Challenging negative attitudes, low self-efficacy beliefs, and math-anxiety in pre-tertiary adult learners.*

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This study examines the attitudes, self-efficacy beliefs, and math-anxiety of a diverse group of pre-tertiary adult learners. The aim is to identify changes in learners' perceptions of mathematics, including their own capabilities, in the context of their participation in a 9-week mathematics foundations course. Analysis of pre/post testing by questionnaire revealed that at the outset participants shared the pervasive negative views attributed to the broader population in many previous studies, whereas these views had changed significantly by the conclusion of the topic, suggesting that adults' perceptions of, and capacity to engage with, mathematical content are strongly influenced by early learning experiences and that negative perceptions may be successfully challenged.

The learning of mathematics is affected by the confidence of learners in their mathematical abilities and the attitudes, beliefs, and feelings they harbour towards mathematics (Coben, 2003). Their conceptions of the subject and their perceptions of themselves and of their relationship to mathematics lie at the heart of their mathematics learning behaviour (Philippou & Christou, 1998). For fear of embarrassment, many adults go to great lengths to avoid admitting that they experience reading difficulties, yet it appears to be normal, even acceptable, in modern life to readily admit to a dislike and misunderstanding of mathematics. Sewell (1981) suggested that at least half the population, including many with high mathematical qualifications, had negative attitudes to mathematics, ranging from lack of confidence to anxiety and even fear. In the USA, math-anxiety workshops are proliferating in response to the prevalence of similar attitudes, with many adults who are capable of learning mathematics being inhibited by their fear from doing so (Biller, 1996). According to FitzSimons, Jungwirth, Maaβ, and Schlöglmann (1996), the relationship of adults to mathematics in school, particularly beyond elementary school, has long suffered emotional strain, dominated by anxiety.

In the positive, however, an Australian large-scale survey of public attitudes towards mathematics found a uniform regard for its importance, with mathematical ability generally taken to be an indicator of intelligence (Galbraith & Chant, 1990). Almost universally, pupils, parents, and teachers regard mathematics as both important and useful (Coben, 2003). Mathematics is valued highly in the academic curriculum and frequently figures prominently in measures of achievement for level placement and tertiary admissions relevant to science and technology (Pajares, 2005). According to Maaβ and Schlöglmann, "mathematics has long been established as the scientific core of the natural sciences and, increasingly, of the social sciences" (FitzSimons, 2002, p.295).

These dual perceptions of mathematics figure prominently in the context of the pre-tertiary adult learners in this study, who are participants in a special entry programme that provides an alternative gateway to tertiary education for adults who have been educationally disadvantaged. In 1996 a compulsory mathematics component was introduced and, although many students were openly concerned and anxious at first, each year the topic achieves a well-distributed set of grades and some of the most anxious participants report dramatic reversals in their previously negative views. Yet, the original design of the programme flowed mostly from intuitive assumptions that had never been verified empirically. The aim of this study is to seek redress by establishing:

- a profile of attitudes, anxiety, and self-efficacy beliefs, together with relevant demographic data
- whether that profile is consistent with corresponding attributes in the wider population, as reported in the literature
- whether the perceived qualitative changes in students' views of things mathematical are quantifiable and statistically significant
- what (if anything) do the changes indicate about the nature and origin of such views? Which aspects of the learning experience might be most instrumental in effecting the changes? What are the implications for teaching and providing mathematics support to students in, or wishing to access, tertiary studies?

There are two principal hypotheses. First, that negative attitudes to mathematics, low mathematics self-efficacy beliefs, and anxiety of mathematics are pervasive and endemic to the broader population and that the subject cohort is representative of that population. Second, that such views and emotions are not immutable – that they arise particularly from prior mathematics learning experiences and may be challenged successfully and that the study will provide supporting evidence for positive change. To test these hypotheses, aspects of attitudes to mathematics, math-anxiety, and mathematics self-efficacy will be discussed in the following section to demonstrate the first part of hypothesis one. The remainder will be established through the use of a survey instrument in a pre-test/post-test methodology reported in a subsequent section. Finally, the implications of the findings will be discussed in the concluding section.

Mathematics attitudes, math-anxiety, and mathematics self-efficacy beliefs

Research on attitudes to mathematics dates from the 1960s (Nicolaidou & Philippou, 2003) but, as Coben (2003) pointed out, while much has been written in a general context, literature that relates this specifically to adults is less prolific by far and "the knowledge-base is as yet insecure" (Coben, 2003, p54). Even so, several observations are now well established, including those of Singh (1993):

- Students commonly identify mathematical abstraction and lack of relevance as causative factors for their dislike of and failure in mathematics
- Fear of failure induced by the nature of some mathematics teaching and assessment practices as a cause of anxiety in adults
- The significant influence of teachers to motivate or estrange mathematics students
- Through socialization processes and mathematics pedagogy and content, negative attitudes towards mathematics may be more pervasive in the female population.

Mathematical self-concepts can be strongly influenced by primary school experiences and the attitudes of parents, with traumatic early mathematics learning experiences being capable of exerting a long term effect (Relich, 1996) so that many people cast themselves as 'non-math' types at an early age (Mitchell & Gilson, 1997), leading to a lack of motivation. The IEA's Third International Mathematics and Science Study (TIMSS) found widespread positive correlation between liking mathematics and mathematics achievement. In several countries more than 40% of eight-grade students reported a dislike of mathematics yet, overall, the majority of students expressed positive attitudes, a dichotomy perhaps indicating that students respect the utility of mathematics more than they actually like doing it. The same study found that gender differences favoured boys rather than girls. Other studies have found a decline in children's attitudes towards mathematics between primary and secondary education (McLeod, 1992). Pupils' conceptions suffer from the destructive effects of "unimaginative instruction and non-positive teacher attitudes" in a recursive phenomenon: many candidate teachers enter university with negative mathematics feelings, often taking these attitudes into their teaching careers, influencing students and yet another generation of prospective teachers to perpetuate the same (Philippou & Christou, 1998).

Anxiety

Extensive literature demonstrates that anxiety, stress, lack of confidence, and phobic reactions in the face of mathematical problems are exhibited in most modern cultures (Macrae, 2003), and math-anxiety is commonly characterized by feelings of tension, apprehension, or fear that impacts on mathematical performance (Ashcraft, 2002). It is associated with loss of self-esteem in confronting a mathematical situation (Acelajado, 2004), negative reactions to mathematical concepts and evaluation procedures, and with many constructs including working memory, age, gender, self-efficacy, and mathematics attitudes (Cates & Rhymer, 2003). The "feeling, often in the background, that one does not comprehend the meanings, purposes, sources or legitimacy of the mathematical objects one is manipulating and using" (Wilensky, 1997, p172) has been identified with statistics anxiety and one might argue similarly for mathematics anxiety since comparable sentiments are frequently involved. Anxiety is also indicated as a factor in attrition rates, regardless of actual ability (Jones, 1996), and literature on mathematics anxiety has typically given support to the existence of a small relationship between mathematics anxiety and performance (Cates & Rhymer, 2003), with Reyes (1984) reporting a consistent negative relationship between mathematics anxiety and achievement. Mathematics anxiety is more closely associated with females than with males (Macrae, 2003), a finding shared by Ashcraft (2002), but the difference tends to be small and perhaps due in part to a more open disclosure of feelings by women, although Ashcraft and Faust (1994) also found the opposite tendency at low anxiety levels. There are differences, too, in teachers' expectations of females and this can result in differential treatment in the classroom (Osborne, Black, Boaler, Brown, Driver, Murray, *et al*., 1997).

Self-efficacy

Students faced with the dual burdens of intractable content and math-anxiety *a posteriori* tend to have weak or negative mathematics self-efficacy beliefs. Bandura (1986) defined self-efficacy beliefs as “people’s judgements of their capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura 1986, p391). Self-efficacy beliefs are a better predictor of success than an inventory of skills or prior achievements, and relationships have been found between self-efficacy for solving mathematics problems and math-anxiety, mathematics attitudes, general mental ability, mathematics self-concept, and mathematics experience (Finney & Schraw, 2003). For the mathematically challenged and mathematics anxious, there is often a history of a complex interplay of influences – poor or uncertain prior performance contrasted with observations of more successful peers while disapproving and disparaging feedback from teachers and other significant individuals fuels anxiety and stress, provoking strong emotional reactions to impending tasks of a similar nature. Even in the absence of mathematics anxiety, a less intense cycle influences many young minds to avoid mathematics instruction and practice, leaving perceptions that mathematics is uninspiring, uninteresting, and irrelevant (Klinger, 2004). Philippou & Christou (1998) cite numerous researchers typically reporting that male students express higher mathematics self-efficacy than do female students, and it seems that the divergence begins during middle school and increases with age. At all levels of schooling, gender differences favour boys, even when girls’ mathematics achievement indexes match or exceed those of boys. Negative views of mathematics clearly prevail during school years and, in the absence of contrary evidence, there can be little doubt that children carry their views into adulthood and into the broader population. While there are few studies that report on the mathematics self-efficacy of adults in a general context, Lussier (1996) investigated gender and mathematics background and found that men report lower anxiety scores and higher self-efficacy scores than women.

About the ‘mathematics foundations’ learning experience

The mathematics foundations core topic undertaken by the subject group is described as an ‘introduction to quantitative methods’. It consists of a series of nine weekly lectures and tutorials constructed from a deliberate ethos that anticipates negative attitudes, low self-efficacy beliefs, and some level of mathematics anxiety. It is assumed, also, that many participants will have endured negative experiences, including humiliation and corporal punishment, during their prior encounters with mathematics learning (the assumption has been justified each year by responses from students when asked to recount their best and worst experiences of mathematics). Tutorials are conducted exclusively by volunteer post-graduate students selected on the basis of their enthusiasm and empathy and the emphasis, throughout, is on mathematics learning as *process* rather than mathematics as a set of ‘universal truths’ communicated by rules. Learning experiences are constructed in a supportive atmosphere where students are encouraged to take reasonable risks, feel free to make mistakes without fear of shame or ridicule, and construct their own learning (with guidance).

Of the nine lectures, the first is a general discussion of the value of mathematical concepts in a broad social context. Here, the issues of mathematics literacy and math-anxiety are addressed explicitly and stereotypical attitudes and behaviours are contrasted with corresponding attitudes and behaviours found in other areas of human endeavour. Students are told that the aim of the topic is not to teach them how to ‘do’ mathematics but rather to present them with a fresh perspective of what mathematics is about, and that this will include brief investigations of the ‘rules’ of the language. In this first lecture, several ‘mathematics myths’, such as the need to have a ‘mathematical brain’, are debunked. Two lectures deal with arithmetic, beginning with an historical context. The idea of ‘basic maths’ as a derogatory term is dispelled by explaining that, while some concepts are certainly fundamental, it has taken thousands of years of human thought to arrive at their formal expression and reduction to rules, some of which were carefully guarded secrets in many earlier societies, and it is absurd to suppose that these should be ‘obvious’ to the uninitiated. Next, two lectures introduce algebra as generalized arithmetic. The concepts are motivated by illustrating the utility of algebra to answer, “What if…?” and to recognize patterns in the world. A further two lectures are dedicated to problem solving as a separate skill – distinct from the formalities of mathematical language, just as essay writing is distinct from the grammar of conjugating verbs. One lecture investigates graphs as another means of describing and communicating mathematical information and the integration of arithmetical, algebraic, and graphical methods is demonstrated in a problem solving context, drawing together and reinforcing the notions presented previously. Finally, students are given a taste of descriptive statistics as (arguably) the most commonly encountered application of mathematics beyond everyday arithmetic.

Methodology

A 95-point survey instrument was developed by adapting the Mathematics Attitude Scale (MAS) – a 50-item questionnaire used by Acelajado (2004), the Mathematics Anxiety Rating Scale – a 10-item questionnaire, also used by Acelajado (2004), the Mathematics Anxiety Questionnaire – an 18-item questionnaire from Stuart (2000), and a Mathematics Self-Efficacy Scale (MSES) – a 10-item subset of the self-efficacy instrument used by Nicolaidou and Philippou (2003). In all, the adaptations yielded a set of 86 items for responses on a 5-point Likert scale: 49 attitude statements in the affective, cognitive, and behavioural domains, 27 anxiety statements, and 10 self-efficacy statements. The adaptations primarily involved transforming school-context statements from the present tense into reflective statements. To these 86 items were added a further nine statements, used by students to describe their previous mathematics learning experiences at primary or high school. For these, a simple "yes/no" response was provided for participants to indicate whether any of the statements were true for them, too. Information is also sought about gender, age group, last year of completed schooling, and last year of completed mathematics education.

The survey form was offered to the entire cohort of some 160 students before the commencement of the topic. Students were advised that participation was entirely voluntary and independent from any topic, course, or assessment activity. 90 completed surveys were collected before the first lecture began. Late responses were set aside and not used in the study.

Factor analysis confirmed that the items were validly partitioned into their respective domains and then the data were further segregated into sets of positive and negative statements, since they are not necessarily mutually exclusive. The reliability of each subset construct was tested by computing the internal consistency coefficients (Cronbach's alphas) for each. For the purposes of a psychometric instrument, alpha coefficients of at least 0.70 are desired (Nunally, 1978); the obtained values ranged from 0.75 to 0.94, indicating that the coefficients were more than satisfactory. To then obtain aggregate scores for each primary construct except 'Experiences', each item was first means-weighted according to its relative severity, with each weight computed as the quotient of the subset mean and the item mean. Aggregate measures were then obtained by summing the weighted scores and re-scaling the results to range from 0–10.

For the post-test, a second survey was prepared, identical to the first modulo the statements concerning prior learning experiences. Reflective statements (i.e. situated in an historical context) were retained as a control with the expectation that no significant changes would be observed for these items. The survey was administered at the penultimate lecture and 52 completed surveys collected during the summary lecture. Matching these with pre-test responses yielded a set of 36 matched pairs from which to measure changes in students' views about mathematics. Here, rather than aggregating data, each survey item was subject to a pre-test/post-test comparison by paired two sample t-test for means with the null hypothesis being H_0: $\mu_2 - \mu_1 = 0$. The pre- and post-test means and standard deviations were computed, as were the mean differences and their standard deviations, together with corresponding *p*-values.

Results

Pre-test

Summary data revealed the trends evident in the literature, such as gender differences in each domain, in favour of males. Small age-related differences were also found: increased positive indicators for attitude and anxiety, decreased negative indicators for attitude and self-efficacy, as well as slight non-linear age-related tendencies in negative anxiety indicators and positive self-efficacy indicators. An inverse dependence on the last year of completed schooling was clearly evident for negative attitude and self-efficacy indicators and, arguably, for the anxiety scale too. The positive scales also appear to indicate a weak inverse relationship for this category in the attitude and anxiety domains and it is clear that the mathematics self-efficacy beliefs of some students decline with further school experience. There were clear tendencies that further mathematics instruction tends to reduce the negative factors and raise the positive values in every domain.

Spearman Rank Correlations for negative and positive factors, respectively, showed highly significant relationships ($p<0.01$) that include the expected strong cross-correlations (from 0.639 to 0.715) between attitude, anxiety, and self-efficacy in the negative scales, as well as between attitude and 'bad' early learning experiences (0.339), though the latter does not correlate significantly with either mathematics anxiety or self-efficacy beliefs in the negative scales. In addition, there were significant modest negative correlations (-0.287 and -0.253 respectively) between attitude and both mathematics education and age group. Very similar highly significant relationships were evident among the positive scales. The correlation between attitude and mathematics education was stronger here (0.443) and, unlike the negative scale, mathematics education also correlated positively with lower anxiety and stronger self-efficacy beliefs (0.312 and 0.336 respectively). The relationships between positive early learning experiences and attitude, anxiety, and self-efficacy were particularly evident (respective correlations of 0.347, 0.394, and 0.453), in contrast with the picture from the negative scales. Notable, also, were significant negative correlations (-0.386, -0.241, and -0.227) for gender in the attitude, anxiety, and self-efficacy domains, indicating evidence that gender differences favour males.

The relationships between prior learning experiences and attitude, anxiety, and self-efficacy on both the positive and negative scales are explored more fully in Table 1. Particularly notable here are the highly significant cross-correlations between positive ('good') experiences and all other factors whereas negative ('bad') experiences only have such a relationship with the negative attitude domain.

Table 1. Correlation matrix for early learning *v* attitude, anxiety, and self-efficacy.

Spearman Rank Correlations (*a*)							
		Attitude (-ve)	Anxiety (-ve)	Self-efficacy (-ve)	Attitude (+ve)	Anxiety (+ve)	Self-efficacy (+ve)
Early learning (+ve)	Corr.	-.311(**)	-.428(**)	-.379(**)	.337(**)	.405(**)	.438(**)
	Sig.	.003	.000	.000	.001	.000	.000
Early learning (-ve)	Corr.	.349(**)	.182	.204	-.035	-.206	-.114
	Sig.	.001	.086	.054	.745	.051	.284
** Correlation is significant at the 0.01 level (2-tailed).							

Post-test

The results of this analysis are presented in three table extracts in the Appendix. In each, if $p < 0.1$ the difference is regarded as significant since it is generally accepted that a coefficient greater than 0.1 provides little or no statistically significant evidence to reject the null hypothesis. Table 3 reports for the mathematics attitude scales, grouped by affective, behavioural, and cognitive domains and with the items sorted within each domain by ascending *p*-value. Likewise, Table gives the results for mathematics anxiety and Table 2 similarly for mathematics self-efficacy beliefs.

Table 2. Pre-test/post-test comparison: mathematics self-efficacy belief scales.

t-Test: Paired Two Sample for Means		n= 36						
		pre		post		difference		
	Descriptor	μ_1	s_1	μ_2	s_2	μ_D	s_D	p
Self-efficacy beliefs	86. I have difficulties in solving one-step problems.	2.28	1.14	1.72	0.91	-0.56	0.91	0.000
	84. When I start solving a mathematical problem, I usually feel that I won't manage to find a solution.	2.83	1.28	2.39	0.99	-0.44	1.16	0.014
	78. I believe that I have a lot of weaknesses in maths.	3.28	1.32	2.89	1.30	-0.39	1.05	0.016
	82. I can usually solve any mathematical problem.	2.44	1.08	2.75	1.18	0.31	0.86	0.020
	80. Mathematics is not one of my strengths.	3.17	1.40	2.89	1.19	-0.28	0.85	0.029
	83. I do not feel sure about myself in problem-solving.	3.06	1.33	2.64	0.93	-0.42	1.36	0.037
	85. I can easily solve two-step problems.	3.67	1.20	3.89	0.92	0.22	0.93	0.080

Discussion

Even though little appears to have been published about adults in relation to the issues raised here, it is suggested that overall the reported data from the pre-test phase are consistent with the available literature and it may be inferred that, within the limitations of the study, the subject group is representative of the broader population and that sound evidence has been found to support the first hypothesis. There are several aspects in these data that suggest further investigation may be fruitful. In particular, it appears that positive experiences in early education years can be more beneficial than negative experiences in those same years are harmful.

As the tables in the Appendix show, the post-test results are quite definite in finding support for the second hypothesis: adults' views of mathematics and of their ability to engage with mathematics learning are amenable to positive change. The first observation is that all significant changes occur in the 'right' direction – that is, respondents' agreement with negative statements shows a decline, while their agreement with positive statements increases – except for one. It is the only reflective statement for which there is a significant change and it is significant at the 0.05 level: in the post-test respondents were more emphatic in their agreement with Item 9., 'I did not enjoy my math classes at school'. That is, their retrospective value judgement of school mathematics classes is harsher after the course than it had been at the outset. One explanation for this may derive from considering the other changes: whilst individually they are only modest (of the order of less than half a point on the Likert scale), they are consistent and reflect a strong overall improvement in participants' attitudes, decreased anxiety, and more optimistic self-efficacy beliefs. This change suggests that their retrospective value judgement of school mathematics classes has been affected by their more recent positive experiences.

In the affective attitudinal domain (Table 3) the most significant change, at the highly significant 0.01 level, is the increased interest in mathematics as an exciting subject. At the 0.05 significance level, respondents feel less afraid of mathematics, less inclined to consider mathematics boring, and more confident about solving mathematics problems. In the behavioural attitudinal domain, they are more stimulated, more willing to engage with mathematics learning, and more inclined to seek assistance. At the 0.01 level, they will more readily discuss mathematics and have a greater respect for the rigour of the subject. In the cognitive domain, students indicate that they regard mathematics rather more highly than before their experience in the course. The most significant change resides in the decline in the view that mathematics understanding is only for the gifted, suggesting that, in principle, mathematics has become more accessible. Table shows that self-deprecatory statements, nervousness, embarrassment and fear have all been significantly affected for the better. These changes may be taken to indicate an increase in students' self-esteem and empowerment to take responsibility for their mathematics learning. Finally, Table 2 shows significantly improved self-efficacy beliefs, particularly in relation to problem solving. However, the changes are not so large as to suggest that self-efficacy beliefs have been over-inflated, rather that students feel more able to make a genuine attempt.

Table 3. Pre-test/post-test: mathematics attitude scales.

t-Test: Paired Two Sample for Means								n= 36
		pre		post		difference		
	Descriptor	μ_1	s_1	μ_2	s_2	μ_D	s_D	p
Attitude - affective	11. I find maths a very interesting and exciting subject.	3.00	1.29	3.39	1.02	0.39	0.96	0.010
	13. I think maths is boring and dull.	2.14	1.02	1.78	0.90	-0.36	0.96	0.015
	2. I hate maths.	2.22	1.24	1.89	0.92	-0.33	0.89	0.016
	6. I feel confident in solving problems in maths.	3.06	1.15	3.39	0.73	0.33	0.96	0.022
	4. I am afraid to take a maths course.	2.69	1.33	2.39	1.25	-0.31	1.04	0.043
	9. I did not enjoy my maths classes at school.	2.39	1.29	2.67	1.43	0.28	0.94	0.043
	14. I feel helpless whenever I solve a maths problem.	2.31	1.21	2.08	1.05	-0.22	0.83	0.059
	5. I am uncomfortable with the thought of taking a math subject.	2.56	1.25	2.28	1.26	-0.28	1.06	0.062
	8. How I wish maths would be completely deleted from my course.	2.06	1.22	1.86	0.90	-0.19	0.75	0.064
	3. I am always anxious in a maths class.	2.67	1.12	2.50	1.08	-0.17	0.74	0.092
	12. I dread maths as if it is a contagious disease.	1.97	1.03	1.72	0.91	-0.25	1.11	0.092
Attitude - behavioural	19. Doing maths trains you to be disciplined.	3.03	1.21	3.56	1.13	0.53	1.03	0.002
	33. I am ashamed to join in any discussion that involves maths.	2.25	1.36	1.89	1.06	-0.36	0.90	0.010
	18. Learning maths trains you to be systematic.	3.75	1.08	4.11	0.95	0.36	0.93	0.013
	25. I am hesitant about attending maths classes.	2.39	1.13	2.06	0.79	-0.33	0.86	0.013
	22. Maths stimulates me.	3.00	1.12	3.36	1.10	0.36	0.99	0.018
	32. I seek help whenever I find difficulties in maths.	3.67	1.17	4.00	0.68	0.33	1.07	0.035
	23. I hesitate to enroll in a course with maths requirements.	2.75	1.23	2.44	1.08	-0.31	1.01	0.039
	16. I am patient when I do maths and I usually persevere until I get the answer.	3.25	1.16	3.53	0.94	0.28	1.00	0.053
	26. I am willing to share my insights about solving mathematical problems.	3.61	1.18	3.86	0.93	0.25	0.91	0.053
	17. Doing maths makes you think logically.	3.86	1.17	4.14	0.96	0.28	1.09	0.067
	24. I try to understand the solutions of my peers/classmates in maths.	3.50	1.00	3.81	0.82	0.31	1.21	0.070
Attitude - cognitive	37. Maths is so difficult that only those who are gifted can understand.	2.06	1.22	1.64	0.93	-0.42	0.97	0.007
	47. I believe life can go on without maths.	2.14	1.38	1.81	1.06	-0.33	0.86	0.013
	39. I think maths is irrelevant.	1.81	1.26	1.44	0.77	-0.36	1.02	0.020
	46. A good maths training is a big advantage in entering any line of work.	3.67	1.07	4.00	1.04	0.33	0.99	0.025
	35. I would like to work in a maths related field.	2.86	1.20	3.08	1.11	0.22	0.76	0.044
	44. I feel responsible for finding and checking errors in my solutions in maths.	3.47	1.23	3.72	1.19	0.25	1.00	0.071
	40. I think maths is challenging.	4.00	1.07	3.78	1.05	-0.22	0.93	0.080

Table 4. Pre-test/post-test: mathematics anxiety scales.

	t-Test: Paired Two Sample for Means							n= 36
		pre		post		difference		
	Descriptor	μ_1	s_1	μ_2	s_2	μ_D	s_D	p
Anxiety	57. I don't know how to study for a maths test.	3.03	1.28	2.42	1.27	-0.61	1.18	0.002
	70. I tell myself that am dumb in maths.	2.25	1.20	1.89	1.06	-0.36	0.72	0.003
	72. I know how to study for a maths test.	2.61	1.02	3.08	1.08	0.47	1.13	0.009
	56. I fear maths more than any other subject.	2.69	1.43	2.28	1.23	-0.42	1.08	0.013
	61. I worry about being called on in maths class.	2.86	1.31	2.56	1.21	-0.31	0.95	0.031
	59. I'm afraid I won't be able to keep up with the rest of the class in maths.	2.89	1.33	2.53	1.32	-0.36	1.13	0.031
	65. I think everyone else is smarter than I am in maths.	2.75	1.23	2.42	1.18	-0.33	1.12	0.042
	67. I get very nervous when taking maths tests.	3.19	1.31	2.89	1.45	-0.31	1.04	0.043
	73. I worry that I will embarrass myself in a maths class.	2.72	1.37	2.33	1.07	-0.39	1.38	0.050
	62. Working in a cooperative group would help me relax in maths class.	3.44	1.16	3.64	1.13	0.19	0.82	0.082

Conclusion

There are many shortcomings to this study. To identify a few: there was no prior experience with the instrument used; psychometric testing is not an exact science; the findings derive from a single sample – perhaps this cohort was 'special' in some sense; and the sample size for the pre/post test was quite small and, in certain respects may be regarded as a self-selecting sample and therefore to be viewed with a degree of caution. Nonetheless, if one is prepared to accept these limitations, it is clear that a profile of attitudes, anxiety, and self-efficacy beliefs was established and found to be consistent with corresponding attributes in the wider population, giving support to the initial research hypothesis. Qualitative changes to that profile, established by a pre-test/post-test methodology, were found to be quantifiable and statistically significant, thereby establishing support for the second hypothesis.

It remains to speculate on what these findings indicate. From the pre-test data, negative early learning experiences manifest by causing or exacerbating negative attitudes. A plausible scenario may be that attitudinal negativity could fuel avoidance behaviour, leading to diminished self-efficacy beliefs, heightened anxiety and, ultimately, perhaps choices to withdraw from mathematics learning. On the other hand, the pre-test data also indicate that, in every measure, greater good derives from positive early learning experiences. In the nine-week foundational mathematics course undertaken by the subjects of this study, considerable effort is expended to provide a positive learning experience in every respect: emphasis is given to values over issues by teaching mathematics as a process rather than a set of 'universal truths', demystifying the doing of mathematics by emphasising that mathematics *is* language, and conducting mathematics teaching in a supportive atmosphere where students are prepared to take reasonable risks, making mistakes – and learning from them – without blame, shame, or judgement. The result is a measurable and significant improvement in the views and beliefs of students towards mathematics itself and towards their capacity and willingness to engage with mathematics learning. The implications for teaching and providing mathematics support to students in, or wishing to access, tertiary studies are clear: if students' goals are blocked or their progress impeded because of their perceptions of mathematics, first challenge their negative attitudes, challenge their self-efficacy beliefs, and challenge their anxiety. These are plastic, not steel. Seek to change their relationship with mathematics.

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