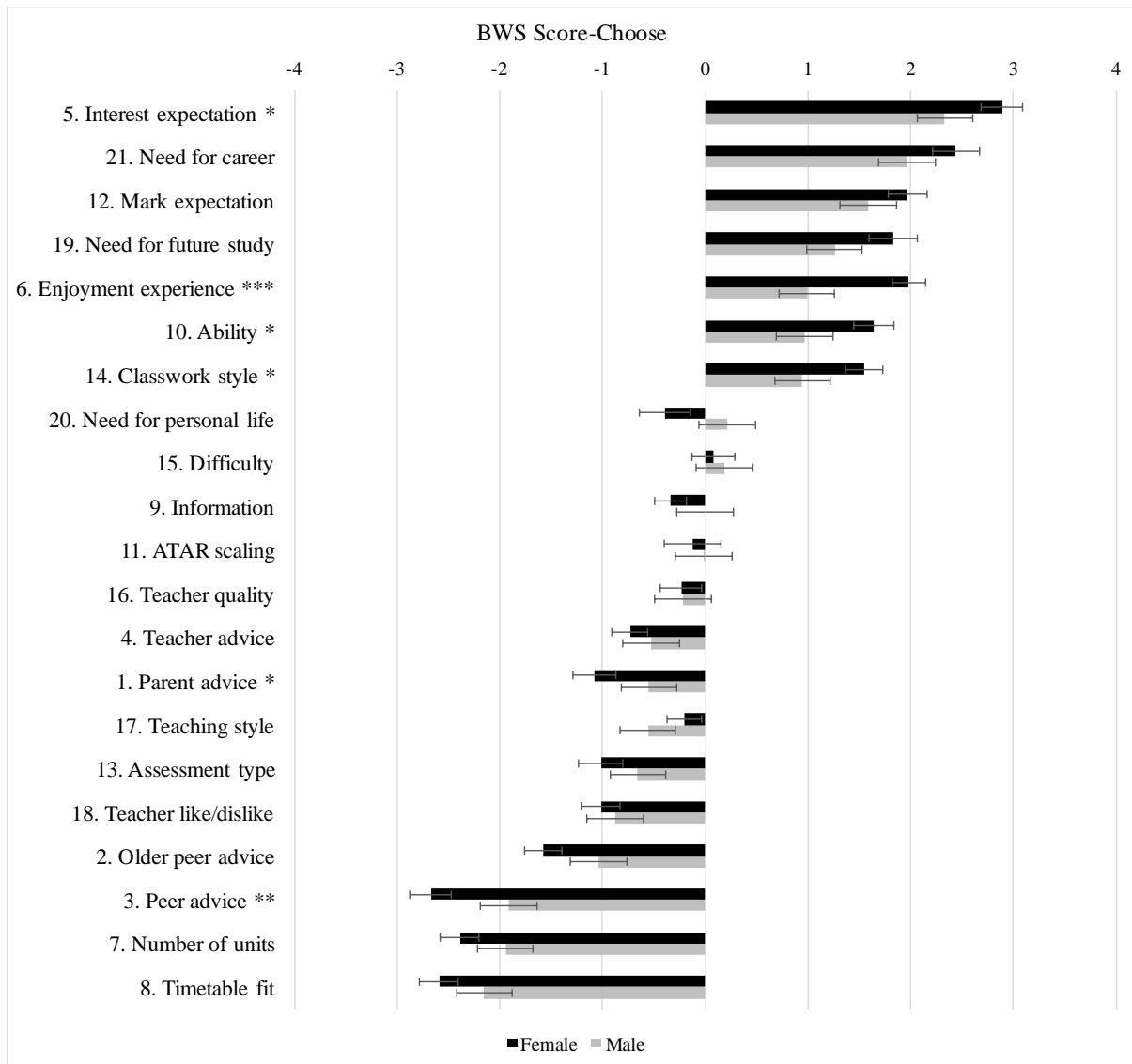
Figure 1. Example of BWS-Choose statement set.

The survey was made available to all Year 10 (ages 14 –17) students at five schools in metropolitan Sydney, Australia. Of the 333 students who completed the BWS survey in full, 157 (47%) completed the BWS-Choose version of the survey and of these 59% were boys and 41% were girls. The BWS-Reject version of the survey was completed by 176 (53%) students of whom 51% were boys and 49% were girls.

RESULTS

BWS-Choose

The BWS-Choose survey allowed the factors that male and female students considered in choosing their subjects for study for their final years of school to be scored using BWS analysis and compared. Figure 2 shows the mean BWS-Choose score ($\pm 1 SE$) and any significant differences between the scores of males and females. These factors are listed from highest to lowest average BWS-Choose male score. Further background to the results and method can be found in Palmer et al. (2017).



* $p < .05$, ** $p < .01$, *** $p < .001$

Figure 2. BWS-Choose comparison of mean male and female BWS scores.

The correlation between the mean female and male BWS-Choose scores for the 21 factors is .98. These results indicate that the pattern of scoring for BWS factors is very similar between male and female students suggesting that girls and boys ranked these factors in a similar manner. There are statistically significant differences between male and female BWS-Choose scores for six of the 21 factors included in the study. Table 2 shows that females scored four factors significantly higher than boys and two factors significantly lower than boys. The factors that girls scored higher were the first ranking factor for both males and females of Interest expectation, Enjoyment experience (ranked 3rd for girls and 5th for boys), Ability (ranked 6th for both genders) and Classwork (ranked 7th for both genders). The factors that girls scored lower than boys were Parent advice (ranked 17th for girls and 14th for boys) and Peer advice (ranked last at 21st for girls and 19th for boys).

Table 2. BWS-Choose male and female statistically significantly different scores

Factor	Mean BWS-Choose Score		Degrees of freedom (DF)	Male verses Female BWS Score		
	Male	Female		t-value	p-value	Significance
5. Interest expectation *	2.8	2.8				*
21. Need for career	2.5	2.5				
12. Mark expectation	2.2	2.2				
19. Need for future study	2.0	2.0				
6. Enjoyment experience ***	1.8	1.8				***
10. Ability *	1.7	1.7				*
14. Classwork style *	1.6	1.6				*
20. Need for personal life	-0.5	-0.5				
15. Difficulty	-0.2	-0.2				
9. Information	-0.3	-0.3				
11. ATAR scaling	-0.2	-0.2				
16. Teacher quality	-0.3	-0.3				
4. Teacher advice	-0.8	-0.8				
1. Parent advice *	-1.2	-1.2				*
17. Teaching style	-0.5	-0.5				
13. Assessment type	-1.0	-1.0				
18. Teacher like/dislike	-1.0	-1.0				
2. Older peer advice	-1.8	-1.8				
3. Peer advice **	-3.2	-3.2				**
7. Number of units	-3.0	-3.0				
8. Timetable fit	-3.5	-3.5				

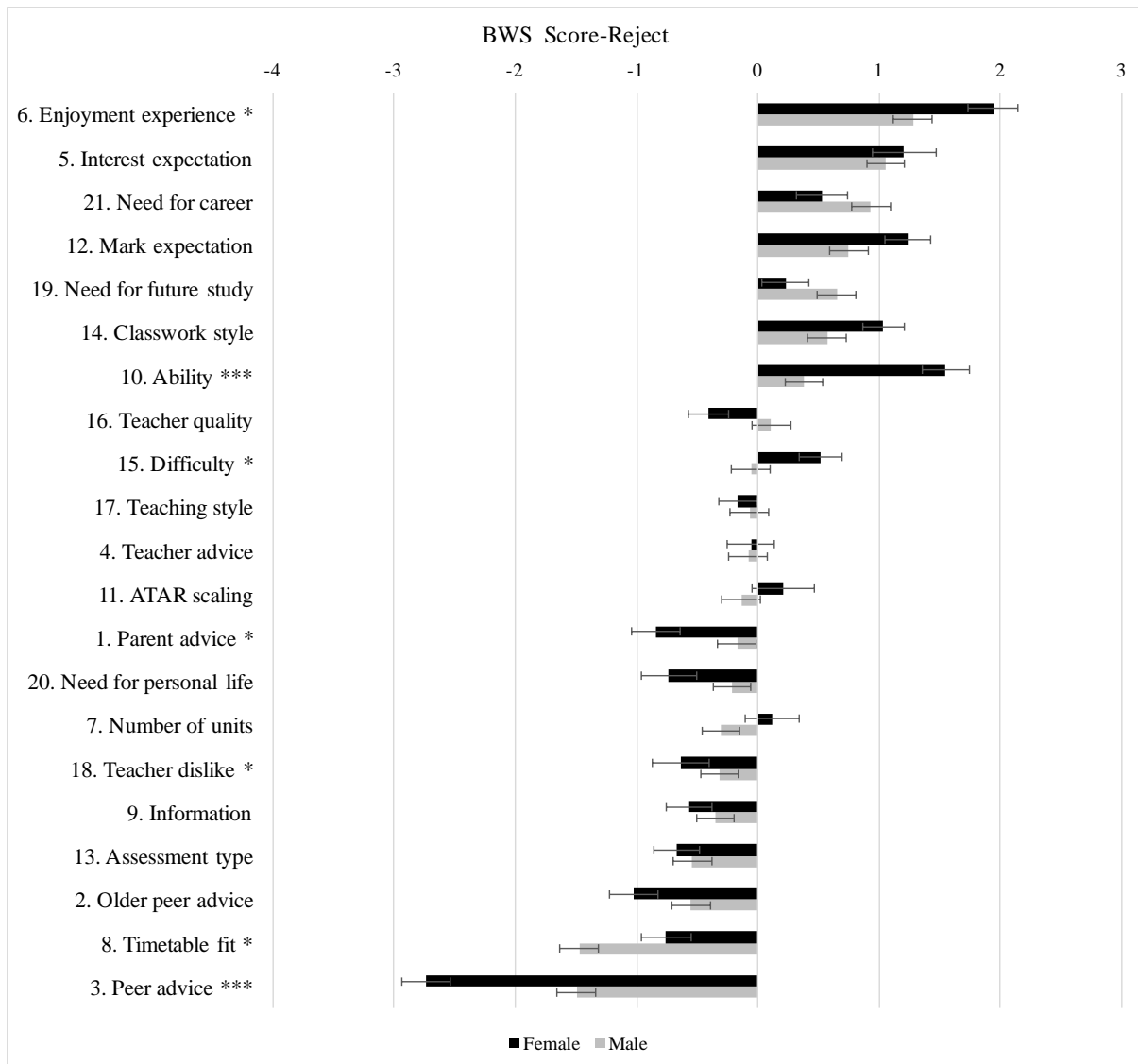
5. Interest expectation	2.33	2.89	156	-2.00	.0469	*
6. Enjoyment experience	0.99	1.98	156	-4.11	.0001	***
10. Ability	0.97	1.64	156	-2.57	.0112	*
14. Classwork style	0.95	1.55	156	-2.27	.0245	*
1. Parent advice	-0.55	-1.08	156	2.07	.0409	*
3. Peer advice	-1.91	-2.67	156	2.92	.0041	**

* $p < .05$, ** $p < .01$, *** $p < .001$

These results indicate that male and female students choose subjects in a similar manner but there are differences in the degree of importance students they placed on some factors. Girls regarded peer advice and parent advice even less important than boys in subject choice and considered being interested and enjoying a subject, their past ability and the type of classwork for a subject as more important than boys in their decision-making process.

BWS-Reject

The BWS-Reject survey allowed the factors that male and female students considered in choosing their subjects for study for their final years of school to be scored using BWS analysis and compared. Figure 2 shows the mean BWS-Reject score ($\pm 1 SE$) and any significant differences between the scores of males and females. These factors are listed from highest to lowest average BWS-Reject male score.



* $p < .05$, ** $p < .01$, *** $p < .001$

Figure 3. BWS-Reject comparison of mean male and female BWS scores.

The correlation between the mean female and male BWS-Reject scores for the 21 factors is .86. These results indicate that the pattern of scoring for BWS factors is very similar between male and female students suggesting that girls and boys ranked these factors in a similar manner.

Although the pattern is similar, Table 3 shows that girls scored four factors statistically significant higher than boys and three factors lower than boys. The factors that girls scored higher were the first ranking factor for both males and females of Enjoyment experience, Ability (ranked 2nd for girls and 7th for boys), Difficulty (ranked 7th for girls and 9th for boys), Timetable fit (18th for girls and 20th for boys). The factors that girls scored lower than boys were Teacher dislike (ranked 15th for girls and 16th for boys), Parent advice (ranked 19 for girls and 13 for boys) and Peer advice (ranked last for both genders).

Table 3. BWS-Reject male and female statistically significantly different scores

Mean BWS-Reject Score	Male verses Female BWS Score
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Factor	Male	Female	Degrees of freedom (DF)	<i>t</i> -value	<i>p</i> value	Significance
6. Enjoyment experience	1.28	1.94	175	-2.21	.0287	*
10. Ability	0.38	1.55	175	-4.34	.0000	***
18. Teacher dislike	0.11	-0.40	175	2.21	.0282	*
15. Difficulty	-0.06	0.52	175	-2.50	.0133	*
1. Parent advice	-0.17	-0.84	175	2.59	.0105	*
8. Timetable fit	-1.47	-0.76	175	-2.42	.0168	*
3. Peer advice	-1.49	-2.74	175	4.66	.0000	***

* $p < .05$, ** $p < .01$, *** $p < .001$

These results indicate male and female students reject subjects in a similar manner but there are differences in the degree of importance students placed on some factors. Similar to the result for choosing subjects, girls regarded peer advice and parent advice, and disliking a teacher even less important than boys in rejecting a subject. Girls considered their past ability and difficulty of a subject as more important than boys did in their decision-making process.

DISCUSSION

This research seeks to inform strategies to increase the number of students choosing science in their final years of schooling. It addresses the research question, “What is the relative importance of the factors that male and female students consider in choosing their subjects for their final years of school?” The BWS results presented here provide quantitative data on the relative importance of the factors that male and female students considered in choosing and rejecting subjects for post-compulsory study at school. This study is the first time that BWS has been used to compare the relative importance of the factors that male and female students consider when choosing their post-compulsory school subjects.

Both girls and boys ranked their expectations of finding a subject interesting and enjoyable as the most important influences when deciding to choose or reject a subject. However, this research indicates that girls may be more inclined than boys to consider how much they enjoy and can succeed in a subject when choosing and rejecting subjects which may have negative implications for science choice if it is perceived as boring and difficult as some research suggests (Osborne, Simon, & Collins, 2003; Shirazi, 2013). These findings suggest enjoyment and interest are key factors on choice of science at school, particularly for girls.

For both genders the ability of students to obtain “good marks” and the need for a subject for their future career are key factors in subject choice. This suggests that supporting students to feel that they can achieve good results in science subjects and broadening students’ views of the value of science may also affect their decisions. Again, this is particularly poignant for girls who tend to underestimate their abilities in science (Regan & DeWitt, 2015). It appears that it is critical that at subject selection time that schools implement strategies that promote positive student perceptions of how they can succeed in science and that the subject can be interesting, enjoyable and useful in a range of careers.

Advice from parents and teachers was a middle ranking item for both genders and girls ranked the importance of parental advice significantly lower than boys. Boys and girls ranked peer advice as relatively unimportant with girls ranking this factor significantly lower than their male counterparts. This is an interesting result given the influence of peers on other aspects of an adolescent’s life is considerable (Ryan, 2000). The relatively low importance that students place on the advice they receive suggests that interventions aimed at changing

students' perceptions of science may be best achieved through a program that encourages students to challenge their own ideas about science rather than being advised.

Given that girls consider enjoyment more highly than boys in choosing subjects and a lack of ability more highly than boys in rejecting a subject then strategies to encourage girls to choose science may have more impact if they feature these aspects. However, the rankings of scores are very similar for both genders with each seeking a subject that is interesting and enjoyable that they can achieve good marks in and will help them in their future career. The challenge remains to help students of both sexes to see that science can be all these things.

ACKNOWLEDGEMENT

Thank you to the teaching professionals, administrators, and students at the participating schools. This work was supported by an Australian Postgraduate Award funded by the Australian Government.

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