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Enabling learners starts with knowing them: Student attitudes, aspiration and anxiety towards science and maths learning in an Australian pre-university enabling program

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Pre-university enabling programs provide an important pathway to university for underprepared and disadvantaged students. In order to adequately prepare students for their university journey, enabling educators need to understand and respond to the evolving needs of their learners; not only their academic disparity, but also their past learning experiences and perceptions towards particular subjects. In the current study, students entering an Australian enabling program, 'OnTrack', were surveyed on their attitudes, emotions and aspirations towards the study of science and mathematics. Responses were associated with student perceptions of their past science and maths learning experiences. There was incongruity between student expectations of what future study would entail and the realities of their degree choices and career aspirations. This study suggests the need for social and emotional learning and teacher training. Greater attention should be given to both student's affective needs and their understanding of future course content during their enabling education experience to *redress negative emotional learning experiences and safeguard student expectations, satisfaction, and retention in the future.*

Keywords: *enabling program, affective domain, attitudes, emotion, science, mathematics*

Introduction

Background

Over the past several decades, Australian universities have undergone significant transformation. Historically, a university education was reserved for the elite minority, however contemporary universities now provide more accessible tertiary qualifications for an increased proportion of the community and from a broader socio-cultural spectrum. This was, in part, driven by the Federal Government's widening participation agenda (Bradley, Noonan, Nugent & Scales, 2008) and the rise of non-traditional pathways to access university, including government-assisted enabling programs (Gale & Tranter, 2011). The Higher Education Support Act (2003), defines an enabling course as 'a course of instruction provided to a person for the purpose of enabling the person to undertake a course leading to a higher education award' (DotAG, 2003, p. 215). For universities, this describes pre-university courses originally designed to prepare mature-age and disadvantaged student groups for degree-level courses. However, an increasing number of students of school-leaving age are now also entering universities via enabling programs. Interestingly, these younger people include those who have not completed secondary schooling due to socio-cultural reasons (Ross & Gray, 2005), and those that Hodges, Bedford, Hartley, Klinger, Murray, O'Rourke and Schofield (2013, p. 16) suggest are 'becoming somewhat strategic and selecting enabling programs as a legitimate pathway for Higher Education'. Indeed, enrolments in *OnTrack*, the principal enabling program at Murdoch University in Perth, Western Australia, have increased steadily and considerably since its inception in 2008 (Lisciandro & Gibbs, 2016).

In parallel with increasing enrolments, the aspirations and undergraduate study choices of *OnTrack* pathway students also diversified over time, with a higher proportion of students choosing to undertake undergraduate study in a variety of science, technology, engineering and mathematics (STEM) disciplines, instead of predominantly the arts and social sciences (Lisciandro & Gibbs, 2014). This is paradoxical given recent national trends indicating declining numbers of students pursuing STEM-related careers and tertiary study more broadly (Dobson, 2006). Similarly, the number of students taking non-compulsory secondary school science has also fallen in recent decades (Hassan, 2008). According to the 2006 Programme for International Student Assessment (PISA) report on scientific literacy in Australia, 'fewer students reported that they will use science when they are an adult' or believe that science has applications in their everyday lives (Thomson & De Bortoli, 2008). Mathematics is intimately entwined in science and technology, yet for years concerns have been raised about Australia's diminishing ability in maths and statistics, and there have been desperate calls for action to reverse a 'fatal course' for mathematical sciences in this country (Hughes & Rubenstein, 2006, p. 1). Indeed, the number of secondary school students choosing to study maths in their senior years has fallen over the last 20 years, and pre-requisite subjects have been removed as a barrier to degree choice at many Australian universities (Nicholas, Poladian, Mack & Wilson, 2015, p. 38).

It is incumbent that enabling programs prepare students for their chosen undergraduate studies, including STEM related courses. However, in order to adequately prepare students for the tertiary curriculum ahead, as well as design engaging and effective learning experiences during the enabling program, it is crucial that educators first know and understand their learners, and their learning needs (Hattie, 2009; Jones, Olds & Lisciandro, 2016b). Recognising and fulfilling the needs of learners may be complicated by large differences in student demographics, educational background, aspirations, interests and motivations (Hodges et al., 2013; Lisciandro & Gibbs, 2014, 2016). Further, enabling students arrive with diverse past learning experiences, some of which may have been negative or even traumatic, influencing student confidence, self-efficacy, beliefs, attitudes and anxiety around learning (Haylock & Manning, 2014; Klinger, 2008a). For example, some earlier research found that adult learners commencing enabling education had lower self-efficacy, negative attitudes and raised anxiety levels related to maths learning than commencing undergraduate students, 'manifesting in lack of confidence, apprehension, and behaviours associated with reduced engagement with maths learning opportunities' (Klinger, 2008a, p. 204). This was linked with both negative past learning experiences and a history of educational disadvantage.

Addressing aspirations, attitudes and emotions amongst enabling program students

The *OnTrack* program is offered as a full-time, on-campus 14-week program delivered biannually across all regional and metropolitan campuses of Murdoch University. It comprises a single, fully integrated and multi-disciplinary curriculum that aims to develop student academic, transitional and socio-emotional learning skills (Jones, Lisciandro & Olds, 2016a). Over time, the program has been shaped in response to the changing needs and evolving demographic of commencing students (Jones et al., 2016b; Lisciandro & Gibbs, 2014). Notably, understanding our learners not only includes understanding their academic disparities, but also their past experiences and perceptions towards subjects, in order to develop and teach curriculum to redress negative emotional learning experiences.

Research shows that attention to student's affective needs is crucial to their learning. The affective domain includes 'feelings, emotions, attitudes, motivations and values' (van der Hoeven Kraft, Srogi, Husman, Semken & Fuhrman, 2011, p. 72) and forms a part of Bloom's Taxonomy of Educational Objectives (Savic & Kashef, 2013). The term 'attitude' refers to 'the tendency to respond to an object or situation in a favourable or unfavourable way' (Parnis & Petocz, 2016, p. 554). According to Osborne, Simon and Collins (2003, p. 1053), attitudes towards science encompass the 'feelings, beliefs and values about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves'. It has also been defined as the perceived usefulness of science, aspirations towards science as a career, and feelings towards having to study science in the curriculum (Hassan, 2008). Research suggests that a student's attitude towards a subject may affect their academic success by influencing behaviour, including effort regulation (Li, 2012; Parnis & Petocz, 2016). Further, emotions experienced by students in academic settings may affect student motivation, cognitive processes and academic performance, as well as students' psychological wellbeing (Pekrun, Goetz, Titz & Perry, 2002). Larkin and Jorgensen completed a study into primary school mathematic experiences contending that 'having negative emotions or attitudes towards mathematics in these formative years may be creating potential for students to create a mathematics habitus that is not conducive to positive experiences of mathematics' (2016, p. 926). Their research stemmed from studies demonstrating that negative experiences with mathematics are linked with negative emotional responses such as anxiety, fear and embarrassment, consequently affecting student outcomes (Frenzel, Pekrun & Goetz, 2007a; Larkin & Jorgensen, 2016; Prawat & Anderson, 1994). Certain demographic characteristics such as female gender and increasing age are also associated with a higher likelihood of negative affective dispositions towards maths (Hill, Mammarella, Devine, Caviola, Passolunghi & Szűcs, 2016; Maloney & Beilock, 2012). In the university context, mature age students are more likely to experience lower levels of maths self-efficacy and increased maths anxiety than traditional school-leavers (Jameson & Fusco, 2014). Since early success in developmental and remedial mathematics courses at university influences student persistence, the importance of addressing affective factors as part of these student outcomes has been increasingly recognised (Benken, Ramirez, Li & Wetendorf, 2015).

The aim of the current study was to characterise the range of past learning experiences, attitudes, emotions and aspirations towards science and maths learning amongst a cohort of students entering an Australian pre-university enabling program. While this has been studied in other contexts (e.g. K-12 school students), affective dispositions towards science and maths learning in enabling contexts requires further attention. Additionally, strategies that address student affective needs, for example through incorporating opportunities for social and emotional learning, are also explored herein. Given national trends in science and maths literacy, understanding students' affective as well as cognitive needs, particularly amongst enabling student cohorts that are likely to have experienced educational disadvantage, will better inform future curriculum design as well as teaching and learning practices in this and similar programs across Australia.

Methods

Study design

Permission was granted by the Human Research Ethics Committee at Murdoch University (Approval No. 2014/032) to conduct a paper-based survey with all *OnTrack* students who enrolled in the program during its two iterations in 2014. The purpose of this survey was to ascertain pre-existing student attitudes, emotions, aspirations and motivation towards studying science and numeracy upon entering the *OnTrack* program. The survey was checked for face validity (ease of use, clarity and readability) before administering.

The anonymous survey was conducted early in the 14-week program (Week 3) and prior to student exposure to any science or numeracy content. The survey was voluntary and no *OnTrack* staff or researchers were present in the room during the process to minimise risks related to non-consent. Completed surveys were collected by a student representative from each class and deposited into a secure assignment box on campus for later retrieval by researchers. Survey responses were transcribed into an electronic database (Microsoft Excel).

Data analysis

The surveys collected nominal and ordinal data (quantitative information), and qualitative responses. All statistical analyses of quantitative data were undertaken using Statistical Package for Social Sciences (SPSS), version 24.

Negative past learning experiences were defined as those rated as ‘not good’ or ‘horrible’, neutral past experiences defined as those rated as ‘ok’, and positive past experiences were defined as those rated as ‘good’ or ‘excellent’ by respondents. A semantic approach using Braun and Clarke’s (2006, pp. 87-93) first five (of six) phases of thematic analysis was selected to qualitatively examine the language used to describe the reasons for student ratings of their past experiences. A ‘semantic’ approach rather than ‘latent’ was utilised, as the focus of this analysis was on student comments (Braun & Clarke, 2006, p. 84). A research assistant who was not involved in the original research collection phase conducted the first three analysis phases to avoid research bias. This involved reading and re-reading the student survey answers (phase 1), and coding the language features (phase 2). Qualitative responses were classified into categorical data where appropriate using NVivo (version 11), and a word frequency query was run to determine frequently used terms, which could then be categorised into loose themes. Synonyms for these terms were used to expand the list of terms. The responses were then re-read for themed terms and coded. From here the coded data was grouped into more refined key themes (phase 3). The research assistant and researchers then mapped and reviewed themes and coding (phase 4), and finally themes were named and defined (phase 5) before a final report could be written.

Commencing *OnTrack* students were asked about their feelings regarding the prospect of future science and maths learning as an indicator of pre-existing attitudes and emotional responses towards science and maths education. Students could nominate as many terms that captured their feelings, or write down others not listed. Correlating response patterns (see Tables 1 and 2) suggested that students could be broadly categorised into three main groups which were not necessarily mutually exclusive: (1) those expressing negative attitudes by indicating that they were 'not interested', 'unhappy' and/or 'uncomfortable'; (2) those expressing positive attitudes by indicating that they felt 'motivated', 'interested', 'happy' and/or 'excited'; and (3) those expressing an anxiety/fear/stress response by indicating that they felt 'scared', 'anxious' and/or 'overwhelmed' by the prospect of future science or maths learning. Negative attitude response patterns generally correlated with anxiety/fear/stress response patterns, and inversely correlated with positive response patterns. These correlating response patterns indicate the reliability (i.e. degree of internal consistency and repeatability) of this measure.

***Table 1:** Feelings towards the prospect of future science education in commencing **OnTrack** students: correlating responses reveal "negative" and "positive" attitude, and "anxiety/fear/stress" response patterns*

Correlations between responses[1,2]	Student responses to the question: *"In general, what is your overall feeling/s towards the prospect of studying science? (tick as many of the responses that apply to you)"*										
	Motivated	Interested	Happy	Not interested	Unhappy	Uncomfortable	Scared	Anxious	Overwhelmed	Don't care	Not sure
Excited	0.525***	0.351***	0.431***	-0.227***	-0.149**	-0.194***	-0.023	0.063	-0.048	-0.214***	-0.211***
Motivated	X	0.344***	0.381***	-0.244***	-0.150**	-0.195***	0.023	0.025	-0.032	-0.216***	-0.241***
Interested		X	0.302***	-0.475***	-0.258***	-0.299***	0.005	0.120*	-0.043	-0.295***	-0.243***
Happy			X	-0.182***	-0.087	-0.157**	0.007	0.029	-0.015	-0.083	-0.149**
Not interested				X	0.214***	0.183***	-0.032	-0.017	0.117*	0.226***	0.055
Unhappy					X	0.333***	0.266***	0.155**	0.180***	0.078	0.045
Uncomfortable						X	0.266***	0.270***	0.182***	0.044	0.048
Scared							X	0.352***	0.316***	-0.047	0.005
Anxious								X	0.267***	-0.071	0.029
Overwhelmed									X	0.051	0.056
Don't care										X	0.154**
	Positive attitude response pattern			*Negative attitude response pattern*			*Anxiety/fear/stress response pattern*			*Other responses*	

[1] Significant associations at the p<0.05 level are highlighted in grey; dark grey indicates a positive correlation and light grey indicates a negative/inverse correlation. Note: not corrected for multiple comparisons, thus exercise discretion in the interpretation of results.
[2] Phi correlation coefficients are reported in order to assess the relationship of dichotomous with other dichotomous variables. Association data not replicated on the bottom left of the table.
* indicates 2-sided p-value <0.05
** indicates 2-sided p-value <0.01
*** indicates 2-sided p-value <0.001

***Table 2:** Feelings towards the prospect of future maths education in commencing OnTrack students: correlating responses reveal "negative" and "positive" attitude, and "anxiety/fear/stress" response patterns*

Correlations between responses[1,2]	Student responses to the question: *"In general, what is your overall feeling/s towards the prospect of studying mathematics? (tick as many of the responses that apply to you)"*										
	Motivated	Interested	Happy	Not interested	Unhappy	Uncomfortable	Scared	Anxious	Overwhelmed	Don't care	Not sure
Excited	0.504***	0.336***	0.409***	-0.208***	-0.131**	-0.173***	-0.027	0.011	-0.030	-0.162**	-0.142**
Motivated	X	0.332***	0.373***	-0.249***	-0.185***	-0.226***	-0.001	-0.010	-0.045	-0.171***	-0.163**
Interested		X	0.320***	-0.401***	-0.276***	-0.272***	-0.102*	-0.023	-0.089	-0.196***	-0.147**
Happy			X	-0.157**	-0.151**	-0.201***	-0.130**	-0.217***	-0.044	-0.022	-0.157**
Not interested				X	0.415***	0.247***	0.091	0.048	0.137**	0.243***	0.006
Unhappy					X	0.487***	0.263***	0.129**	0.271***	0.064	-0.073
Uncomfortable						X	0.338***	0.260***	0.367***	-0.025	-0.060
Scared							X	0.378***	0.355***	-0.123*	0.003
Anxious								X	0.331***	-0.156**	0.005
Overwhelmed									X	0.027	-0.046
Don't care										X	0.044
	Positive attitude response pattern			*Negative attitude response pattern*			*Anxiety/fear/stress response pattern*			*Other responses*	

[1] Significant associations at the $p<0.05$ level are highlighted in grey; dark grey indicates a positive correlation and light grey indicates a negative/inverse correlation. Note: not corrected for multiple comparisons, thus exercise discretion in the interpretation of results.
[2] Phi correlation coefficients are reported in order to assess the relationship of dichotomous with other dichotomous variables. Association data not replicated on the bottom left of the table.
* indicates 2-sided p-value <0.05
** indicates 2-sided p-value <0.01
*** indicates 2-sided p-value <0.001

In order to measure the degree of correlation between two binary variables, phi correlation coefficients were used. Where frequency data are reported, Pearson Chi-square ($\chi 2$) analyses were undertaken to investigate associations. Associations were considered statistically significant if p-values were less than 0.05.

Findings

Cohort demographics and student response rate

Of the students enrolled in the *OnTrack* program at the point of administering the survey, 59% (300/509) were female and 38% (185/509) attended one of the university's regional campuses. Fifty eight per cent (296/509) of students were aged 19 years or younger, 29% (147/509) were aged 20–29 years, 6.5% (33/509) were aged 30–39 years, and 6.5% (22/509) were aged 40 years or older. Thirty per cent (153/509) of the cohort were from low SES backgrounds and 9% (47/509) were from non-English speaking backgrounds.

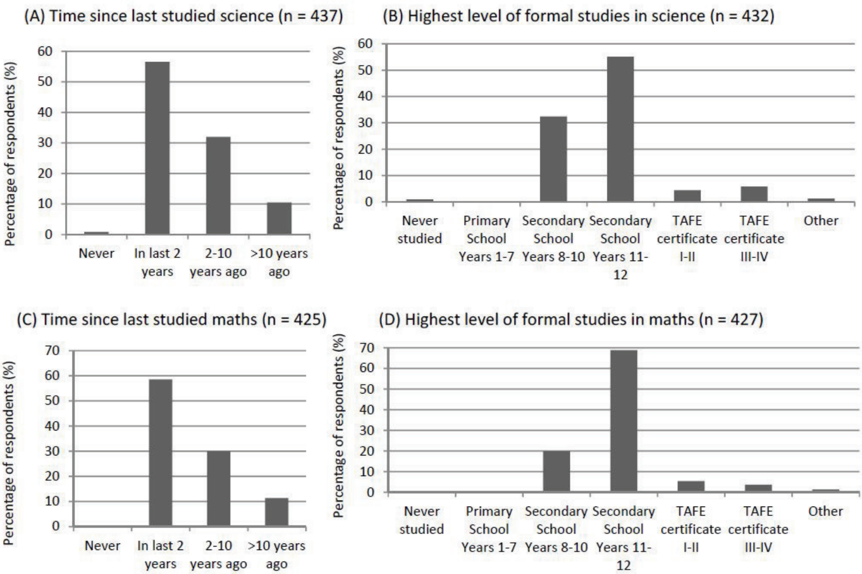
The response rate to the surveys was 89% (287/324) in the first iteration, and 82% (152/185) in the second iteration of the program during 2014. The response rate overall was 86% (439/509).

Past learning experiences of the respondents

The past educational experiences of students in relation to science and maths learning were diverse, as shown in Figure 1. More than half of students had studied science or maths in the two years that preceded their *OnTrack* enrolment, whilst approximately one third of respondents indicated that they had not studied these subjects for more than 2 years (but less than 10 years) and around a tenth of the respondents had not studied these subjects for more than 10 years. A small number of respondents (less than 1%) indicated that they had never studied science or maths (Figure 1a/c).

In terms of highest level of formal studies in science or maths (Figure 1b/d), most respondents indicated that they had studied science and maths in secondary school. However, 32% and 20% of students had ceased studying science and maths, respectively, between Years 8–10. Approximately one tenth of respondents indicated that they had studied science or maths in Technical and Further Education (TAFE), and a small number (approximately 1% or less) had either never studied or had not progressed with their studies beyond primary school.

Figure 1. The diversity of past educational science and maths experiences of *OnTrack* students



Respondents were also asked to rate their past learning experiences (Table 3). In relation to past science learning, 17% of respondents indicated that they had negative experiences (rated as 'horrible' or 'not good'), 41% perceived their experiences as positive (rated as 'good' or 'excellent') and 41% rated their past learning experiences as 'ok' (i.e. neutral). Regarding past maths learning, 26% indicated their experiences to be negative, 41% indicated positive experiences and 32% rated their experiences as 'ok' (neutral).

Table 3. *Student ratings of past science and maths learning experiences*

	Rating by respondents*					
	Horrible	**Not good**	**Ok**	**Good**	**Excellent**	**N/A**
Past science learning	22 (5%)	53 (12%)	176 (41%)	135 (31%)	44 (10%)	5 (1%)
Past maths learning	38 (9%)	73 (17%)	139 (32%)	139 (32%)	38 (9%)	2 (1%)

**Counts and row percentages are shown*

Students were asked open-ended questions about the reasons for rating their past learning experiences as negative, positive or neutral. The themes emerging from the thematic analysis were: 'teacher quality', 'interest level', 'enjoyment level', 'academic outcomes', and 'conceptual understanding'. These were then analysed in relation to student ratings of past experience in both science and maths (Table 4). The dominant theme of 'teaching quality' was apparent in the analysis of responses to past experiences in science, and was most prevalent in those responses from students with 'positive' past experiences. There was also a correlation between students who cited a positive 'teacher quality' – namely good or quality teachers – with a theme of 'enjoyment' (n=15). Many of these responses cited teacher engagement and the teacher making the topics fun and enjoyable: *'Exceptional teacher. Thorough explanations – yet simple to understand. Didn't rush students along'* (Respondent (R) 154); *'Teachers made it fun, interesting and relevant'* (R329) and *'Fun teachers, hands on and interesting'* (R165). Additionally, there were students who fell into the 'neutral' experience category and cited reasons such as the subject was 'hard' or 'difficult' but they also noted that it was the teacher who helped them to get through. For example: *'hard to understand but passed due to good teacher'* (R275). Both poor teaching and students' conceptual understanding of science was cited by a subset of students (n=8), with respondents commenting: *'The teacher I had* *did not care if people in the class were falling behind, he wouldn't slow down or stop if you missed something or didn't understand'* (R70) and *'I never really understood it and it wasn't really taught to me properly. I was in a big class in high school and there was a selected few the teachers were willing to help'* (R361). 'Interest' in science was the second dominant theme, and while there were some students who suggested this was influenced by their teachers (positively n=9 and negatively n=1), this theme was dominated by general student interest in the area. The most significant finding in this analysis is the impact of teacher quality on student experiences and their perceptions of science. Notably, academic outcomes did not feature prominently as a rationale for negative or positive ratings of past experiences in learning science.

Table 4: *Student ratings of past science and maths learning experiences, and associated reasons provided**

	Main reasons indicated					
Rating of past *science* learning experiences	Teacher quality	Interest level	Enjoyment level	Academic outcomes	Conceptual understanding	Total respondents
Negative	16 (26%)	11 (18%)	13 (21%)	5 (8%)	15 (25%)	61
Neutral	21 (16%)	23 (18%)	31 (24%)	3 (2%)	23 (18%)	131
Positive	49 (33%)	40 (27%)	65 (43%)	6 (4%)	21 (14%)	150

	Main reasons indicated					
Rating of past *maths* learning experiences	Teacher quality	Interest level	Enjoyment level	Academic outcomes	Conceptual understanding	Total respondents
Negative	13 (22%)	8 (14%)	16 (27%)	3 (5%)	32 (54%)	59
Neutral	20 (33%)	9 (15%)	20 (33%)	7 (11%)	22 (36%)	61
Positive	19 (21%)	9 (10%)	31 (34%)	9 (10%)	21 (23%)	92

**Counts and row percentages are shown. Note: more than one theme may have been identified in student responses. The total number of respondents is also shown.*

In regards to past learning experiences in maths (Table 4), 'teacher quality' and 'enjoyment' levels were dominant related themes across all student responses. There was a closer relationship between the themes of 'interest', 'enjoyment' and 'conceptual understanding' for students who had negative or neutral past experiences, with significantly more students noting 'struggles' or 'difficulties' with 'understanding' the topic and 'concepts'. Student responses included such remarks as *'Find maths hard'*

(R261), *'Mathematics was one of the subjects I wasn't fully successful in and found it hard to understand'* (R364), and *'It becomes confusing if you don't fully understand the concepts'* (R108). Teacher quality was again a significant theme in this analysis, with responses indicating that the teacher was 'boring', or did not explain the subject matter. For example: *'Was never great at understanding it. Teacher didn't help at all'* (R184), *'Teachers weren't explaining things properly throughout my high school experience which made it that little bit harder to focus and understand'* (R156), or *'Not a great teacher, could not explain information in alternative ways. Teacher not available for clarification or extra time'* (R331). Another student stated *'When it comes to maths teachers really need to be willing to put time and effort into making sure students understand how things work. Teachers often don't do this, possibly because they have a lack of time or motivation'* (R80). The most significant theme from those who had a positive learning experience in maths came from those who noted personal enjoyment from maths.

Associations between past learning experiences and attitudes, confidence and aspiration in commencing OnTrack students

Respondents were asked to specify their overall feelings towards the prospect of studying science or maths in the future, as an indicator of existing attitudes and emotions around science and maths learning amongst the entering student cohort. Students could select as many responses that captured how they felt, or specify others not listed. Generally, student replies to this question revealed correlating response patterns, which could be broadly classified as suggesting 'positive attitudes', 'negative attitudes', 'anxiety/fear/stress' and 'other' (see Tables 1 and 2). These response patterns were compared with student ratings of past learning experiences (Table 5). Negative perceptions of past science and maths learning experiences significantly correlated with current negative attitudes and anxiety/fear/stress responses to the prospect of future science or maths education. Conversely, students who rated their past maths and science learning experiences as positive were more likely to have indicated positive attitudes, but not negative attitudes or anxiety/fear/stress responses towards the prospect of future science or maths learning. In summary, past science and maths learning experiences appear to be associated with existing student attitudes and anxiety about the prospect of studying these subjects again in future.

Table 5: *Attitudes and feelings towards the prospect of future learning correlates with ratings of past learning experiences in commencing* ***OnTrack*** *students*[1]

	Attitudes towards the prospect of future science learning		
Rating of past *science* learning experiences	Negative	Positive	Anxiety/fear/ stress response
Negative	**0.382*****	**-0.342*****	**0.238*****
Neutral	0.022	-0.089	-0.045
Positive	**-0.315*****	**0.351*****	**-0.138****

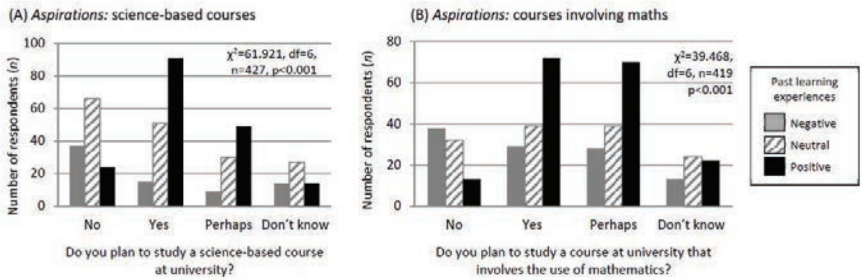
	Attitudes towards the prospect of future maths learning		
Rating of past *maths* learning experiences	Negative	Positive	Anxiety/fear/ stress response
Negative	**0.428*****	**-0.343*****	**0.306*****
Neutral	0.023	-0.093	0.080
Positive	**-0.402*****	**0.393*****	**-0.348*****

1 Phi correlation coefficients are reported (n = 420-422). Correlations significant at the 5% level are highlighted in boldface.
*** indicates 2-sided p-value <0.01*
**** indicates 2-sided p-value <0.001*

Students were also asked about their aspirations for future study and whether they planned to study a science-based course or a course involving maths at university. Thirty per cent (127/427) of students indicated that they did not have science in their plans for future study, 37% (157/427) indicated that they did plan to study science and the remaining 33% indicated that ‘perhaps’ they will study science (88/427) or that they did not know (55/427). Students who perceived their past science learning experiences as negative were significantly less likely to have science in their future study plans (10% or 15/157 respondents), than students who had positive past learning experiences (58% or 91/157 respondents; Figure 2a).

When asked whether their future study plans involved the use of maths, 20% (83/419) of respondents answered ‘no’, 33% (140/419) answered ‘yes’, 33% (137/419) answered ‘perhaps’ and the remaining 14% (59/419) indicated that they did not know. Similar to the trend observed for science aspiration and past experiences, student perceptions of prior maths learning experiences too were significantly associated with aspirations for courses involving the use/study of maths in future (Figure 2b).

Figure 2. Past science and maths learning experiences influence student aspirations for future study



Of note, ratings of past learning experiences significantly correlated with the pursuit of science or maths education prior to student enrolment in OnTrack (Table 6). Students who had positive past learning experiences were more likely to have studied science and maths at higher levels (Secondary School Years 11–12 and TAFE) than students who perceived their past learning experiences as negative. Taken together, these results suggest a tendency towards avoidance behaviour, both in the present and in the past, for those that had negative educational experiences related to these subjects.

Table 6: *Rating of past learning experiences correlate with the pursuit of science and math education prior to having enrolled in the* ***OnTrack*** *program*

	Highest level of science studied prior to enrolling in OnTrack[1,2]				
Rating of past *science* learning experiences	Primary School Years 1-7	Secondary School Years 8-10	Secondary School Years 11-12	TAFE	Other
Negative	0 (0%)	40 (55%)	25 (34%)	6 (8%)	2 (3%)
Neutral	1 (1%)	65 (37%)	89 (51%)	17 (10%)	1 (1%)
Positive	0 (0%)	33 (19%)	122 (69%)	19 (11%)	2 (1%)

	Highest level of science studied prior to enrolling in OnTrack[1,3]				
Rating of past *math* learning experiences	Primary School Years 1-7	Secondary School Years 8-10	Secondary School Years 11-12	TAFE	Other
Negative	2 (2%)	36 (33%)	63 (57%)	7 (6%)	2 (2%)
Neutral	0 (0%)	27 (20%)	100 (72%)	11 (8%)	0 (0%)
Positive	0 (0%)	21 (12%)	130 (74%)	21 (12%)	4 (2%)

1 Counts and row percentages are shown.
2 Pearson Chi-square test statistic ($\chi 2$) = 38.846, df = 8, $p<0.001$; n = 422.
3 Pearson Chi-square test statistic ($\chi 2$) = 29.133, df = 8, $p<0.001$; n = 424.

Respondents were also asked to write down the name of the course that they planned to study. Of note, there appeared to be a substantial mismatch for some students in their answers to these questions. For example, a number of students indicated that they did not plan to study a course involving science or maths at university, but listed an undergraduate degree that was either science-based or involved learning/using maths, respectively. Furthermore, a large number of students appeared uncertain about whether their study plans involved science or maths answering 'perhaps' or 'don't know' to the question (Table 7).

Table 7: *Undergraduate course nominated versus student perceptions of whether their study plans are going to involve studying science or maths*

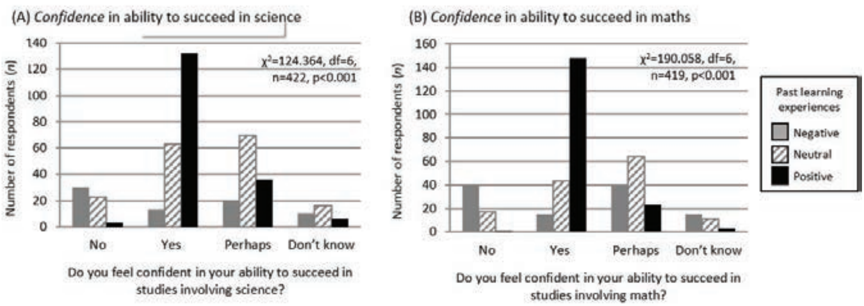
		Undergraduate course*				Undergraduate course*	
		Not science-based	Science-based			Does not involve maths	Involves use of maths
'Do you plan to study a *science-based* course at university?'	No	85	5	'Do you plan to study a course at university that involves the use of *maths*?'	No	40	22
	Yes	3	144		Yes	15	102
	Perhaps	17	39		Perhaps	30	68
	Don't know	14	13		Don't know	10	28

**Counts are shown. Only students who listed the specific undergraduate course that they planned to study are included here.*

For the 22 respondents who indicated that they were not intending to study a course at university involving the use of maths, but listed an undergraduate course that will, in reality, involve the use of maths, the most common courses listed were: (a) science majors (54% or 12/22) such as Biomedical Science, Animal Science, Biology, Physiology, Sports Science or Environmental Science; (b) Psychology (27% or 6/22); and (c) Nursing (9% or 2/22). Of note, negative past maths learning experiences (10/21), maths anxiety/fear/stress responses (11/22) and negative attitudes towards the prospect of future maths learning (15/22) was pervasive amongst this subset of students. This suggests that not only were their expectations inconsistent with reality, but they may be at a higher risk of being dissatisfied with, and experiencing barriers to, their future study/career plans in the longer term.

Survey respondents were also asked to self-report on whether they felt confident in their abilities to succeed in studies involving science or maths as an indicator of their self-efficacy beliefs. More students signalled that they felt confident in their ability to succeed in science education (49% or 208/422) than not (13% or 56/422). Similarly, 49% (206/419) of respondents were confident and 14% (58/419) of respondents lacked confidence in their ability to succeed in maths education. However, a large proportion of students did not appear to be sure whether they were confident (answering 'perhaps' or 'don't know'). Student confidence levels were compared with student ratings of past learning experiences. Students who held positive perceptions of their past learning experiences were significantly more likely to feel confident in their ability to succeed in future, whilst students who reported negative past experiences were more likely to indicate that they were not confident (Figure 3).

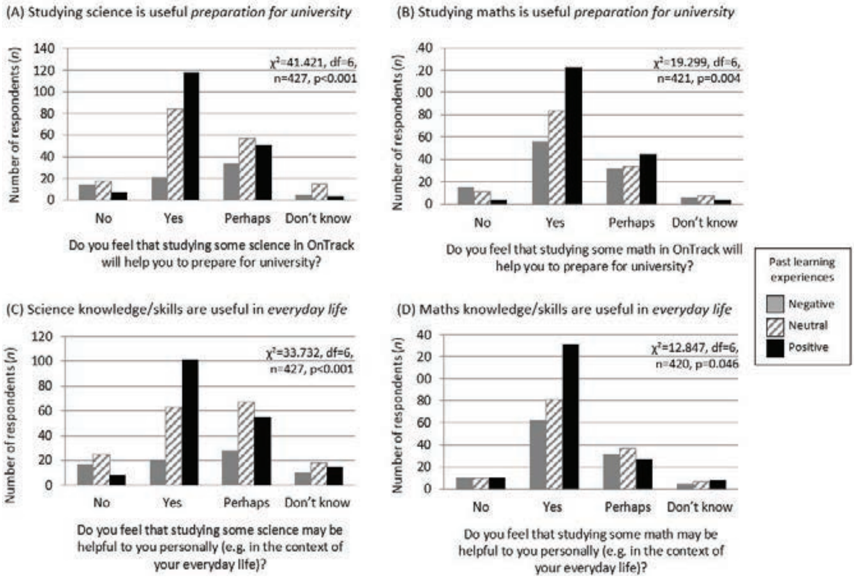
Figure 3. Past science and maths learning experiences influence student self-perceptions of confidence



Associations between past learning experiences and perceptions about usefulness of science and maths learning in commencing OnTrack students

Students were questioned about their perceptions of the value of studying science and maths during *OnTrack*, both for university preparation and for assisting them personally in the context of their everyday lives. Whilst most students felt that studying science or maths was likely to be useful or helpful to them for these purposes, perceptions of usefulness differed significantly depending on student ratings of their past learning experiences. Positive past learning experiences were associated with an increased propensity for students to identify the value of studying science or maths, whilst negative past experiences were associated with a decreased propensity (Figure 4).

Figure 4. Past learning experiences correlate with perceptions about the usefulness of studying science and maths in the *OnTrack* course for (A/B) preparation for university and (C/D) in the context of everyday life.



Discussion

Pre-university students entering the Western Australian enabling program, *OnTrack*, were characterised by diverse science and maths attitudes, beliefs, feelings, aspirations, and confidence, which appeared to stem from their past learning experiences. For example, students with negative perceptions of their early learning experiences tended towards avoidance of these subjects, expressing adverse attitudes, reduced confidence and increased anxiety. They were also less inclined to see the value of science and maths education. The opposite was true for those with positive early learning experiences. These results are in line with previous findings in both the enabling education (Klinger, 2006, 2008a) and university context (Klinger, 2008b).

The quality of the classroom teaching and learning experience appeared to be especially important and influential on how students perceived and rated their past learning experiences. In particular, students mentioned 'the teacher' frequently, and this correlated with reported levels of interest and enjoyment experienced, as well as their understanding of concepts. These findings are consistent with research which shows that candidate teachers enter university with diverse attitudes towards maths, which they carry into their careers and propagate to the next generation of students (Philippou & Christou, 1998). This may occur, at least in part, by the transmission of emotions between teachers and students in the classroom, which consequently modulate students' 'learning-related motivation, self-regulatory efforts, activation of cognitive resources and performance' (Frenzel, Goetz, Lüdtke, Pekrun & Sutton, 2009, p. 705). Although, we have not studied the relationship between past learning experiences, student affect and demographic variables in the current study, a previous study suggests that teachers with maths anxiety may influence the maths beliefs and achievement of female but not male students (Beilock, Gunderson, Ramirez & Levine, 2010). Interestingly, although early learning experiences can have long-lasting impacts on student affect, aspiration and achievement, research shows that it is possible to successfully challenge and redress long-held negative student attitudes, perceptions and emotions (Frenzel et al., 2009; Klinger, 2006).

Implications for future teaching and learning in enabling programs: Overcoming the legacy of negative early learning experiences

Research indicates that students experience a wide range of emotions, attitudes and motivations in learning situations, yet the affective domain has traditionally received little attention when planning for teaching and learning across most disciplines, including in science and maths (Frenzel et al., 2007a). Here, we consider a variety of strategies that educators may incorporate when designing curricula and pedagogy related to science and maths that aims to address not only the cognitive, but also the affective, needs of students transitioning to university via an enabling program. Given there are known constraints that need to be taken into account when designing enabling curricula (e.g. time, resourcing, teacher expertise/training, student cohort sizes and modes of delivery), the following discussion provides ideas for consideration rather than a single approach.

Addressing attitudes and emotional reactions toward maths and science as part of a holistic curriculum that incorporates social and emotional learning (SEL) could be one way of supporting those students with negative experiences or negative perceptions of these discipline areas. Evidence shows that SEL leads to improved academic outcomes, confidence, resilience, attitudes and motivations towards learning (Durlak, Weissberg, Dymnicki, Taylor & Schellinger, 2011; Zins, Bloodworth, Weissberg & Walberg, 2004). A method of embedding SEL within curricula is to include opportunities for transforming students' beliefs and attitudes associated with learning towards a 'growth mindset'; an idea pioneered by Dweck and colleagues (Dweck, 2009, 2010, 2012). Dweck suggests that people with 'fixed' learner mindsets believe that intelligence is an inborn trait and tend to engage in behaviour that is self-limiting for their learning, such as avoidance. People with growth mindsets instead believe that intelligence is developed and that learning requires effort and strategy (Dweck, 2010, 2012). Although the impact of explicitly teaching growth mindset practices has not been well defined in adult learning contexts, in one study it improved student motivation, resilience, self-efficacy and self-esteem, and led to higher engagement and academic achievement (Cutts, Cutts, Draper, O'Donnell & Saffrey, 2010). Further, in our own enabling program, 89% of OnTrack students reported a positive impact on their overall academic growth and development, including transformation of beliefs and attitudes towards learning, after including this in the curriculum (Jones et al., 2016a). Thus, teaching students to challenge any existing fixed mindsets and cultivate a growth mindset may be one strategy to successfully shift negative attitudes towards maths and science, and boost their self-concept and self-efficacy. Notably, it is also important to provide training for teaching staff on learning mindset theory to increase self-awareness of their own mindsets and attitudes towards maths and science, so they do not inadvertently propagate their own negative perceptions. Other SEL interventions that have been found to be effective include fostering students' metacognition (Ee, 2009), emotional intelligence, reflective capacity and self-awareness (Jones et al., 2016a; Lisciandro, Jones & Strehlow, 2016), introducing students to strategies for developing resilience/'grit' (Duckworth, Peterson, Matthews & Kelly, 2007) and managing stress/anxiety through techniques like mindfulness (Langer, 2016). Notably, this is not assuming that students are operating from a deficit model, but recognises that reminding or upskilling all students and practitioners in these practices is one technique that is showing positive impact.

Of all disciplines of study, mathematics appears to elicit the strongest emotions amongst students, particularly anxiety, and this is associated with the perceived amount of difficulty or confusion experienced during previous learning experiences (Frenzel et al., 2007a; Prawat & Anderson, 1994). Prawat and Anderson (1994, p. 219) suggest that this 'points to a problem which may be endemic to how we teach mathematics: a strong performance orientation'. Similarly, Klinger (2011, p. 10) suggested that traditional forms of instruction and conventional pedagogies 'echoing negative early encounters in the mathematics classroom' are ineffective for adult learners and only 'serve to validate the student's poor perceptions'. In implementing a 9-week mathematics foundation course as part of an enabling program, Klinger (2006, p. 166) demonstrated that pervasive negative perceptions towards maths can be successfully challenged when teaching and learning experiences are constructed 'from a deliberate ethos that anticipates negative attitudes, low self-efficacy beliefs, and some level of mathematics anxiety'. This included seeking to change the relationship students have with maths by; (a) explicitly addressing maths anxiety and the pre-conceptions that underpin negative self-efficacy beliefs, (b) demonstrating maths learning as a *process*, and (c) demystifying the 'doing' of maths by emphasising maths as a *language*. Further, he stresses that careful selection of empathetic and enthusiastic staff, and provision of a supportive learning environment where students can risk making mistakes without shame or judgement, is essential (Klinger, 2006). Indeed, research shows that the perceived learning environment significantly influences student emotion, value beliefs, motivation and achievement (Frenzel, Pekrun & Goetz, 2007b; Meyer & Turner, 2006) and requires significant attention in order to overcome barriers to learning, such as fear, for those who previously experienced trauma during their learning (Perry, 2006). Further, teacher enthusiasm can mediate the transmission of positive emotions like enjoyment to the student, independent of whether the student enjoyed maths in the past (Frenzel et al. 2009). Therefore, focussing on student mastery rather than performance, and cultivation of a positive and supportive learning environment, may serve to halt negative student perceptions and emotions carried into their enabling education experience as a result of past learning. This has some implications for practice in enabling programs, particularly those with interdisciplinary curricula that demand diverse teachers. Creating an environment where staff are encouraged to share and attend to their own strengths and weaknesses and develop strategies through professional development, mentoring and engaging in a community of practice may contribute to improved outcomes for students.

Designing teaching and learning using relevant, authentic and real-life contexts may be another way to foster student engagement and challenge negative perceptions and value beliefs about the utility of science and maths learning among pre-tertiary learners. In science, some labels to this approach have included 'everyday science' (Feinstein, 2009), 'humanistic–cultural aspects of science' (Aikenhead, 2004) and 'citizen science' (Jenkins, 2011), with a common aim of producing competent and critical citizens who can 'access and interpret science in the context of complex, real-world problems' (Feinstein, Allen & Jenkins, 2013, p. 316). This is in contrast with conventional approaches to science education which tend to be dominated by the 'pipeline' ideology – that is, teaching scientific facts and principles in a decontextualised fashion in order to deliver 'science-ready' students to universities (Feinstein et al., 2013). This approach ignores the fact that not all students who study science want to be pipelined into science-based careers and as a result, students may lose interest and form negative attitudes when 'they feel science is not relevant to their lives or they are simply not good at science' (Jenkins, 2011, p. 501). Feinstein (2009, p. 766) asserts that 'the best way to encourage long-lasting interest in science, especially amongst students traditionally considered most difficult to reach, is to reveal how science can be a tool for meeting one's own goals'. This includes demonstrating how 'science education can help people solve personally meaningful problems in their lives, directly affect their material and social circumstances, shape their behaviour, and inform their most significant practical decisions' (Feinstein, 2011, p. 169). Similarly, situating mathematical problems within meaningful and realistic contexts is also important to facilitate learning (Ginsburg & Gal, 1996; Kemp, 2009). Notably, a curriculum that allows learners to engage with the concepts in the context of their own lives may also foster opportunities for a change in their frame of reference (perspective, value, belief or point of view), resulting in transformative learning (Lisciandro & Gibbs, 2014; Mezirow, 1997).

Addressing dissonance between student expectations and the realities of degree choice and career aspirations

An interesting finding in our study was that many students enrolling in enabling education appeared to have misconceptions and/or uncertainties about the realities of their degree choice and career aspirations. One explanation for this is that students are not researching or being provided with adequate and detailed information about course content prior to attempting university entrance. Alternatively, students might have preconceived ideas about the work conducted or the role of a graduate from their chosen course, thereby overlooking the detail of the course content (O'Donnell, 2011). Perhaps they fail to appreciate the relevance of mathematics or science in the context of their course. For example, in their study of nursing students, Caon and Treagust (1993) found that some students failed to see how learning science was relevant to the nursing profession. The commodification of higher education in Australia has created a competitive marketplace, resulting in some students choosing courses based on employability and career prospects over their personal interest in the subject (Maringe, 2006), and the removal of pre-requisite subjects at many universities (Nicholas et al., 2015) is likely to add confusion over what subject-knowledge might be expected at commencement and during a chosen degree.

In our study, students who believed that mathematics was not needed in the context of a science, nursing or psychology degree, also tended to have a history of negative past maths experiences, negative maths attitudes and maths-anxiety. It is not clear whether the dissonance between student expectation and reality in this instance is related to student affect and/or poor past experiences, although Ozga and Sukhnandan (1998) suggest that student expectations are generally shaped by prior educational and life experiences. Importantly, 'students who experience dissonance between expectations and experiences, are more at risk of withdrawal from higher education' (O'Donnell, 2011, p. 54). Therefore, this study suggests that, as well as teaching in the affective domain, there is a need for enabling programs to increase student awareness of the skills and knowledge demanded by their chosen course and/or career in order to safeguard student expectation, satisfaction and retention in the longer term.

Conclusion

Students entering enabling programs are characterised by diverse affective responses in relation to science and math learning that stem from previous educational experiences, and continue to influence aspiration, confidence and expectations of future study. Greater attention to students' affective needs, for example through addressing social and emotional learning, may create more positive and engaging learning experiences that better prepare students for their transition to university studies.

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