Experience, the difference: maths attitudes and beliefs in commencing undergraduate students and pre-tertiary adult learners

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The attitudes, self-efficacy beliefs, and math-anxiety of commencing undergraduate students and of pre-tertiary adult learners were evaluated using the IMAES instrument previously developed by the author. Using those data, a profile of math learning characteristics was developed for each group, with the profiles then being subjected to analysis to expose significant differences. The results support previous findings that adults' perceptions of mathematics and their capacity to engage with mathematical content are strongly influenced by early learning experiences, while highlighting the numeracy gap experienced by those who have been educationally disadvantaged. The findings also indicate that lack of educational opportunity is at least as great a determinant as gender bias in predicting negative attitudes towards mathematics, including poor self-efficacy beliefs and raised levels of math-anxiety.

It is well established that 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). Philippou and Christou (1998) reported that learners' conceptions of mathematics, their perceptions of themselves, and their perceptions of their relationship to the subject, lie at the heart of their math learning behaviour. More than a quarter of a century ago, Sewell (1981) reported that there were negative math attitudes in at least half of the adult population and the situation appears no better in more recent times – in 2006, the Confederation of British Industry reported findings that nearly half of the adults (equivalent to some 15 million adults in the 16 to 65 age group in England) participating in a study of functional skills had numeracy attainment levels that were at or below the standard expected of 11 year-olds finishing primary school (CBI, 2006).

Practitioners and researchers in the field of adult mathematics learning have consistently found that many adults (perhaps even in the majority) exhibit at least some degree of anxiety when confronted with overtly mathematical tasks, that they have only a vague concept of what mathematics is really all about, lack confidence in their own mathematical abilities, and often fail to appreciate the extent to which they actually and routinely engage in essentially mathematical thinking as they go about their daily activities. Even so, and somewhat counter-intuitively, pupils, parents, and teachers appear, almost universally, to regard mathematics as both important and useful (Coben, 2003:93). Earlier findings from an Australian large-scale survey of public attitudes towards mathematics showed a uniform regard for its importance, with mathematical ability generally taken to be an indicator of intelligence (Galbraith and Chant, 1990) and, in measures of achievement for level placement and tertiary admissions relevant to science and technology, mathematics continues to figure prominently and frequently (Pajares, 2005), affirming its highly-valued place in the academic curriculum.

Such dual perceptions of mathematics were notable features of previous studies (Klinger, 2007a; Klinger, 2007b). The first involved pre-tertiary adult learners, henceforth referred to here as the PTAL group, who were volunteers among some 160 participants who, being unable to qualify for university entry by traditional means, were seeking to gain admission to undergraduate study by undertaking a 'foundation' or 'access' course – that is, a special entry programme providing an alternative pathway to tertiary education for adults who have been educationally disadvantaged. The second (a companion study following methodology similar to the first) involved 158 commencing undergraduate students who were volunteers among some 270 participants in a 4-day academic transition programme. These transition students are collectively referred to here as the TS group. This group was divided into two parts according to academic strand. The nomenclature TS(sc) is adopted for one sub-group, comprising those who were commencing undergraduate studies in science-based degree programs; the other sub-group is designated TS(a/h) to denote those who were commencing in arts- or humanities-based degree programmes. Where it is necessary to clarify meaning, the term TS(all) will be used to denote the full cohort.

To briefly re-cap, the former study (Klinger, 2007a) involved pre/post testing 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 consisting of a series of nine weekly lectures and tutorials constructed from a deliberate ethos that anticipated negative attitudes, low self-efficacy beliefs, and some level of math-anxiety. The emphasis, throughout that course, was on math learning as *process* rather than mathematics as a set of 'universal truths' communicated by rules. Learning experiences were constructed in a supportive atmosphere where students were encouraged to take reasonable risks, feel free to make mistakes without fear of shame or ridicule, and construct their own learning (with guidance). They were told that the aim of the topic was 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 would include brief investigations of the 'rules' of the language. The results of the study revealed that at the outset participants shared the pervasive negative views attributed to the broader population in many previous studies, whereas those views had changed significantly and substantially 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 latter study (Klinger, 2007b) sought to identify differences between TS(sc) and TS(a/h) sub-groups in their perceptions of mathematics, including their own capabilities. It was shown that the TS(a/h) students exhibited essentially the same pattern of negative maths attitudes, low mathematics self-efficacy beliefs, and anxiety of mathematics observed in the PTAL group from the earlier study, whereas their TS(sc) colleagues had attitudes and beliefs that were significantly more positive. In both studies, attitudes to mathematics, math-anxiety, and mathematics self-efficacy beliefs were found to be strongly linked both to gender and to early mathematics learning experiences. Moreover, gender was discovered to be a highly significant and major contributing factor in the observed differences between science and arts/humanities students. This was due to the substantially poorer views of mathematics held by female students entering arts and humanities degree programmes, compounded by the strong gender imbalance in those disciplines, which favoured females over males in the ratio 5:2. Those findings were consistent with long established literature reports of a very strong gender imbalance in any study that considers mathematics anxiety, attitudes towards mathematics, and mathematics self-efficacy beliefs, and that this imbalance consistently is to the detriment of females, who generally suffer greater than their male peers in incidence rates, severity of presentation, and degree of impact (e.g. Beaton, Mullis, Martin, Gonzalez, Kelly and Smith, 1996; Lussier, 1996; Osborne, Black, Boaler, Brown, Driver, Murray, *et al*., 1997; Philippou and Christou, 1998; Ashcraft, 2003; Macrae, 2003).

Arising from the hypothesis that pre-tertiary adult learners would fare worse than commencing undergraduate students in measures of mathematics attitude, anxiety, and self-efficacy beliefs, thus demonstrating and highlighting the 'numeracy gap' identified in the CBI report (CBI, 2006) and noted commonly throughout the literature as a characteristic of the educationally disadvantaged, the present study was motivated by a desire to gain a greater understanding of the factors contributing to any observable significant differences between the two cohorts. In particular, both of the earlier studies referred to above had shown that adults' perceptions of mathematics and their capacity to engage with mathematical content are strongly influenced by early learning experiences impacting on emotional, cognitive, and behavioural attitudinal domains. The influence of positive experiences in developing and supporting affirmative self-efficacy beliefs and the corollary of contrary influence due to negative experiences leads to mathematics learning situations where the inextricable link between cognition and emotion (Damasio, 1996; Greenspan, 1997; and Rolls, 1999; cited in Ingleton and O'Regan, 2002) directs the success or otherwise of learning outcomes and determines willingness to engage in further learning activities of a similar nature. Consequently, the analysis and results presented here also aim to assess whether, and to what extent, lack of educational opportunity is a determinant in predicting negative attitudes towards mathematics, including poor self-efficacy beliefs and raised levels of math-anxiety.

Methodology

The *Inventory of maths attitude, experience, and self-awareness* (IMAES) instrument (Klinger, 2007a) was administered separately to both groups. The IMAES instrument is a multi-part questionnaire that uses (mostly) 5-point Likert scales for responses to 95 statements about math attitude, math-anxiety, math self-efficacy beliefs, and past/early math learning experiences, with the attitudinal statements involving the affective, behavioural, and cognitive domains. The questionnaire also provides for the collection of information about each respondent's gender, age-group, ethnicity, last year of completed schooling, and last year of completed math education. When administered to the TS group, the questionnaire was augmented to also identify the area of study by recording the name of the degree in which the respondent was enrolled. Students were advised that participation was entirely voluntary and independent from any topic, course, or assessment activity. Incomplete questionnaires were set aside and not used in the study, leaving a total of 248 valid response sets from both surveys, collectively.

Factor analysis confirmed that the survey items were validly partitioned into their respective domains and these were then further segregated into sets of positive and negative statements (since these are not necessarily mutually exclusive). The reliability of each subset construct was tested by computing the internal consistency coefficients (Cronbach's alphas) for each and these ranged from 0.75 to 0.94 (mostly in the top of the range) – more than satisfactory since they exceed the 0.70 level desired of alpha coefficients for the purposes of a psychometric instrument (Nunally, 1978).

To 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. Further aggregation joined negative and positive subsets on single scales, such that an overall score of zero indicates neutrality, providing primary construct measure for Mathematics Attitude, Mathematics Anxiety, and Mathematics Self-efficacy. Sub-aggregate results also provide partitioning of attitude into affective, cognitive, and behavioural domains as well as yielding separate positive and negative scales for each construct.

In the case of the PTAL group, the pre/post methodology required the IMAES instrument to be administered twice, once prior to undertaking the core mathematics course, and again at its conclusion. To distinguish the two sets of results, the first set will be referred to here as PTAL(pre) and the second as PTAL(post). For the latter, only a subset of the PTAL(pre) respondents also provided valid responses to the second survey, reducing the size of this sample to 36 response sets.

In all, three data sets were available for further analysis, providing the opportunity to compare responses between the PTAL and TS groups using the standard statistical technique of independent sample t-tests for significance in mean differences. These were all undertaken as one-tailed tests as the direction of each difference is directly observable and thus amenable to interpretation. The tests were undertaken to compare PTAL(pre) and PTAL(post) responses each with the TS(all) group and the TS(sc) and TS(a/h) sub-groups, yielding six sets of results. The comparisons were undertaken with the aggregated and sub-aggregated survey data, as well as at the individual IMAES item level. Following convention, t-test scores with p-values of 0.05 or smaller are considered to be significant results (i.e. having a significance level of 5%), while those with p-values of 0.01 (significance level of 1%) or less are considered to be highly significant. For brevity, only those results indicative of significant and highly significant difference are reported, except where it is of interest to report the absence of any significant difference.

Results

Comparison 1: PTAL(pre) *v* TS(all)

Highly significant differences were observed in the sub-aggregate scale for negative self-efficacy beliefs and in both of the positive and negative experience scales. The PTAL subjects rated themselves more strongly in their negative self-efficacy beliefs, particularly those relating to problem solving and comparison with their peers. They reported more negative early mathematics learning experiences, most notably those involving physical punishment at school, parental anger and chastisement, all of which were highly significant. On the other hand, they reported fewer experiences of positive feedback from their teachers.

A significant difference observed in the negative attitude scale in the affective domain, again to the detriment of PTAL subjects, was found to be due to feelings of tension in past school mathematics classes. Otherwise, there were no significant differences in any of the attitude measures in the affective domain. Similarly, examination of the behavioural attitude domain revealed few significant differences except where the factors involve behaviour that would appear to be associated with low confidence and lack of positive self-efficacy beliefs, leading to reduced engagement with maths learning.

An unexpected finding presented from scales in the cognitive domain for attitude, with PTAL subjects showing highly significant differences in their greater regard for mathematics, apparently valuing maths activities as relevant to career and workplace success, as well as indicating a greater appreciation of the importance of mathematics outside school. On reflection, it might be inferred that this is a consequence of the greater life experience shared by this cohort compared to that of the commencing undergraduates, whose numbers tend to be dominated by immediate, or at least recent, school-leavers.

While insufficient to be revealed in the aggregated anxiety scale, significant differences were observed in about half of the individual anxiety measures, of which more than half again were highly significant. These were all to the disadvantage of the PTAL subjects and again revealed a close association with self-efficacy beliefs (lack of confidence, nervousness, uncertainty about how to study for maths tests) and negative experiences (discomfort in seeking help, fear of asking questions, fear of being called upon by teachers).

Comparison 2: PTAL(pre) *v* TS(sc) and TS(a/h)

An unremarkable result is that PTAL subjects fared significantly worse than TS(sc) subjects in all but three of the seventeen aggregate measures, the exceptions lying entirely with the attitude scales in both the affective and cognitive domains, where PTAL subjects scored higher in the negative scales, and also with the positive behavioural domain, where TS(sc) subjects scored higher. Compared to TS(sc) students, PTAL subjects recorded a considerably higher mean on the negative early maths learning scale and much lower on the positive one.

In stark contrast, the PTAL subjects displayed no significant differences in the aggregate scales when compared with TS(a/h) subjects, *except* in the measure for negative early maths learning experiences, where the PTAL cohort fared substantially worse, and in the positive attitudinal scale, in which PTAL subjects scored higher. For the latter, closer examination of the corresponding sub-aggregate scales revealed that the difference lay exclusively within the positive affective domain in items relating to interest and enjoyment, which comprised one third of the fifteen items contributing to the scale.

Although the PTAL and TS(a/h) cohorts showed no statistically significant difference in the aggregated anxiety scale, inspection of the twenty-seven individual items identified highly significant differences in four of them. Here, PTAL subjects fared worse in three of the four, all related to lack of confidence and low self-efficacy beliefs. The exception, of sufficient magnitude to counter the influence of the other three in the aggregate scale, was a substantially stronger response indicating excitement or arousal

– that is, despite their various other reservations and lack of confidence, PTAL subjects felt stimulated by attendance at a maths class. Their mean response to the statement, ‘I am excited to come to maths class’ was 65% higher than that of the TS(a/h) cohort. It is a matter for speculation that this is consistent with a higher regard for the value of mathematics and an indicator perhaps of greater maturity, as well as demonstrating determination to overcome the limitations imposed by their early mathematics learning histories.

Still considering the anxiety scales, PTAL(pre) subjects fared considerably worse than the TS(sc) cohort in seventeen of the twenty-seven items, but for one, where their response was substantially higher (by 27%). This, again, occurred with the ‘excitement’ statement. It is suggested that this rather unexpected observation gives further evidence to support the previous speculation, highlighting the enthusiasm, commitment, and engagement that many adult learners (particularly those seeking non-traditional pathways to higher education) bring to their studies.

In all of the self-efficacy scales, TS(sc) subjects scored consistently better than their PTAL counterparts, with differences associated with *p*-values ranging from 0.03 to 0.001. This is contrasted strongly in the comparison between the TS(a/h) and PTAL groups for these scales, where there was only one item with a significant difference. That finding, indicating that PTAL subjects experience greater difficulties solving one-step problems, while significant with $p = 0.037$, was inconsistent with closely related cross-check items and thus considered to be a spurious, or at least anomalous, result.

Comparison 3: PTAL(post) *v* TS(all)

Comparing PTAL(post) subjects with the TS(all) group revealed a striking reversal of the observations for PTAL(pre) subjects, with the most significant difference found in the positive affective domain of the attitude scale. Closer analysis identified the contributing factors, which indicated that the negative feelings of tension in past school maths classes had given way to considerably stronger positive emotions indicating interest, confidence and excitement associated with present maths classes and maths experiences. These affective responses were reinforced by changes in the behavioural domain so that PTAL(post) subjects were seen to have more positive engagement with their mathematics learning than the TS(all) cohort, reporting substantially greater stimulation, willingness to share insights, greater patience, perseverance, and a substantial improvement in help-seeking behaviour.

Consistent with observations for PTAL(pre) subjects, the PTAL(post) group showed highly significant differences in their greater regard for mathematics compared to the TS(all) group. In nine of the fifteen individual factors comprising the cognitive domain of attitude, differences favouring the PTAL(post) group were observed and in every instance these were greater in magnitude than those observed with the pre-test group.

Significant differences were observed in just five of the twenty-seven anxiety factors and only one of these was highly significant: the substantially stronger response by the PTAL(post) group to the statement, ‘I am excited to come to a maths class’. While (as before), these five differences combined were insufficient to show up in the aggregated anxiety scale, their magnitudes considered together with the reduction in the number of factors displaying differences are considered to be strongly indicative of substantially reduced anxiety levels after these subjects had completed their foundation maths course.

Only two of the individual factors for self-efficacy beliefs showed significant differences and these both favoured the PTAL(post) group, indicating greater self-confidence and reduced perceptions of maths weaknesses. In a reversal of the PTAL(pre) results, these subjects no longer rated themselves more strongly than their TS(all) peers in their negative self-efficacy beliefs.

Comparison 4: PTAL(post) *v* TS(sc) and TS(a/h)

Whereas the PTAL(pre) subjects had fared significantly worse than TS(sc) subjects in most of the seventeen aggregate measures, the PTAL(post) subjects displayed significant differences in just four scales, faring worse in their self-efficacy beliefs and, to a lesser extent, in their attitude – specifically in the negative affective domain and the overall scale for positive maths attitude. However, the two groups showed no significant differences in any of the individual self-efficacy factors. Moreover, the number of anxiety factors exhibiting significant differences was reduced by more than two-thirds from the PTAL(pre) comparison, with just five of the twenty-seven factors contributing to higher math-anxiety among the PTAL cohort.

The changes experienced by the PTAL subjects during their participation in the foundations mathematics course are demonstrated even more effectively when they are compared with the TS(a/h) subjects. Here, only three significant differences were observed in the aggregate scales and these occurred in the positive affective, cognitive, and behavioural domains for attitude. Each favoured the PTAL(post) group, as did all but one of the remaining aggregate scales (the exception being an insignificantly and marginally poorer score for the mean negative self-efficacy measure).

In the affective domain for attitude, PTAL(post) subjects scored higher means for positive factors and lower means for negative ones in every instance, with nine of the fifteen results being statistically significant and half of these, highly significant. The behavioural domain displayed the same characteristics and the cognitive domain even more so.

Finally, as with the PTAL(pre) analysis (Comparison 2, above), the PTAL(post) and TS(a/h) cohorts showed no statistically significant difference in the aggregated anxiety scale. However, eleven of the individual anxiety factors revealed significant to highly significant differences, all favouring PTAL(post) subjects except for a single factor involving an historical statement about past maths learning. Similarly, half of the individual self-efficacy factors were found to be significantly different for the two groups and, again, the TS(a/h) subjects fared worse.

Discussion and Conclusion

The IMAES scores and analyses reported here provide empirical evidence that pre-tertiary adult learners do indeed fare worse than students in transition to undergraduate studies in measures of maths attitude, self-efficacy, as hypothesised, although not entirely according to expectations. The strongest pattern of differences in the reported results reveals that mathematics self-efficacy beliefs and early maths learning experiences are clearly related in their influence on the subjects' maths learning characteristics. Compared to all commencing undergraduates, and before undertaking the foundations maths course, PTAL subjects were found to have lower mathematics self-efficacy beliefs and greater levels of math-anxiety, manifesting in lack of confidence, apprehension, and behaviours associated with reduced engagement with maths learning opportunities. Such differences were particularly marked in the comparison with those transition students choosing to follow science-based academic careers, being greater in magnitude and appearing in substantially more factors than observed with the full tertiary cohort. Without considering actual maths *ability*, which lies outside the scope of the present work, taken collectively the observed differences represent what might be termed an emotional, cognitive, and behavioural numeracy gap between the two primary cohorts.

Reference to the first companion study (Klinger, 2007a), which examined the results for PTAL subjects exclusively, identifies that these scales show correlations with gender (favouring males), clear tendencies that greater school-age math instruction tends to reduce the negative factors and raise the positive values in every domain, and very strong correlations between early maths learning experiences and attitude, anxiety, and self-efficacy beliefs. It appears a clear conclusion, then, that the dominant cause of the observed numeracy gap lies in the combination of educational disadvantage and the influence of early mathematics learning experiences on the attitudes, anxiety, and self-efficacy beliefs of PTAL subjects.

Whereas it was shown previously (Klinger, 2007b) that there is a similar pattern of differences between students who are commencing undergraduate degrees in the sciences (and related disciplines) and their peers in arts and humanities programmes (that is, there is something of a numeracy gap between the two academic strands), in this study it is clear that PTAL subjects have perceptions of mathematics and their own maths ability that closely parallel those of the TS(a/h) cohort. This might suggest that the numeracy gap is rather less than indicated.

However, in Klinger (2007b), it was reported that ‘a major contributing factor to the observed differences [between the two academic strands of Sciences and Arts/Humanities] was the substantially poorer views of mathematics held by female students in arts and humanities degree programmes’. In the TS(a/h) group, females outnumber males in the ratio 5:2 (which is essentially identical to the commencement enrolment statistics of the day), whereas the PTAL cohort has a gender ratio of 5:4 (as does the TS(sc) group). Interpreting the current findings from a gender perspective indicates that educationally disadvantaged PTALs, with a near-even gender distribution, display a profile of attitudes, anxiety, and self-efficacy beliefs that closely parallels the profile of the female-dominated and educationally *advantaged* TS(a/h) group, and for very similar reasons that are clearly rooted in early mathematics learning experiences.

The present results strongly suggest, therefore, that educational disadvantage occasioned by lack of educational opportunity is at least as strong a determinant as gender in predicting negative attitudes towards mathematics, including poor self-efficacy beliefs and raised levels of math-anxiety.

The ethos and methodology adopted in the foundation mathematics course undertaken by the PTAL cohort very much follow the model developed over numerous years of providing academic mathematics support, described in Klinger (2004), and the substantially stronger and more optimistic results after completing their course is encouraging. This finding highlights the very real possibility of bringing about transformations in adult learners' perceptions of mathematics and their own capacity and inclination to attempt mathematics learning later in life, despite the anxieties and uncertainties that dog them from past experience.

Experience, in the context of prior mathematics learning and educational opportunity, impacts on math learning profiles, with negative or poor experiences contributing to, if not causing, the numeracy gap observed here. On the other hand, experience, in the context of new opportunities, can also impact on math learning profiles, with better and more positive experiences than those of the past serving to shrink, and even eliminate, the numeracy gap. It has been shown, moreover, that experiences which foster positive self-efficacy beliefs have greater impact than negative experiences (Klinger, 2007a).

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