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Identities and Transformational Experiences for Quantitative Problem Solving: Gender Comparisons of First-Year University Science Students

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Women are underrepresented in science, technology, engineering and mathematics (STEM) areas in university settings; however this may be the result of attitude rather than aptitude. There is widespread agreement that quantitative problem-solving is essential for graduate competence and preparedness in science and other STEM subjects. The research question addresses the identities and transformative experiences (experiential, perception, & motivation) of both male and female university science students in quantitative problem solving. This study used surveys to investigate first-year university students' (231 females and 198 males) perceptions of their quantitative problem solving. Stata (statistical analysis package version 11) was used to analyse gender differences in quantitative problem solving using descriptive and inferential statistics. Males perceived themselves with a higher mathematics identity than females. Results showed that there was statistical significance ($p<0.05$) between the genders on 21 of the 30 survey items associated with transformative experiences. Males appeared to have a willingness to be involved in quantitative problem solving outside their science coursework requirements. Positive attitudes towards STEM-type subjects may need to be nurtured in females before arriving in the university setting (e.g., high school or earlier). Females also need equitable STEM education opportunities such as conversations or activities outside school with family and friends to develop more positive attitudes in these fields.

***Key words**:* Gender; Problem solving; Transformational; STEM: First-year students

Introduction

Women are under-represented in the science, technology, engineering and mathematics (STEM) areas at universities and within careers. Many educators and industry partners want to provide more opportunities for females to create a gender balance and reach maximum potential with the available human resources (Leicht-Scholten, Weheliye, & Wolffram, 2009). Women are also under-represented in STEM university coursework in various Western countries (e.g., for engineering, see Rohatynskyj, Davidson, Stiver, & Hayward, 2008). Increasing the number of women in university STEM courses is being promoted throughout the world to combat this deficiency in gender representation (Bianchini, Whitney, Breton, & Hilton-Brown, 2002). In the United States of America (USA), the National Research Council (2003) has found that women who enter engineering careers do so at equal rates as men. However, this is contradictory to the university enrolment rates occurring in Australia (i.e., less than 16% of Australian women enrol in engineering degrees; Mills, Mehrtens, Smith, & Adams, 2007). Yet, the National Research Council report finds that women have a greater chance of securing a position at interviews in STEM careers.

Myers and Myers (2008) claim that women have made advances in the STEM areas but not at the same level as males. Part of the reason appears to lie within attitudes, including stereotyping female competencies. For example, engineers in the field largely consider certain femininities and masculinities associated with particular engineering activities (Foor & Walden, 2009). Females need to have open-ended career choices not limited by stereotyping but by providing them with opportunities to discover employment prospects in STEM-related fields. Targeting females in their senior years is an option, especially if they are more connected with STEM content towards career choices than in junior years (Cantrell & Ewing-Taylor, 2009).

Adolescent females need to be nurtured into STEM areas if they are to have options about constructing STEM career identities. Projects are being devised to attract women into STEM areas in Australia and elsewhere. For instance, Little and de la Barra (2009) claim that females prefer group work and practical activities and, as such, practical learning aids chosen as a result of pedagogic gender inclusivity may assist females in their learning of STEM-related subjects (Chatoney & Andreucci, 2009). Despite intervention programs that aim to advance females' opinions about STEM subjects, females may consider STEM but fear the prospect at the same time (Steinke et al., 2009).

Nevertheless, females with more knowledge about STEM increase their university degree aspirations in these fields, although still less than male aspirations. Keys to increasing STEM aspirations include explicit education and the provision of STEM career choices (Porche, McKamey, & Wong, 2009).

When analysing gender differences in earlier years, a USA study (Bacharach, Baumeister, & Furr, 2003) shows that boys achieve higher than girls in the primary school (also noted in National Center for Education Statistics (1999) tests) and this disparity continues to increase through high school years. However, this gender trend appears to be the reverse in Malaysia (Ahmad, 2009). Nevertheless, studies (e.g., She, 2001) have also found that teachers may target boys more than girls when asking questions or providing feedback within STEM subjects. Although what appears as a banal study, Johnson, Kahle, and Fargo (2007) present evidence that effective science (and STEM) teaching can increase achievement and close the achievement gap between students.

Aptitude in STEM areas does not appear as a key issue between boys and girls. For instance, standardised tests in the USA show equivalent scores in mathematics between the genders (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). In addition, a longitudinal study (Haworth, Dale, & Plomin, 2009) considered gender differences, etiology (study of origins) and high performances in science by collecting data on 3000 twins when they were nine, ten and twelve years of age. Analysing data with test scores at an 85th percentile minimum, they uncovered that there was no evidence in the etiology of science excellence between boys and girls, and concluded that any differences in STEM career choices may be due to attitudes and not aptitudes. When involved in STEM-related subjects, girls may perform equally as well as boys, however, their confidence in the subject is lower (Klahr, Triona, & Willams, 2007). Indeed, Martin and Smith-Jackson (2008) showed that attitude to problem solving may commence at a very young age, which was demonstrated when they presented children aged six to nine with instructions for assembling interlocking toys. Boys who could not assemble the toys blamed the instructions while girls blamed themselves. Other studies (e.g., Farland-Smith, 2009) about middle-school females' pragmatic involvement in STEM-type subjects indicate that females can develop more positive attitudes about seeking a STEM career. Attitude and perceptions about STEM subjects must be key target areas for advancing females' prospects into STEM. Furthermore, there needs to be more studies that aim to identity specific reasons for this gender disparity within STEM areas. For example, girls' attitudes towards problem solving within STEM-related subjects may also be linked to attitudes about mathematics (Coates, 2007), which could give an understanding of how to advance females' STEM education.

Quantitative Problem Solving

There is widespread agreement that quantitative skills or quantitative problem-solving (QPS)[1] are essential for graduate competence and preparedness in science (American Association for the Advancement of Science [AAAS], 2010; National Research Council [NRC], 2003). The recent Group of Eight (2009) report, *Review of Education in Mathematics, Data Science and Quantitative Disciplines*, is another in a long line of high-profile reports that identify a looming crisis in Australian education at all levels. Not only are secondary school students holding negative views of quantitative subjects, they are also underperforming in mathematics and science (Australian Council on Educational Research [ACER], 2009). The lack of quantitative confidence and preparedness is presenting significant challenges to the tertiary sector, particularly for science-based disciplines that rely on quantitative competency. This issue is not limited to Australia, as evidenced by a recent report in the United Kingdom (UK) that stated, "Science examination standards at UK schools have eroded so severely that the testing of problem-solving, critical thinking and the application of mathematics has almost disappeared….urgent action is required before it is too late" (UK Report Science Skills, 2009, p. 20). This is within the context of rapid changes in science resulting from technological advances in recent decades that require more interdisciplinary knowledge and greater levels of quantitative skills (AAAS, 2009; NRC, 2003).

Declining enrolments in STEM are well-documented in Australia (Group of Eight, 2009), the USA (Augustine, 2007; NRC, 2003) and the UK (UK Report Science Skills, 2009). This is within the context of rapid changes in science resulting from technological advances in recent decades that require more interdisciplinary knowledge and greater levels of quantitative skills (AAAS,

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[1]We define quantitative problem-solving (QPS) as the ability to apply mathematical thinking and reasoning within a given external context (in this case science) to solve quantitative problems.

2009). Graduate employability is increasingly influencing university curricula and there is widespread agreement that quantitative skills are essential for modern science.

Wood and Solomonides (2008) argue that when teaching mathematics, a context-based approach produces graduates who are more workplace-ready. Thus, many academics seeking to engage students in learning QPS favour a context-based approach (Matthews, Adams, & Goos, 2009). While placing material in context may be a useful motivator, it is also widely recognised that the contextual nature of the problems requiring QPS poses additional challenges for many science students (LeBard, Thompson, Micolich, & Quinnell, 2009). However, in science the context is inescapable. Used effectively, QPS should provide an advantage in terms of engaging students as a transformative experience.

The notion of transformation in education is not new and theories of transformative learning have been well-documented in adult education in the past two decades, including the higher education context (e.g., Mezirow, 1991; Taylor, 1997). Until recently, there have been few empirical studies as educational researchers have struggled to operationalise the complex, abstract theory of transformative learning and its application in the educational setting (Taylor, 2007). The complexity of transformative learning theory is exemplified by the multiplicity of factors involved in Mezirow's two-dimensional notion of 'frame of reference', which consists of 'habit of mind' and 'a point of view' (Mezirow, 1997). For Mezirow, transformative learning occurs when a person's 'frame of reference' changes. Long before Mezirow's contribution of the theory of transformative learning, Dewey was writing prolifically on the topic of transformative experiences (TE) in education (Dewey & Boydston, 1990). Dewey argued against the duality of content versus process in science teaching, suggesting that the worth of knowledge is knowing the "ways by which anything is entitled to be called knowledge" (Dewey, 1995, p. 395). Inspired by Dewey, modern science education researchers have revived his work (e.g., Kruckeberg, 2006) and established a working definition of TE in the context of science education and developed a methodology for identifying TE on a large scale. *Transformative experiences* occur when students apply science concepts to everyday life in meaningful ways (Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2010. Findings from Pugh et al. (2010) revealed that students with a strong science disciplinary identity and mastery goal orientation were more likely to report higher levels of engagement in TE. The study also found that TE was a factor in students' ability to transfer the concepts to other contexts.

QPS and Science

The research question for this study was: What are the identities and transformative experiences (experiential, perception, and motivation) of university science students in quantitative problem solving?

Context of the Study

This study is situated within a large Australian university that conducts both undergraduate and post-graduate programs. The Bachelor of Science (BSc) is a large, generalist degree program with more than 3,000 undergraduate students. Applicants are required to have completed high school English, science (chemistry or physics) and mathematics, which includes the study of functions, sequences and series, an introduction to calculus, and probability and statistics. In 2006, the undergraduate science curriculum was reviewed with a more structured program implemented from 2008 that intended to instill a greater level of quantitative skills in science students (Strong, Mattick, McManus, Matthews, & Foster, 2008). One strategy to achieve this goal was the development of a new course that connects theory and practice in science. This is an introductory course offered in the first semester for first-year students that is highly recommended for all new science students, regardless of the student's major. The course is interdisciplinary in nature, demonstrating the mathematical foundations that underpin a range of science disciplines. For the sake of brevity further description of the course is available in the literature (Matthews et al., 2009; Matthews, Adams, & Goos, 2010).

Methods

This quantitative study investigates first-year university science students' perceptions of their identities and transformative experiences for quantitative problem solving. Secondary analysis examined the differences by gender. A survey was developed based on the work of Pugh et al. (2010), who designed, tested and validated a survey to measure transformative experiences in science using three scales: motivated use, expansion of perception and experiential value. Pugh et al. (2010) also developed, tested and validated a scale to measure science identity. For the purposes of the study, the science identity scale was used to create a measure for mathematics identity. All survey items used a five-point Likert scale with 1 representing the most negative level of agreement, 5 being the most positive choice, and 3 being neutral.

A central university unit not affiliated with the course administered the survey online. Students were emailed information about the survey along with the survey link in the final week of the first semester. The survey was combined with the mandated course evaluation questionnaire, comprised of several generic questions about the course and the lecturers. The unit coordinator offered an incentive to entice students to complete the survey, which is common practice (Berk, 2006) and was not viewed by the authors as a factor causing bias in student responses. The central unit collected identified student demographic information, although only de-identified, aggregate data were used for analysis and reporting as allowed by the university's ethics committee.

Study Participants

At the conclusion of the first semester in their first year of study, a total of 489 science students (48% male, 52% female) from the campus earned a final grade in the science unit. The ages ranged from 16 to 50 years with an average of 18.78 years. Ninety percent of students were enrolled in the Bachelor of Science or a science-based degree programme (e.g., Biomedical Science, Biotechnology), while the remaining 10% consisted of a mix and match of Engineering related programs such as engineering, information technology and science-dual degree programs (e.g., Science/Arts, Science/Engineering). A total of 433 students responded to the survey for an overall response rate of 86%. Four students had not identified their gender and were dropped from the study, for a total of 429 useable surveys. Early analysis of the data revealed 14 missing data points across the Likert scale items. Since the missing data were random and represented less than 5% of the total responses, the missing data were imputed to the neutral value of three. This is acceptable practice and is preferable to deleting observations with randomly missing data as similar results will be yielded while avoiding wastage of data and reduction of the sample size (Tabachnick & Fidell, 2007).

Analysis

Stata (statistical analysis package version 11) was used to analyse the results. Descriptive statistics (mean, standard deviation, standard error) and inferential statistics (confidence interval, two-sided *t*-test) were calculated for each item by gender. The index for science identity and mathematics identity were created from four items with Cronbach alpha scores indicating strong reliability for each index (0.93 and 0.92, respectively). The motivation index consisted of 12 items (r=0.94), the experiential value index had ten items (r=0.94), and seven items are included in the perception index (r=0.90). Each index is combined to create an overall Transformative Experiences score in the context of quantitative problem solving in science (r=0.93). Two-sided *t*-test of means were run for each item and index to test whether a difference exists between females and males, and *p*-values are reported with 0.05 being used as the minimum threshold for statistical significance (Tabachnick & Fidell, 2007).

Results and Discussion

The first-year university science students were asked to locate themselves on identities related to science (items 1-4) and mathematics (items 5-8, Table 1). The mathematics identity mean range (2.40-3.06) was lower for both males and females compared with the science identity mean range (3.70-4.22). Considering they were enrolled in a science course, it was expected the perceptions of their science identities would be higher for both genders. Nevertheless, males perceived a stronger identity in mathematics than females. To illustrate, *t*-tests extracted no statistical significance between males and females about their science identity, and despite mathematics being a fundamental tool for science careers, *t*-tests showed significance between the genders for their mathematics identities (p<0.05, Table 1). Quantitative problem solving (QPS) in science-related areas involves mathematical calculations yet females do not see themselves in a mathematics-related career or doing mathematics in the future as much as males in this science degree. Explanations may include that more males have a higher self-efficacy in mathematics than females, make the mathematical connections to science, and/or have had more experiences in mathematics.

Table 1
Science and Mathematics Identities (females=231, males=198)

Item		Gender	*M*	*SD*	SE	*t*-test	*p*-value
1.	I consider myself a science person.	F	3.91	1.04	0.069	-1.03	0.302
		M	4.02	0.98	0.070		
2.	I can see myself doing science in the future.	F	4.10	1.01	0.067	-0.34	0.738
		M	4.14	0.99	0.070		
3.	I can imagine myself being involved in a science related career.	F	4.19	0.99	0.065	-0.29	0.775
		M	4.22	0.93	0.066		
4.	Being involved in science is a key part of who I am.	F	3.70	1.18	0.077	-0.54	0.587
		M	3.75	1.12	0.080		
5.	I consider myself a maths person.	F	2.56	1.32	0.087	-2.80	0.005
		M	2.92	1.38	0.098		
6.	I can see myself doing maths in the future.	F	2.78	1.26	0.083	-2.24	0.026
		M	3.06	1.34	0.095		
7.	I can imagine myself being involved in a maths-related career.	F	2.40	1.22	0.080	-3.36	0.003
		M	2.78	1.37	0.097		
8.	Being involved in maths is a key part of who I am.	F	2.43	1.30	0.086	-2.81	0.005
		M	2.80	1.39	0.099		

Three constructs (experiential, perception, & motivation) associated with transformative experiences indicated statistically significant *t*-test scores between males and females for QPS ($p<0.005$). The lower standard deviation (*SD*) with higher mean scores (*M*) for males on each construct produced paired *t*-tests in the range of -2.45 to -3.61, further highlighted that these males' perceived transformative experiences higher than females' perceptions

(Table 2). Subscales (experiential, perception, & motivation) were created for the total transformative experiences related to QPS for these first-year university science students.

Table 2
Transformative Experiences with Quantitative Problem Solving (females=231, males=198)

Index	Gender	*M*	*SD*	SE	CI (95%)	*t*-test	*p*-value
Experiential	F	3.59	0.73	0.048	3.50 - 3.68	-2.45	0.015
	M	3.76	0.68	0.049	3.66 - 3.85		
Perception	F	3.34	0.73	0.048	3.25 - 3.44	-3.61	0.000
	M	3.58	0.65	0.046	3.49 - 3.68		
Motivation	F	3.03	0.77	0.051	2.93 - 3.13	-2.92	0.004
	M	3.24	0.72	0.051	3.14 - 3.34		
Transformative experiences	F	3.32	0.69	0.046	3.23 - 3.41	-3.22	0.001
	M	3.53	0.64	0.045	3.44 - 3.62		

Analysing each of these constructs (i.e., experiential, perceptions and motivations) provided further insights into males and females' perceptions and attitudes about QPS. Males perceived themselves with higher experiential value of QPS than females in half of the items listed in Table 3 ($p<0.05$). It appeared that males were more interested in QPS both within the university setting and externally. Males find it more exciting to think about QPS than females (females *M*=3.11, males *M*=3.41). However, mean scores showed that both males and females in this study claimed quantitative scientific thinking would be useful for future studies or work (females *M*=4.07, males *M*=4.08). This usefulness was also noted where there was a direct relationship to lectures and understanding science, including using QPS in everyday life (Table 3).

Table 3
Experiential Value of Quantitative Problem Solving (females=231, males=198)

Item	Gender	*M*	*SD*	SE	*t*-test	*p*-value
During science lectures, I think the stuff we are learning about quantitative scientific problem-solving is interesting.	F	3.75	0.94	0.062	-2.06	0.040
	M	3.93	0.85	0.062		
I find it interesting in science lectures when we talk about quantitative scientific problem-solving in terms of science.	F	3.92	0.88	0.058	-1.18	0.238
	M	3.91	0.79	0.056		
The ideas of quantitative scientific thinking are useful for me to learn for my future studies or work.	F	4.07	0.84	0.056	-0.03	0.978
	M	4.08	0.72	0.051		
I think quantitative scientific problem-solving is an interesting topic.	F	3.57	0.91	0.060	-2.85	0.005
	M	3.81	0.87	0.062		
The ideas of quantitative scientific problem-solving help me to better understand science.	F	3.92	0.83	0.055	-0.88	0.377
	M	3.98	0.73	0.051		
The ideas of quantitative scientific problem-solving make science much more interesting.	F	3.53	0.93	0.061	-2.38	0.018
	M	3.74	0.90	0.063		
Knowledge of quantitative scientific problem-solving is useful in my current, everyday life.	F	3.46	0.89	0.060	-1.92	0.056
	M	3.62	0.84	0.060		
I'm interested when I hear things about quantitative scientific problem-solving outside of uni.	F	3.31	1.01	0.066	-2.77	0.006
	M	3.57	0.95	0.068		
I find that the ideas of quantitative scientific problem-solving make my current, out-of-uni experience more meaningful and interesting.	F	3.35	0.94	0.062	-1.64	0.102
	M	3.49	0.87	0.062		
I find it exciting to think about quantitative scientific problem-solving outside of uni.	F	3.11	1.06	0.070	-3.09	0.002
	M	3.41	0.98	0.070		

Males and females responded to eight statements about their perceptions of QPS for which there was statistical significance in the gender comparison on all eight items ($p<0.05$, Table 4). Males claimed that they think about QPS more than females at university and outside of the university setting. Differences in gender perceptions were noted when thinking about QPS for completing science assignments, lecture content, and seeking examples of QPS outside of the university. Indeed, there was high statistical significance in the difference between the genders when noting a scientific-related concept either in real life or media and making the relationship with QPS ($t=-3.94$, $p<.001$). However, mean scores indicated that both genders noticed examples of QPS during university lectures (females $M=4.00$, males $M=3.81$, Table 4).

Table 4
Perception of Quantitative Problem Solving (females=231, males=198)

Item	Gender	*M*	*SD*	SE	*t*-test	*p*-value
During science lectures, I see things in terms of quantitative scientific problem-solving.	F	3.56	0.86	0.057	-3.00	0.003
	M	3.80	0.75	0.053		
When I am working on a science assignment about certain science concepts, I tend to think of them in terms of quantitative scientific problem-solving.	F	3.53	0.89	0.059	-2.30	0.022
	M	3.72	0.84	0.060		
I notice examples of quantitative scientific problem-solving during science lectures.	F	3.81	0.80	0.053	-2.39	0.018
	M	4.00	0.77	0.055		
If I see a really interesting science-related concept (either in real life, in a magazine, or on TV) then I think about it in terms of quantitative scientific problem-solving.	F	3.14	0.95	0.620	-3.94	0.000
	M	3.48	0.84	0.060		
I notice examples of quantitative scientific problem-solving outside of uni.	F	3.37	0.93	0.061	-2.81	0.005
	M	3.61	0.81	0.058		
I look for examples of quantitative scientific problem-solving outside of uni.	F	2.83	0.94	0.062	-3.17	0.002
	M	3.12	0.95	0.068		
I can't help but see science in terms of quantitative scientific problem-solving now.	F	3.13	0.96	0.063	-2.66	0.008
	M	3.37	0.89	0.063		

It appeared that when females were involved directly with QPS where discussions and concepts about QPS were forthcoming (e.g., lectures), they recognised QPS similar to males. This may strengthen Chatoney and Andreucci's (2009) argument of immersing females in first-hand STEM experiences to engage them in STEM concepts. Indeed, males' experiential values were higher than females; hence females would require more experiences with STEM. Consequently, the relationship to QPS was more apparent when experienced directly by these females.

Finally, these males and females were asked to respond to statements about their motivation for QPS, for which there was statistical significance between the genders on eight of the twelve items ($p<0.05$, Table 5). For example, males indicated they were more motivated than females in applying QPS and thinking about QPS outside of university. Yet, there were statements that had lower mean scores for both genders indicating that both males and females were not strongly motivated to talk to parents, partners, or family about QPS (*M* range=2.70-2.74), or talking about QPS for the fun of it (*M* range=2.45-2.74) or love of it (*M* range=2.59-2.95). Motivation to engage in activities is linked to personal gain (Herzberg, Mausner, & Snyderman, 1959) for which females in this study may not have recognised the personal gains attached to learning about QPS. Even though QPS may not necessarily motivate many female university science students, it is likely that many will engage in QPS during their careers, which may indicate a lack of prior experiences in QPS and limited awareness of career expectations.

Table 5
Motivation for Quantitative Problem Solving (females=231, males=198)

Item	Gender	*M*	*SD*	SE	*t*-test	*p*-value
I talk about quantitative scientific problem-solving with others during science lectures and tutorials	F	3.36	0.98	0.065	-0.10	0.920
	M	3.37	0.95	0.068		
I think about quantitative scientific problem-solving when I have to for science lectures and tutorials.	F	3.80	0.83	0.054	-1.38	0.168
	M	3.91	0.79	0.056		
I apply the knowledge I've learned about quantitative scientific problem-solving when I have to for science courses at uni.	F	3.68	0.89	0.059	-1.58	0.114
	M	3.81	0.85	0.061		
When my parents/partners/family ask about uni, I talk with them about quantitative scientific problem-solving.	F	2.70	1.14	0.075	-0.42	0.677
	M	2.74	1.11	0.079		
I think about quantitative scientific problem-solving when I read about or see a TV show about science.	F	3.14	0.99	0.065	-2.17	0.031
	M	3.34	0.90	0.064		
I think about quantitative scientific problem-solving outside of science.	F	3.07	1.04	0.068	-2.68	0.008
	M	3.32	0.94	0.067		
I apply the stuff I've learned about quantitative scientific problem-solving even when I don't have to.	F	3.00	0.94	0.062	-2.57	0.011
	M	3.20	0.93	0.066		
I love talking about quantitative scientific problem-solving.	F	2.59	0.96	0.063	-3.77	0.000
	M	2.95	1.02	0.073		
I talk about quantitative scientific problem-solving just for the fun of it.	F	2.45	1.06	0.070	-2.86	0.004
	M	2.74	1.04	0.074		
I think about quantitative scientific problem-solving outside of science just because I'm interested in the ideas.	F	2.99	1.04	0.069	-2.87	0.004
	M	3.27	0.93	0.066		
I find myself thinking about quantitative scientific problem-solving in all kinds of everyday situations.	F	2.78	0.91	0.060	-3.42	0.001
	M	3.09	0.98	0.069		
I seek out opportunities to apply my knowledge of quantitative scientific problem-solving in my everyday life.	F	2.82	0.92	0.060	-3.45	0.001
	M	3.13	0.92	0.066		

In summary, males perceived themselves with greater transformative experiences than females on 21 of the 30 QPS items (Tables 3 - 5). Males' experiential, perception, and motivation for QPS were statistically higher than females. Indeed, females and males met the same entry requirements for the science university course, indicating that their aptitude for science (and QPS) would be equivalent. Yet, the survey items showed that females' identity with QPS was different to males, which assumes that it may be attitude rather than aptitude that was a contributing factor. There appears to be only two explanations: either this attitude is a genetic makeup difference between males and females or that the attitude has been derived through environmental factors (e.g., media, education, family, networks). The first explanation means that little can be done about changing females' attitudes to STEM-related areas, assuming the latter hypothesis means educating females through these environmental factors to alter this attitudinal difference. Indeed, the attitudinal differences may stem from experiences beyond the school, given the long-standing media conditioning where girls are aligned with dolls and beauty products while boys are aligned with engineering-type toys. Understanding gender differences along these lines would require further research into influences beyond the school; however there needs to be more research in schools to understand if linking mathematics more clearly with science can change females' less positive attitudes towards mathematics, particularly when entering into a STEM-related degree that requires mathematical knowledge.

Conclusion

This study explored first-year university science students' perceptions of their identities for science and mathematics. It also differentiated between males and females' perceptions of their transformative experiences for QPS across three constructs (i.e., experiential, perceptions, and motivations). Males associated themselves with QPS more than females on most of the surveyed items. Males appeared to have a willingness to be involved in QPS at times outside of science coursework requirements. All of these students entered the degree programme with the same secondary school mathematics requirements intonating that aptitude was not a reason for the statistically significant differences between males and females involved in this study. However, it was not known if more males undertook higher level mathematics in high school, which may have affected these results, and if this is the case, then it means that females require more guidance during their high schools to undertake STEM-related subjects. Females displayed less positive attitudes towards QPS, despite mathematics being the foundation for understanding scientific concepts. Further studies need to be conducted to understand their career choices and motives for entering into a science degree programme, along with their high school attainments in these subjects, in order to form a clearer picture of what else may influence their transformative experiences in STEM.

Universities need more high school students to undertake STEM courses to fill career gaps currently existing in Australia (Panizzon & Westwell, 2009). Girls have been targeted in STEM programs to advance their thinking about STEM subjects as this is a human resource largely under supplied in STEM areas. For instance, summer programs such as week-long camps for girls can instil ideas about STEM subjects as university subject choices. Indeed, research on these programs indicates that girls are nearly as much as ten times more likely than those without such opportunities to seek enrolment in a STEM degree (Bee, Puck, & Heimdhl, 2003). Various avenues need to be explored in boosting the transformational experiences and identities of females. For example, websites have been launched to address the gender gap in STEM-related subjects such as engineering (e.g., http://www.engineergirl.org/, Muller et al., 2005) which aims at changing females' attitudes towards STEM areas. These reform measures are in the early stages and may not have had the desired impact for changing females' perceptions about STEM or QPS as indicated in this current study.

All students require equal opportunities for learning about STEM though it is pertinent to facilitate ways that would create greater equity in these fields. Contextualising STEM education in high schools may increase females' mathematics identities and QPS transformational experiences. However, such identities and experiences could include the influences of peers, family, school and media, which also need to be analysed when presenting STEM education for career choices. To increase the pool of females who may enter STEM university coursework with positive attitudes towards the STEM-related subjects would require targeting attitudes in the high school or earlier (e.g., English & Mousoulides, 2009). Indeed, Carpinelli, Hirsch, Kimmel, Perna, and Rockland (2007) claim students start to make career choices in middle school, yet many do not know about the STEM career choices at this stage. Furthermore, females in particular, may not engage in STEM conversations (e.g., QPS) or activities outside school with family and friends; hence females need equitable STEM education opportunities for positive attitude development in STEM subjects. Hence, educational institutions need to employ surveys at the beginning of coursework to understand students' prior experiences and attitudes towards STEM areas that may assist curriculum developers to devise differentiated learning plans.

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