Int J of Sci and Math Educ (2017) 15:1501–1520
DOI 10.1007/s10763-016-9753-7

An Enquiry into the Influence of Mathematics on Students' Choice of STEM Careers

Elena Prieto[1] **· Nicola Dugar**[1]

Received: 2 December 2015 / Accepted: 12 May 2016 / Published online: 2 June 2016

Abstract Australia currently faces a skill shortage in Science, Technology, Engineering and Mathematics (STEM) professions unlikely to improve if the current trend of low enrolments in high-level mathematics in secondary school continues. Many factors seem to contribute to this trend, and amongst them, research recognises student a*ttitudes* towards mathematics and careers in STEM. Research also shows that teachers and classroom practices are key agents to change these attitudes. This paper examines teachers' perceptions of students' attitudes towards mathematics and careers in STEM, as well as classroom practices emanating from those perceptions. Combining data from two studies, a large-scale survey and an intervention, we argue three main points: (1) student attitudes and teachers' perceptions of those attitudes quite clearly differ, (2) targeted interventions showing links between mathematics and careers in STEM can have an influence on students' perceptions of STEM careers and (3) an implementation of classroom ability grouping based on standardised test scores can be disadvantageous to students who have a natural inclination towards STEM and positive attitudes towards mathematics.

Keywords Ability grouping · Attitudes towards careers in STEM · Attitudes towards mathematics · Perceptions of STEM careers · Post-compulsory high school mathematics

Introduction

In Western nations, such as Australia, the UK and the USA, the percentage of high school students electing to study higher levels of mathematics in secondary school has steadily declined (Kennedy, Lyons & Quinn, 2014). This has negatively impacted on the rate of students commencing tertiary studies in the fields of Science, Technology,

✉ Elena Prieto
elena.prieto@newcastle.edu.au

1 The University of Newcastle, Callaghan, NSW, Australia

Engineering and Mathematics (STEM), despite an increasing number of people entering and graduating from university (Dobson, 2013). Furthermore, data from the university sector worldwide shows that there has been an increase in the percentage of students entering STEM degrees without the necessary mathematics prerequisites (Holton, Muller, Oikkonen, Sanchez Valenzuela & Zizhao, 2009). This has had a particularly significant impact in Australia where, since the mid-1990s, dwindling participation in high-level school mathematics, physics and chemistry has led to decreased enrolments in these tertiary degrees (Office of the Chief Scientist, 2012, 2014).

There are various reasons reported in the literature as possible causes for the decline in enrolments in higher level mathematics in secondary schools (for a review, see McPhan, Morony, Pegg, Cooksey & Lynch, 2008). This reasons range from school influences such as curriculum, pedagogy or even timetabling issues to maximising entry scores to university since few Australian universities require higher levels of mathematics to enter STEM degrees (Australian Mathematical Sciences Institute, 2012). Amongst these reasons, students' attitudes towards mathematics due to a perceived lack of relevance seems a strong common theme (see Boaler, 1993; McPhan et al., 2008; Tytler, Osborne, Williams, Tytler & Cripps Clark, 2008). Students often perceive mathematics as 'difficult' or 'not useful' in their everyday lives (Brown, Brown & Bibby, 2008, p. 4). Students also do not see a clear career pathway in which mathematics would be useful. A potentially powerful method for students to see the usefulness of mathematics and perhaps increase their interest and their motivation to continue studying is to link mathematics and their applications to achievements in STEM fields. There is, however, a large number of misconceptions and knowledge gaps around STEM fields and the extensive number of sub-occupations that constitute them (Prieto et al., 2009). These misconceptions are concerning, and consequently, as Tai, Qi, Maltese and Fan (2006) argue, a shift in perceptions surrounding scientific occupations is needed to encourage students to study mathematics in higher secondary schooling and go on to enter the STEM pipeline at tertiary and professional levels.

There have been a number of studies showing how classroom interventions and exposure to role models working in STEM fields are successful methods to influence student perceptions surrounding STEM careers. Positive interventions range from showing videos about STEM careers (Wyss, Heulskamp & Siebert, 2012; Wyss, 2013), organising visits of scientists to schools (Bodzin & Gehringer, 2001), or engaging students in 'thinking and acting as real scientists' (Chen & Howard, 2010, p. 133). These intervention have, at least, a short-term positive effect on student disposition towards mathematics and STEM fields due to a number of factors ranging changes to stereotypes of the 'old, white male' scientist (Wyss et al., 2012) to creating an awareness of STEM professions (Kukreti, Islam, Oerther, Davies, Turner, Maltbie & Fowler, 2005).

The extensive scholarship around affect in mathematics and science education indicates that student attitudes, interest, motivation and perceived usefulness of science and mathematics significantly influence students' decisions to continue their study in senior high school (see, for example, Leder & Grootenboer, 2005; Osborne, Simon & Collins, 2003). Attitudes and self-concept are also known to be significant factors in career choice in all learning areas, but particularly in science and mathematics (Ainley & Khoo, 2005; Bandura, Barbaranelli, Caprara & Pastorelli, 2001; Tripney, Newman, Bangpan, Niza, Mackintosh & Sinclair, 2010).

Mathematics teachers and their classroom practices are also a significant influence on students. Many studies over the years have examined teachers characteristics that influence student achievement (Wayne & Youngs, 2003), and these characteristics often relate to factors such as qualifications (Darling-Hammond, 2000) or experience (Hattie, 2003). However, teachers also have the potential to significantly influence students' attitudes towards careers, and particularly scientific ones (Dick & Rallis, 1991; Maltese & Tai, 2010, 2011; Wang & Staver, 2001), or affect students' decision to continue studying mathematics in senior secondary school (Grootenboer, 2013; Hayes, Mills, Christie & Lingard, 2006). In particular, researchers have argued for some time now that the practice of grouping students into different classrooms according to their ability level (a practice known as 'streaming' in Australia, 'tracking' in the USA or 'setting' in the UK) can have an influence on students' self-concept and ultimately achievement (Mehan, 1996). This is significant in the light of literature that suggests student affect and self-concept plays a significant role in motivation and disposition towards careers, particularly in STEM and mathematics (Bandura et al., 2001; Office of the Chief Scientist, 2014; Pajares & Miller, 1995; Trautwein, Lüdtke, Marsh, Köller & Baumert, 2006).

Therefore, knowledge gaps that make it hard for teachers to link curriculum content with students' career aspirations may prove detrimental to these aspirations, as can pedagogical or classroom practices that negatively influence students' self-concept or attitudes. It is important to note that showing how mathematical content relates to STEM careers is not a simple task, and as most teachers can testify, getting some students to like mathematics and see its relevance is a difficult task. Despite the initiatives of governments, professional bodies and schools, disenchantment towards mathematics persists and participation in mathematics at secondary level and STEM at tertiary continue to decline. Literature shows that mathematics teachers confront a vast number of barriers to provide relevance in their classroom or show links to STEM. These barriers include lack of resources and professional development, behaviour management issues and time and curriculum constraints (Prieto-Rodriguez, 2016).

This paper examines two factors recognised as having an impact on STEM career choice: attitudes towards mathematics and perceptions of careers in STEM. The objective of the researchers is to ascertain whether teachers' attitudes and classroom practices could have any bearing on students' attitudes and perceptions of careers. We measure the impact of teachers' attitudes and practices by analysing attitudinal survey data, subject choice in senior high school and intended career choice. We use in our analysis extensive survey data and contrast and illustrate these data with focus groups and interviews following a 10-week classroom intervention. We believe that the comparative analysis of teacher and student attitudes may provide important clues towards confronting the issue of low participation in post-compulsory mathematics at secondary level and STEM at tertiary.

Methods

This paper links data from a study conducted in 2013 with data from another study finalised in 2008. Broadly speaking, both studies investigated factors that influence students' career choices in STEM disciplines; however, they used different methodologies, and the 2013 study had a more clear focus on mathematics as an enabler of STEM careers.

The 2008 Study. This was an Australia-wide project funded by the Australian Research Council in collaboration with Engineers Australia, a professional body, and the engineering firm Ampcontrol. This large-scale project sought to find out which factors influence young people's choice of a career in engineering. In particular, it considered combinations of factors and analysed when they become important in this choice. The methodology used was largely quantitative. A full explanation of the overall sample strategy for this study, a full justification of the items and scales used and a brief synthesis of results can be found in the final report of the project (Prieto et al., 2011). Young people's attitudes towards mathematics and their perception of STEM careers are known factors influencing engineering career choice. Consequently, scales to test for their relative importance were included in surveys of secondary students and their teachers which were part of this study.

The 2013 Study. This study focused on teachers' and students' attitudes towards mathematics and perceptions of the relevance of mathematical concepts taught in their classrooms. The study also had an emphasis on whether the use of Information and Communication Technologies (ICT) would aid conveying that relevance which is not reported in this paper. The methodology used was a mixed methods research design. The study was divided into two stages. In the first stage, mathematics teachers in NSW public high schools completed a survey about their attitudes to and perceptions of relevance of mathematics. The second stage consisted of a 10-week intervention at one of these high schools. Here, pre-test and post-test data were collected in the form of surveys. Focus groups with students and interviews with teachers were also conducted at this second stage of the study. The intervention consisted of a series of enriched lessons designed to teach trigonometry showing how it can be applied to real-world situations and how STEM professionals use trigonometry in a range of fields. All enriched lessons included the use of technology to emphasise real-world connections, in particular how trigonometry and mathematics are used by STEM professionals. The topics addressed ranged from GPS technology in computer science to surveying techniques in civil engineering. Students used the internet to investigate concepts, spreadsheets to explore real data and dynamic geometry software to observe patterns and make connections between multiple representations (Goos, Galbraith, Renshaw & Geiger, 2003).

The scales to test for attitudes towards mathematics and perceptions of STEM careers used in the surveys were the same in the 2008 and in the 2013 studies. We have included data from both studies in order to be able to generalise some of our conclusions.

Research Questions

The 2013 study aimed to answer two research questions. The first one queried whether teachers possess necessary resources and dispositions to convey relevance utilising ICT. The analysis uncovered encouraging yet perhaps not surprising results: For the most part, teachers are eager and equipped to convey relevance utilising ICT resources, but teachers' ultimate goal is a good pedagogy for mathematics, ICT and relevance are two helpful tools to help them achieve it (Prieto-Rodriguez, 2016).

The second research question posed in the study queried whether relevance is a determining factor in increasing the number of students choosing high-level mathematics courses. However, as explained in the previous section, we sought to investigate whether other influences could have an impact in students' decisions regarding this choice. In particular, we also explored perceptions that teachers and students had of current issues in science, technology, engineering and mathematics and their opinions of engineering as a profession. To complement this and in light of Australian universities' concerns about student entering STEM degrees—particularly Engineering ones—without the necessary mathematics, we included a series of items to examine mathematics teacher and students' beliefs about the level of mathematics required for particular degrees. Thus, this paper addresses to two new research questions emerged from our previous studies:

1 Do teachers and students have different perceptions about aspects of STEM careers?
2 Do teachers' perception of students' attitudes towards mathematics affect students' subject/career choice?

In answering these two questions, we aim to unearth a set of closely related influences which will provide insight into some of the reasons why students choose (or not) to continue higher level mathematics beyond those already expressed in previous studies (see, for example, Brown et al., 2008; McPhan et al., 2008).

Sample

This study contains samples from 3 separate datasets with linked questions.

The First Dataset, *n* = 88. Dataset 1 contains answers to a *survey* of mathematics teachers in the first stage of the *2013 study*. In this case, a link to the online survey was sent via e-mail to all public high schools in NSW teaching years 11 and 12 (total sample size $N = 462$). In Australia, most high schools cater for students from years 7 to 12 and these comprised the majority of our sample (total sample size $N = 395$). However, our sample also included Central Schools (total sample size $N = 67$). These are commonly small in size, located in rural and remote areas, and provide K-12 education. The survey link was sent to the school Office Administrator with a request that it was to be forwarded to their mathematics faculty. Two reminders were subsequently sent, 2 and 4 weeks later. The survey was closed 2 weeks after the final reminder was sent.

The total number of respondents to this survey was n = 103, although only 88 respondents answered the questions reported in this paper. Out of these, 40 were located in urban areas, 26 in regional and 12 in rural areas. We acknowledge that it is a self-selected sample which may over-represent teachers who have a preference for ICT in their pedagogy of mathematics. However, the final sample compares to other recent studies in the field and to the overall population of mathematics teachers (Harris & Jensz, 2006; Zuber & Anderson, 2013), so we believe that the survey sample is representative of Australian mathematics teachers as a whole.

The Second Dataset, n = 49 + 2. Dataset 2 contains answers to pre- and post-intervention *surveys* of students as well as *focus group and interview* data obtained in the second stage of the *2013 study*. In this stage of the project, two classes of year 10 students and their two mathematics teachers from a public high school participated in an intervention led by the first author of this paper. The school has a mid-range socioeconomic status, just slightly above the state average. It has a low proportion of indigenous students and approximately 15 % of students have a background language other than English. The school has traditionally performed considerably well in numeracy standardised tests at year 9 level and its students are streamed by ability from year 8.

The two teachers, Mr. Brown and Mrs. Tate, have been teaching mathematics for more than 5 years. Mr. Brown is 35 years old and Mrs. Tate is 52. These are not their real names[1]. The two classes that participated in the research were the top level stream in mathematics in this high school. The school has a total of 7 class groups per year level. In New South Wales, students in the top stream follow a syllabus known as Stage 5.3 Syllabus. This syllabus contains a more in-depth approach to mathematical topics and a slightly wider variety of topics that the other two available syllabi, Stage 5.2 and Stage 5.1. Students completing the Stage 5.3 Syllabus would normally be expected to take up high level (calculus based) mathematics courses into the senior years of high school.

Of the n = 49 students who participated in the study, 25 were in Mr. Brown's class and 24 in Mrs. Tate's. Out of all participating students, 57 % were male and 43 % female. Their ages ranged between 14 years of age (12 %) and 16 years of age (4 %). All of them completed the survey before the intervention, and most of them (88 %) completed it after the intervention. Also, some students participated in one of two focus groups conducted during the intervention. The first one (from Mr. Brown's class) had 7 students, 5 of which were male and the second (from Mrs. Tate's) had 8 students, 4 of which were male. Students participating in the focus groups were selected by their teacher thinking they would represent the class in terms of their mathematical ability and their career aspirations. During the intervention, only Mrs. Tate's class received the enriched lessons delivered by the researcher. Students in Mr. Brown's class participated in the data collection process, and their responses are

[1] All individuals were de-identified for the purpose of this research. Responses to the survey were anonymous and could not be linked to individuals in the focus groups. Both the 2008 and 2013 studies had Human Ethics research approval at our institution.

used for comparison purposes. Both Mr. Brown and Mrs. Tate were interviewed in the intervention stage of the project and their responses are considered part of this dataset.

The Third Dataset, *n* = 493. Dataset 3 contains the answers to a survey of secondary students obtained in the *2008 study*. The survey was designed to survey 1400 students who were taking at least one science subject in year 11. A total of 493 students across four Australian states provided usable data for the questionnaire (a response rate of 35 %). This response rate was somewhat disappointing, but increasingly common for research in schools. Response rates were higher in urban areas, reflecting the particularly high demands on schools to participate in research. Students from a total of 22 schools participated. The overall distribution by gender of the year 11 science students was reasonable (slightly more than half the sample was female). With respect to location, the sample was composed 84 % of urban students, 13 % regional and 4 % from rural locations. The sample included 86 % of students from government schools and 14 % of students from Catholic schools. This compares with the national distribution of secondary students which is 73 % government, 17 % Catholic and 10 % independent schools. Students for whom English was a second language at home constituted 50 % of the sample. This is atypical, in part reflecting the urban bias of the sample.

Instruments

Two main instruments informed our research: a *survey* and a *focus group/interview* schedule.

In the 2013 study, the survey was administered to teachers (in the first stage of the research) and students (before and after the intervention in the second stage). This instrument contained items in two scales: 'perceptions of STEM careers'" and 'attitudes towards mathematics and STEM'. The themes contained Likert-type items in a 4-point scale.

In the 2008 Australia-wide study, the survey was administered to year 11 students and contained items in the same two scales: 'perceptions of STEM careers' and 'attitudes towards mathematics and STEM'. In this survey, themes also contained Likert-type items in a 4-point scale and their reliabilities were $\alpha = 0.65$ and $\alpha = 0.72$ respectively.

The focus groups and interviews are only part of the 2013 study in the school where the intervention took place. In these, participants were asked to briefly elaborate their perceptions and attitudes towards mathematics and STEM careers. In the case of two teachers, they were invited not only to talk about their own attitudes but also speculate what they thought their students' perceptions and attitudes would be.

Both the survey and the focus group/interview schedule contained items other than the ones reported in this paper. The full instrument for the 2008 study can be found in (Prieto et al., 2011) and the 2013 instrument can be found in (Prieto-Rodriguez, 2016). The survey questions analysed in this paper are the same across all three datasets and are described in full in the Results section of this paper.

Analysis of Survey Data

We report the results in this section in two sections which correspond to the two research questions specified in 'Research Questions'. Plausible reasons and implications of the analysis in this section, illustrated with some of the focus group and interview data, will be considered in the 'Summary of Results and Discussion' section.

In our analysis, we report means and standard deviations to give the reader an approximate idea of how respondents viewed the issues as a whole. We also use the Mann–Whitney-Wilkinson (MWW) *U* test to find whether there are significant differences instead of the perhaps more commonly used Student's *t* test. We are aware that using these measures with ordinal data is sometimes seen as controversial, but their use is widespread in Social Sciences reporting of Likert scale results (Carifio & Perla, 2008). The rational for the choice of the MWW *U* test has to do with the nature of the non-parametric data studied. While using Student's *t* tests is common practice in the Social Sciences, it has been shown that for Likert scales with a small number of points, both tests have equivalent power and that 'MWW had a power advantage when one of the samples was drawn from a skewed or peaked distribution' (De Winter & Dodou, 2010, p.1) which is the case with our data, heavily skewed towards one of the values (Agree = 2).

Do Teachers and Students Have Different Perceptions About Aspects of STEM Careers?

To answer this question, teachers (Dataset 1) and students (Dataset 2) were asked to provide an indication of their agreement with a series of statements about careers in STEM. The items were ordered in a 4-point scale ranging from 'Strongly agree' (which we coded as 1), Agree (which we coded as 2), Disagree (coded as 3) and 'Strongly disagree' (coded as '4'). The means and standard deviations are reported in Table 1.

While many of the items in this part of the survey were responded to similarly by teachers and students, a few showed statistically significant differences. In particular, students were less aware of assumed knowledge for STEM degrees (U = 1238, p = .000), less aware of the financial benefits of careers in STEM (U = 1118, p = .000) and had a propensity to think that car mechanics are in fact engineers (U = 1239, p = .015).

This result prompted us to question whether our sample of students was particularly ill informed of issues regarding STEM careers. To test whether this was the case, we used the 2008 data sample from Dataset 3 described in Section Sample. When using this dataset results were similar, in particular, in terms of assumed knowledge for STEM degrees (U = 17,724, p = .008) and the fact that they thought car mechanics are engineers (U = 12,891, p = .000).

In light of the reported misconceptions about assumed knowledge to enter STEM degrees that students—and sometimes teachers—have, we included in the survey items about the level of mathematics required to succeed in a range of STEM tertiary degrees. Here, 'level of mathematics' was measured in terms of the corresponding the course students take in the last 2 years of high school. There are four such courses in New South Wales: General Mathematics, Mathematics (2-unit), Extension Mathematics 1 and Extension Mathematics 2. The first one does not contain any calculus and is often

Table 1 Teachers perceptions of STEM careers

		Number	Mean	Std. Dev.
You must know a lot of mathematics to be an engineer	Teacher	88	1.55	0.66
	Student	47	1.32	0.47
Extension 1 and 2 mathematics are prerequisites in many STEM degrees	Teacher	85	2.04	0.78
	Student	45	1.53	0.55
Other countries have greater success in encouraging more students into STEM degrees	Teacher	77	2.12	0.63
	Student	45	2.22	0.67
Only very good students have a chance of becoming engineers or scientists	Teacher	86	2.23	0.71
	Student	46	2.43	0.89
Any shortfall of engineers and scientists in Australia should be made up by skilled migration	Teacher	86	2.69	0.86
	Student	43	2.53	0.70
Engineering is a well remunerated profession	Teacher	86	1.94	0.62
	Student	46	1.41	0.54
At school good maths students are encouraged to become scientists[a]	Teacher	86	1.90	0.77
	Student	46	2.09	0.89
A car mechanic is an engineer	Teacher	85	2.84	0.70
	Student	39	2.46	0.91
Students from higher income backgrounds are more likely to become engineers and scientists	Teacher	87	2.24	0.79
	Student	47	2.47	0.91
Engineers and scientists need to be good at thinking creatively	Teacher	87	1.72	0.60
	Student	47	1.81	0.65
The community is well informed about what mathematicians, engineers and scientists do	Teacher	87	3.28	0.68
	Student	47	3.55	0.50
Female students can become excellent mathematicians	Teacher	87	1.18	0.42
	Student	47	1.40	0.74

[a] In the teacher survey, this item was worded: "I encourage my bright students to pursue STEM degrees"

taken by students who want to choose tertiary studies which do not require any mathematics. The other 3 present an increasing level of difficulty[2].

The degrees were Physics, Electrical Engineering, Computer Science, Biology, Chemistry, Chemical Engineering, Civil Engineering, Telecommunications, Geology, and Mathematics and the distribution of results can be found in Fig. 1. A possible interpretation of the differences between teachers' and students' answers will be elaborated in the following section.

Do Teachers' Perception of Students' Attitudes Towards Mathematics Affect Students' Subject/Career Choice?

To answer this research question, teachers were asked to speculate as how many of their students would be interested in different aspects of mathematics and STEM. The items

[2] A full description of all the NSW Senior Mathematics courses can be found in the link http://www.boardofstudies.nsw.edu.au/syllabus_hsc/course-descriptions/mathematics.html

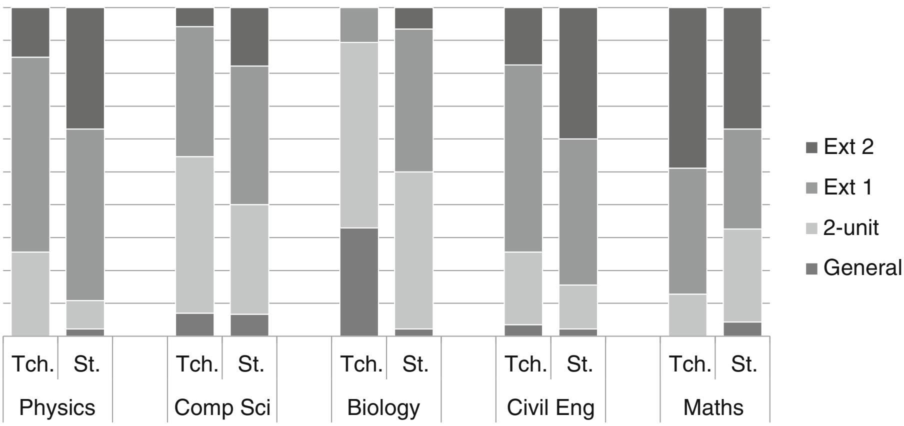

Fig. 1 What level of Mathematics is recommended for the following degrees?

were ordered in a 4-point scale ranging from 'All or almost all' (which we coded as '1') to 'None or almost none' (coded as '4'). The means and standard deviations are reported in Table 2.

We found that, in general, teachers in Dataset 1 did not believe that most of their students were interested in mathematics or admired scientists or engineers; however, most agreed that some of their students did see the usefulness of mathematics and felt that young people respect scientists and engineers.

The same questions were asked to young people in the participating school, the students in Dataset 2. In this case, the 4-point scale also ranged from 'Strongly agree' (which we coded as 1) to 'Strongly disagree' (which we coded as '4'). In this case, we were interested in seeing if our intervention had any impact on students' responses, i.e. whether students in Mrs. Tate's class in any way changed their perceptions after the 10 weeks of enriched lessons (Table 3).

It is notable that before the intervention, there were no statistically significant differences between Mr. Brown and Mrs. Tate's classes in any of the items. Most students found mathematics not particularly exciting even though they saw it would be useful important for their future careers. They felt that science and engineering are

Table 2 Teachers' perceptions of their students' attitudes towards STEM

Students in your year 10 class: teacher responses	Number	Mean	Std. dev.
Would like more of their school time spent on mathematics	87	3.10	0.61
Think mathematics is useful in everyday life	87	2.68	0.60
Find mathematics exciting	87	3.14	0.53
Think that mathematics is important in their future careers	86	2.44	0.64
Think that the mathematics they have learnt so far will be useful in their future career	87	2.83	0.59
Admire scientists and engineers	87	3.15	0.58
Feel science and engineering are respected professions	87	2.43	0.76

Table 3 Students' attitudes towards STEM before the intervention

Students in your class: student responses	Group	Number	Mean	Std. dev.
Would like more of their school time spent on mathematics	Mr. Brown	25	2.48	0.59
	Mrs. Tate	24	2.75	0.85
Think mathematics is useful in everyday life	Mr. Brown	25	1.88	0.83
	Mrs. Tate	24	1.79	0.83
Find mathematics exciting	Mr. Brown	25	3.00	0.82
	Mrs. Tate	23	3.13	0.97
Think that mathematics is important in their future careers	Mr. Brown	25	1.44	0.71
	Mrs. Tate	24	1.67	0.82
Think that the mathematics they have learnt so far will be useful in their future career	Mr. Brown	25	2.00	0.87
	Mrs. Tate	24	2.04	0.75
Admire scientists and engineers	Mr. Brown	25	2.60	1.08
	Mrs. Tate	24	2.75	1.07
Feel science and engineering are respected professions	Mr. Brown	25	1.76	0.83
	Mrs. Tate	24	1.79	0.83

respected professions, but they did not particularly admire scientists and engineers themselves.

After the intervention, students who had not received the enriched lessons did not change attitudes towards any of the items is this scale. However, students in Mrs. Tate's class, who had received the 10 weeks of trigonometry developed by the researcher, showed a significant change in the items pertaining the importance of mathematics in the future. In particular, the item asking if students in their class 'think that the mathematics they have learnt so far will be useful in their future career' showed a statistically significant change (U = 102, p = .001) (Table 4).

It is interesting to note that comparing what the sample of teachers in Dataset 1 thought of their students' attitudes towards mathematics, and what the students in the participating school thought themselves (Dataset 2), it became apparent that there is a statistically significant difference in their perceptions in all but one item in the scale (see Table 5 for details). We can conclude that, in general, students in our sample (N = 47) liked mathematics, thought it was most useful and admired scientists and engineers more than what teachers thought they did (N = 87).

We found this to be a very interesting result, which prompted us to question whether our sample of students was particularly disposed towards mathematics and readily recognised its usefulness in their future. To test whether this was the case, we used the data sample from Dataset 3 described in Section Sample. Here, a random sample of students answered the same questions except for the last one. The results are remarkably similar to the ones from the students in our participating school and the tests of significance make apparent that in general students in Dataset 3 (N = 492) 'liked mathematics', thought it was 'more useful' and 'admired scientists and engineers' more than what teachers thought they did (N = 87). In this case, the item 'Students in your class find

Table 4 Students' attitudes towards STEM after the intervention

Students in your class: student responses	Group	Number	Mean	Std. dev.
Would like more of their school time spent on mathematics	Mr. Brown	22	2.50	1.01
	Mrs. Tate	21	2.95	0.97
Think mathematics is useful in everyday life	Mr. Brown	22	1.82	0.80
	Mrs. Tate	21	2.24	0.83
Find mathematics exciting	Mr. Brown	22	2.73	0.88
	Mrs. Tate	20	3.10	0.79
Think that mathematics is important in their future careers	Mr. Brown	22	1.73	0.83
	Mrs. Tate	21	2.29	1.10
Think that the mathematics they have learnt so far will be useful in their future career	Mr. Brown	22	1.91	0.75
	Mrs. Tate	21	2.67	0.66
Admire scientists and engineers	Mr. Brown	22	2.45	1.06
	Mrs. Tate	20	2.40	1.00
Feel science and engineering are respected professions	Mr. Brown	22	1.91	0.87
	Mrs. Tate	21	1.86	1.01

mathematics exciting' also showed a better perception from the students than from the teachers. An indication of students' and teachers' perceptions (as evidenced by the means and standards deviations) can be found in Table 6. The statistical tests showing that the differences are in fact significant are presented in Table 7.

These results show that students and teachers attitudes quite clearly differ, with students reporting a greater positive attitude towards mathematics and STEM careers than teachers perceive.

Table 5 Statistical differences in items in attitudes towards STEM (I)

	Mann–Whitney U	Asymp. Sig. (2-tailed)
Would like more of their school time spent on mathematics	1179.5	.000
Think mathematics is useful in everyday life	915.5	.000
Find mathematics exciting	1691.5	.061
Think that mathematics is important in their future careers	829.5	.000
Think that the mathematics they have learnt so far will be useful in their future career	876	.000
Admire scientists and engineers	1387	.001
Feel science and engineering are respected professions	1193	.000

Grouping Variable: teacher or student in participating school

Table 6 Comparison of teachers and students' attitudes towards STEM

Students in your class:	Group	Number	Mean	Std. dev.
Would like more of their school time spent on mathematics	Teachers	87	3.10	0.61
	Students	484	2.78	0.87
Think mathematics is useful in everyday life	Teachers	87	2.68	0.60
	Students	492	2.04	0.73
Find mathematics exciting	Teachers	87	3.14	0.53
	Students	486	2.59	0.87
Think that mathematics is important in their future careers	Teachers	86	2.44	0.64
	Students	490	1.94	0.80
Think that the mathematics they have learnt so far will be useful in their future career	Teachers	87	2.83	0.60
	Students	485	2.06	0.76
Admire scientists and engineers	Teachers	87	3.15	0.58
	Students	483	2.17	0.73

Summary of Results and Discussion

In this section, we discuss the analysis of data from the surveys presented above and attempt to contextualise it using responses obtained in the student focus groups and teacher interviews. For the second research question, we are also able use the actual students' subject choices in mathematics. In our discussion, we consider the two research questions and examine the survey data and teachers' attitudes and practices in the light of: the qualitative responses obtained, decisions made by teachers with regards to classroom arrangements and students' subject choice after Year 10.

Table 7 Statistical differences in attitudes towards STEM (II)

	Mann–Whitney *U*	Asymp. Sig. (2-tailed)
Would like more of their school time spent on mathematics	17,013	.002
Think mathematics is useful in everyday life	11026.5	.000
Find mathematics exciting	13,489	.000
Think that mathematics is important in their future careers	13210.5	.000
Think that the mathematics They have learnt so far will be useful in their future career	9786	.000
Admire scientists and engineers	6943.5	.000

Grouping variable: teacher or student in national survey

Do Teachers and Students Have Different Perceptions About Aspects of STEM Careers?

The first research question prompted us to find out teachers' and students' perceptions of STEM careers. We found that the perceptions are indeed quite similar. One of the differences had to do with a common misconception regarding engineers ('A car mechanic is an engineer') which in spite of not being very common in either group seems to be more prevalent amongst students. Another has to do with the assumed knowledge for entering STEM (teachers were more aware). Importantly, we also found that, in spite of being in agreement, both teachers and students held certain misconceptions with regard these assumed knowledge. In general, teachers in Dataset 1 were better informed of assumed knowledge to commence university than students in Dataset 2. It is surprising that students would think that General Mathematics is sufficient to start a Physics or a Mathematics degree, although it is more surprising that 19 teachers would think that General Mathematics is enough to start a Civil Engineering degree.

This finding is troublesome as young people entering STEM degrees in recent years in Australia are not doing it so with the appropriate level of mathematics and this is leading to high attrition in STEM degrees and ultimately contribute to skill shortages. In this case, we would tend to agree with Mrs. Tate, who elaborated extensively about this issue:

> [To do engineering] I would say a minimum of two unit[3]. Three unit if possible would be of benefit and I would always push them to do four unit if they can. But anything, I mean two unit if they only do two unit and don't do it really well, they are going to be trouble with engineering level mathematics at uni. Definitely. If they have even been exposed to three unit and did adequately with it, they will still be better off at uni because things will be that much easier. It won't be brand new, learning from scratch. Just even a modicum of familiarity is going to make it just that much easier, even if they don't do amazingly well at three unit.

The idea of financial benefits also figured differently in student and teacher responses, the teachers being better aware of the potential financial rewards of an engineering career. Both Mrs. Tate and Mr. Brown talked about remuneration of engineers, but in opposite ways. Mr. Brown, when asked if he would encourage his students to be scientists, mathematicians or engineers, responded "Yes. Much better money than what we get". Mrs. Tate, answering the same question, said she would definitely encourage them, but elaborated further:

> We don't have enough [engineers and scientists] and it is just not valued enough in society. I mean, the amount of people going into management and economic

[3] Mrs. Tate uses in the quote outdated language for the names of the courses. 'Three unit' refers to Extension 1 Mathematics under the new NSW Curriculum terminology, and 'four unit' to Extension 2. This use of outdated terminology is very common. The documents containing the official NSW Syllabus still refer to the courses in the same way as Mrs. Tate.

> degrees, and business degrees is because they smell the money. […] I would love them to go into science and mathematics, but a big issue is that they don't see the financial rewards of it, because our society doesn't value those jobs enough by paying them appropriately for how it benefits… society benefits hugely from all of those…

Do Teachers' Perception of Students' Attitudes Towards Mathematics Affect Students' Subject/Career Choice?

In line with the data analysis, we argue that the survey analysis reported in the previous section allows us to answer our second research question. Our results show that student attitudes and teachers' perceptions of those attitudes quite clearly differ. From the responses to the surveys in the three datasets, students report a greater positive attitude towards mathematics and careers in STEM than teachers seem to believe they have.

The focus group and interview data illustrate both students' attitudes and teachers' perceptions and give the research further depth. During the focus groups, students quite clearly indicated that they feel mathematics is important for the future, particularly 'if you want a well-paying job' (student in Mr. Brown's class, Dataset 2). Young people in Mrs. Tate's class elaborated on the fact that statistics was going to be important for their future careers and in their everyday lives. Mrs. Tate emphasised this everyday live aspect of her teaching:

> Even if they don't use mathematics in their career, they need to be able to make sure that they are being paid appropriately, they need to be able to do financial maths to make appropriate decisions about investments, about their superannuation, about buying a fridge, ordinary things like that, unit pricing in the grocery story, percentage of sugar in the cereal for the children.

Mr. Brown, in contrast, believed that his students' most important motivation to study mathematics was to 'chase the ATAR', i.e. obtaining highest possible grade to enter university. Issues surrounding how the Australian Tertiary Admission Rank (ATAR) and the NSW High School Certificate scores are calculated are believed to be leading to students to take lower level mathematics and are currently in the spotlight in Australia (Pitt, 2015; Tisdell, 2014).

The objective of our research was to ascertain whether teachers' perceptions of their students can have any bearing on their students' attitudes towards mathematics and careers in STEM. While we acknowledge that this is a very difficult task, we planned an intervention aimed at changing students attitudes and attempted at seeing if a very similar group of students that did not receive that intervention would show any significant difference from the intervention group.

Our intervention, described in the 'Methods' section, took successful elements from the interventions mentioned in the introduction such as the use of role models, the use of video and the linking between mathematical concepts and STEM careers with innovative pedagogies.

To measure the success of the intervention, we used the student pre- and post-intervention surveys discussed in the previous section. Further to the results obtained with the surveys, we also considered students' choices for senior high school mathematics. Students in both classes were in year 10 at the time of the intervention and the choice of senior mathematics subjects was made approximately 1 month after the intervention took place. We believe that students' intention to study high level mathematics indicates their potential interest in following the STEM career path.

Unknown to the research team at the time of preparing the intervention, students in the two classes at the school participating in the study had been further streamed by their teachers. Both classes followed the same Stage 5.3 Syllabus, but students in Mr. Brown's class were told from the outset that they had been selected as the top class within the Stage 5.3 stream. Mrs. Tate's students were still in the top of the school, but were told they were the second class. The streaming had been performed according to their test scores in the National Assessment Program – Literacy and Numeracy (NAPLAN), a national standardised test they took in year 9. Students in Mr. Brown's class had the 25 top scores, and students in Mrs. Tate's the following 24 scores.

Even though students' attitudes and interest in mathematics and careers in STEM were virtually identical in both classes, as evidenced in Table 3, their choices after year 10 were vastly different. Table 8 below shows a breakdown of students' choices in the two classes.

This apparent discrepancy prompted us to investigate and compare how students had answered the questions relating to the importance of mathematics in their future careers during the focus group discussions. When asked what career they wanted to pursue and what level of mathematics they thought they would need in order to pursue it, most of Mr. Brown's students indicated that only low or mid-level mathematics was necessary for what they wanted, but that they would probably needed to study more 'if you want a well-paying job'. Two said they wanted to become primary school teachers ("I am doing primary teaching, so don't really need a higher level"), while others wanted to be a physiotherapist, in the defence force and a doctor 'or something interesting like that'. Only one student, who wanted to be a pharmacist, advanced: "I probably need a level of maths". Many agreed with a student that said: "for what I want to do I don't need high level, so [I will do] just basic [maths]". In contrast, students in Mrs. Tate class were well aware of the need to study mathematics and chose professions such as pilot ("I will definitely need trig and stuff"), or anaesthetist ("[…]maths is definitely something I will need in my senior levels"), electrical engineer, chemical engineer, zoologist and radiologist. Only two chose non-STEM professions, an artist and a policeman.

Therefore, it would appear that, at the time of the intervention, the two groups of students were pretty similar in their attitudes towards mathematics and STEM careers, with Mrs. Tate's class demonstrating a greater positive attitude. In fact, Mrs. Tate herself was more proactive at encouraging her students in the STEM career path,

Table 8 Student choices after year 10 by gender

	General mathematics		2-Unit mathematics		Extension 1 and 2 mathematics	
	Male	Female	Male	Female	Male	Female
Mr. Brown's class	0	1	5	8	6	9
Mrs. Tate's class	8	2	8	4	2	0

whereas Mr. Brown seemed more concerned in facilitating his students' optimisation of ATAR scores.

The facts discussed above would seem to indicate that the difference in subject choice could be explained by factors to do with the division of the top group of the school into two separate classes according to achievement in the national standardised test. This would mean that students' prior achievement is the most significant factor in influencing students' choice of subject, and not their personal liking for the subject or inclination towards a STEM career in the future. While prior achievement is known to be an important factor in subsequent student achievement, it is not the main one (Hattie, 2003). In this case, the research team believes that students' self-concept, and particularly the way they perceived what their teachers thought they were capable of, played also a major role. In fact, because of the conversations held with students summarised above, we hypothesise that the streaming into two classes played a major influence on students' self-concept and consequently their choice of senior mathematics. This is consistent with research both on the impact of teacher's explicit praise of their students (Cohen & Garcia, 2014) and their school learning environment (Shouse, 1996). We aim to investigate the issue further as future research emerging from this project.

Conclusions

In the analysis of results, three main themes strongly emerged from the study of our three datasets. Firstly, with regard to attitudes to mathematics, usefulness of mathematics in the future and STEM professions, we found out that teachers in our sample had a perception of their students' attitudes that clearly (and with statistical significance) differed from students' self-reported attitudes. This result is important considering how much influence teachers' perceptions have proven to potentially affect student self-concept and ultimately career choice (Cohen & Garcia, 2014; Maltese & Tai, 2011; Metheny, McWhirter & O'Neil, 2008).

Secondly, we found that an intervention designed to show relevance of mathematical content and link it to careers in STEM, while not having an effect in terms of students liking of mathematics, did change their views with regard to its usefulness in future career paths corroborating previous research on the effectiveness of such initiatives (Maltese & Tai, 2011; Wyss et al., 2012).

Lastly, even though the intervention did show an increase in students' perceptions of the usefulness of mathematics for their future careers, unexpectedly, the students who participated in the enriched classes were heavily skewed towards choosing General Mathematics (a lower level course unsuitable for most STEM degrees) for senior high school. The main characteristic that distinguished the two classes was the streaming of students based on results from a national standardised test taken in year 9. While we acknowledge that this is only a small sample of students, we believe our results would suggest that an implementation of streaming based on standardised test scores can be disadvantageous to students who have a natural inclination towards STEM and positive attitudes towards mathematics such as those in the focus group of the intervention class. This conclusion, notwithstanding the reservations expressed above, is consistent with previous research indicating that streaming has a negative impact on academic self-concept for students who are not placed in the top stream, and positive impacts on students in top streams, particularly in mathematics (Mehan, 1996; Zevenbergen, 2001, 2005). Our results are not conclusive, and thus, we aim to investigate the issue further.

Future Research

It appears there is enormous potential to bridge the gap between classroom mathematics and STEM career opportunities; however, several very important factors have to be taken into consideration, such as academic self-concept motivated by streaming practices. Findings of the present study would be strengthened by larger research into the impacts and interactions of streaming and perceptions of STEM/STEM careers. Results of the present study speak to salient points within research on the importance of awareness surrounding STEM fields and classroom intervention to increase student interest with literature on the effects of streaming and high-stakes-test focussed classroom practices and school environments. These are important findings that have significant implications for researchers, teachers and policymakers invested in increasing interest and enrolment in higher levels of mathematics and STEM fields. These findings suggest that policy changes targeting mathematics and STEM enrolment (as well as equity in mathematics education) cannot be looked at in isolation from the practices of individual schools and the broader context that shape these practices.

Also, an issue of concern to the researchers is the fact that two students who wanted to be primary school teachers felt that the lowest level of senior mathematics was sufficient preparation for this role. While this is perhaps a common perception amongst preservice teachers and we did not specifically tested for it in the comparisons reported in Fig. 1, we believe the issues of misconceptions surrounding the level of mathematics to undertake certain professions are pertinent to this research. In fact, an Australia-wide shortage of STEM graduates will not only lead to a shortage in the engineering and scientific workforce, but also a shortage of future science and mathematics teachers. This factor, teacher qualification, is significantly associated to high student achievement, particularly in mathematics (Wayne & Youngs, 2003, p. 102). Australian figures estimate that more than half of teachers in junior secondary mathematics do not have a 3-year qualification in this subject (McKenzie, Weldon, Rowley, Murphy & McMillan, 2014). A line of future enquire for the research team is testing the two research questions in this study in the junior secondary school context.

References

Ainley, J. & Khoo, S. T. (2005). *Attitudes, intentions and participation (Longitudinal Studies of Australian Youth Report No. 41)*. Melbourne, Australia: ACER.

Australian Mathematical Sciences Institute (2012). *Maths for the Future: Keep Australia Competitive*. Australia: Australian Mathematical Sciences Institute.

Bandura, A., Barbaranelli, C., Caprara, G. V., Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187–206.

Boaler, J. (1993). The role of contexts in the mathematics classroom: do they make mathematics more "real"? *For the Learning of Mathematics, 13*(2), 12–17.

Bodzin, A. & Gehringer, M. (2001). Breaking science stereotypes. *Science and Children, 38*(4), 36–41.

Brown, M., Brown, P. & Bibby, T. (2008). "I would rather die": reasons given by 16-year-olds for not continuing their study of mathematics. *Research in Mathematics Education, 10*(1), 3–18.

Carifio, J. & Perla, R. (2008). Resolving the 50-year debate around using and misusing Likert scales. *Medical Education, 42*(12), 1150–1152.

Chen, C.-H. & Howard, B. (2010). Effect of live simulation on middle school students' attitudes and learning toward science. *Journal of Educational Technology and Society, 13*(1), 133–139.

Cohen, G. & Garcia, J. (2014). Educational theory, practice, and policy and the wisdom of social psychology. *Policy Insights from the Behavioral and Brain Sciences, 1*(1), 13–20.

Darling-Hammond, L. (2000). Teacher quality and student achievement. *Education Policy Analysis Archives, 8*, 1.

De Winter, J. C. & Dodou, D. (2010). Five-point Likert items: t test versus Mann–Whitney-Wilcoxon. *Practical Assessment, Research and Evaluation, 15*(11), 1–12.

Dick, T. P., & Rallis, S. F. (1991). Factors and influences on high school students' career choices. *Journal for Research in Mathematics Education*, 281–292.

Dobson, I. (2013). *Unhealthy science? University Natural and Physical Sciences 2002 to 2009/10*. Melbourne, Australia: Monash University Centre for Population and Urban Research.

Goos, M., Galbraith, P., Renshaw, P. & Geiger, V. (2003). Perspectives on technology mediated learning in secondary school mathematics classrooms. *The Journal of Mathematical Behavior, 22*(1), 73–89.

Grootenboer, P. (2013). The praxis of mathematics teaching: developing mathematical identities. *Pedagogy, Culture and Society, 21*(2), 321–342.

Harris, K.-L. & Jensz, F. (2006). *The preparation of mathematics teachers in Australia: Meeting the demand for suitably qualified mathematics teachers in secondary schools*. Melbourne, Australia: Centre for the Study of Higher Education.

Hattie, J. (2003). *Teachers make a difference: What is the research evidence?* Melbourne, Australia: ACER.

Hayes, D., Mills, M., Christie, P. & Lingard, B. (2006). *Teachers and schooling making a difference: Productive pedagogies, assessment and performance*. Crows Nest, Australia: Allen & Unwin.

Holton, D., Muller, E., Oikkonen, J., Sanchez Valenzuela, O. A. & Zizhao, R. (2009). Some reasons for change in undergraduate mathematics enrolments. *International Journal of Mathematical Education in Science and Technology, 40*(1), 3–15.

Kennedy, J., Lyons, T. & Quinn, F. (2014). The continuing decline of science and mathematics enrolments in Australian high schools. *Teaching Science, 60*(2), 34.

Kukreti, A., Islam, S., Oerther, D., Davies, K., Turner, M., Maltbie, C. & Fowler, T. (2005). *Investigating student interest in post-secondary STEM education.* Paper presented at the American Society for Engineering Education Annual Conference, Portland, OR.

Leder, G. & Grootenboer, P. (2005). Affect and mathematics education. *Mathematics Education Research Journal, 17*(2), 1–8.

Maltese, A. V. & Tai, R. H. (2010). Eyeballs in the fridge: sources of early interest in science. *International Journal of Science Education, 32*(5), 669–685.

Maltese, A. V. & Tai, R. H. (2011). Pipeline persistence: examining the association of educational experiences with earned degrees in STEM among US students. *Science Education, 95*(5), 877–907.

McKenzie, P., Weldon, P. R., Rowley, G., Murphy, M. & McMillan, J. (2014). *Staff in Australia's schools 2013: Main report on the survey.* Melbourne, Australia: ACER.

McPhan, G., Morony, W., Pegg, J., Cooksey, R. & Lynch, T. (2008). *Maths? Why not*. Canberra, Australia: Department of Education, Employment and Workplace Relations.

Mehan, H. (1996). *Constructing school success: The consequences of untracking low achieving students*. New York, NY: Cambridge University Press.

Metheny, J., McWhirter, E., O'Neil, M. (2008). Measuring perceived teacher support and its influence on adolescent career development. *Journal of Career Assessment*, 218–237.

Office of the Chief Scientist (2012). *Mathematics, engineering & science in the national interest*. Canberra, Australia: Australian Government.

Office of the Chief Scientist (2014). *Science, technology, engineering and mathematics: Australia's future*. Canberra, Australia: Australian Government.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049–1079.

Pajares, F. & Miller, M. D. (1995). Mathematics self-efficacy and mathematics performances: the need for specificity of assessment. *Journal of Counseling Psychology, 42*(2), 190.

Pitt, D. G. (2015). On the scaling of NSW HSC marks in mathematics and encouraging higher participation in calculus-based courses. *Australian Journal of Education, 59*(1), 65–81.

Prieto-Rodriguez, E. (2016). It Just Takes so Much Time!: A Study of Teachers' Use of ICT to Convey Relevance of Mathematical Content. *International Journal for Technology in Mathematics Education, 23*(1), 13–24.

Prieto, E., Holbrook, A., Bourke, S., O'Connor, J., Page, A., & Husher, K. (2009). Influences on engineering enrolments. A synthesis of the findings of recent reports. *European Journal of Engineering Education, 34*(2), 183–203.

Prieto, E., Bourke, S., Holbrook, A., O'Connor, J., Page, A., & Husher, K. (2011). *Engineering Choices, Engineering Futures*. Australia: The University of Newcastle.

Shouse, R. C. (1996). Academic press and sense of community: Conflict, congruence, and implications for student achievement. *Social Psychology of Education, 1*(1), 47–68.

Tai, R., Qi, L. C., Maltese, A. & Fan, X. (2006). Career choice. Planning early for careers in science. *Science, 312*(5777), 1143–1144.

Tisdell, C. (2014). Maximising ATARs: why studying maths doesn't add up. *The Conversation*. Retrieved from: http://theconversation.com/maximising-atars-why-studying-maths-doesnt-add-up-32602.

Trautwein, U., Lüdtke, O., Marsh, H. W., Köller, O. & Baumert, J. (2006). Tracking, grading, and student motivation: using group composition and status to predict self-concept and interest in ninth-grade mathematics. *Journal of Educational Psychology, 98*(4), 788.

Tripney, J., Newman, M., Bangpan, M., Niza, C., Mackintosh, M. & Sinclair, J. (2010). *Factors influencing young people (aged 14–19) in education about STEM subject choices: A systematic review of the UK literature*. London, United Kingdom: EPPI.

Tytler, R., Osborne, J., Williams, G., Tytler, K. & Cripps Clark, J. (2008). *Opening up pathways: Engagement in STEM across the primary-secondary school transition*. Canberra, Australia: Department of Education, Employment and Workplace Relations.

Wang, J. & Staver, J. R. (2001). Examining relationships between factors of science education and student career aspiration. *The Journal of Educational Research, 94*(5), 312–319.

Wayne, A. J. & Youngs, P. (2003). Teacher characteristics and student achievement gains: A review. *Review of Educational Research, 73*(1), 89–122.

Wyss, V. L. (2013). Developing videos to better inform middle school students about STEM career options. *TechTrends, 57*(2), 54–62.

Wyss, V. L., Heulskamp, D. & Siebert, C. J. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental and Science Education, 7*(4), 501–522.

Zevenbergen, R. L. (2001). Is streaming an equitable practice?: Students' experiences of streaming in the middle years of schooling. In J. Bobis, B. Perry & M. Mitchelmore (Eds.), *Numeracy and beyond: Annual Conference of the Mathematics Education Research Group of Australasia* (Vol. 2, pp. 563–570). Sydney, Australia: MERGA.

Zevenbergen, R. L. (2005). The construction of a mathematical habitus: Implications of ability grouping in the middle years. *Journal of Curriculum Studies, 37*(5), 607–619.

Zuber, E. & Anderson, J. (2013). The initial response of secondary mathematics teachers to a one-to-one laptop program. *Mathematics Education Research Journal, 25*(2), 279–298.