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Analysis of student beliefs in a tertiary preparatory mathematics course

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Every year approximately 800 students enrol in the tertiary preparatory course TPP7181 at the University of Southern Queensland. Successful completion of this course will allow students to enrol in either further preparatory level mathematics courses or undergraduate study. For many of the students enrolled in this course, the study of mathematics was undertaken quite some time ago and usually in a school setting. Drop out rates for this course are quite high and it is hypothesized that motivation may be a key factor in determining student success or otherwise. In this study scales assessing self-efficacy were utilized in an attempt to gauge aspects of the motivation of students enrolled in the course. Initial results suggest that only specific measures of student confidence predict their performance and that both gender and age mediate the strength of this prediction.

1. Introduction

The cost of failure at university studies to a community and the individual, both in social and financial terms, can be quite high and there is an imperative to better understand the factors that affect students' academic performance. Educational research into student achievement has broadly focused on two major areas: cognition and motivation [1]. In the area of cognition, researchers have found that factors such as prior knowledge and the use of cognitive and metacognitive strategies will influence the type of learning undertaken and consequently student achievement. In the area of motivation, research has concentrated on why learners display certain behaviours and how these in turn affect their achievement. Some evidence suggests that motivational factors may in fact play a more important role in the prediction of academic achievement than cognitive factors [2].

The purpose of this study was to investigate motivational effects on the performance of students in a Tertiary Preparatory Mathematics Course with particular focus on student confidence in their ability to succeed in mathematics as the primary motivational effect. Secondary purposes of the study were to investigate

- the relationship between student beliefs on intelligence, their confidence towards mathematics and their subsequent performance;

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- the relative predictive strengths of mathematics confidence measured at three levels of specificity; confidence to succeed in the course, confidence to succeed in a mathematics topic and confidence to succeed in a specific mathematics question.

2. Theoretical framework

The underlying framework for this study is based on Bandura's social cognitive theory [3], which maintains that even if a student has received reinforcement in the past for displaying a certain desirable learning behaviour, they must believe in the value of this behaviour if they are to continue displaying it. It is student beliefs about the value of a learning activity, their expectation of success and their enjoyment of it that will motivate them to undertake it [4].

Several constructs have been established in order to gauge the effect of motivation on student achievement and considerable research has been directed at two of these; achievement anxiety and self-efficacy. Anxiety regarding the consequences of failure is known to motivate undesirable learning behaviours, which in turn result in diminished academic performance [2, 4–6]. Belief in their confidence to succeed in a given task (self-efficacy) is known to motivate desirable learning behaviours in students leading to subsequent academic success [7–11]. It is known that these two factors are inversely correlated [4, 12] and Bandura [3] argues that when anxiety is known to correlate with performance this relationship diminishes or disappears altogether when the effect of self-efficacy is removed. For this reason, it was felt that the current study into motivational effects should concentrate on self-efficacy.

Self-efficacy is known to predict achievement in mathematics [10–12], however, it is hypothesized that student beliefs on the nature of intelligence may in fact mediate this relationship. This hypothesis is supported by Stodolsky [13], who suggests that mathematics is an area in which student views on intelligence play a dominant role in performance. It is known that a student's belief regarding the nature of intelligence, that is whether it is a fixed entity (you either have 'it' or you don't) or whether it is incremental (you can improve your intelligence by learning new things) will influence the type of learning behaviours that they adopt [14]. This study seeks to investigate the relationship between student beliefs on intelligence, their confidence towards mathematics and ultimately their performance.

Evidence reported in a meta-analysis of self-efficacy studies by Multon *et al.* [9], suggests that the effect on performance of self-efficacy will be greater for older and low achieving students. As many of our students fit into this category this study seeks to investigate the mediating effects of age and previous achievement on mathematics self-efficacy and mathematics performance. In this study we also examine the effects of gender on both self-efficacy and performance.

Research shows that the strength of the association between a student's self-efficacy and their educational performance relies on the proximity (both in time and in nature) of the self-efficacy measure to the performance measure. Using the Motivated Strategies for Learning Questionnaire (MLSQ) [4], which is a general measure of self-efficacy, McKenzie *et al.* [15] found a 0.19 correlation between student confidence in their ability to succeed in a course and their

subsequent performance. Pajeres and Graham [10] on the other hand, were able to obtain a correlation of 0.57 between student confidence in their ability to solve specific mathematical problems and their subsequent performance in these problems. Using an item that is too specific, however, defeats the purpose of research, making the results too contextually based to be useful [16]. In an attempt to overcome this conflict between strength of association and applicability of results, Nielsen and Moore [17] developed a scale of intermediate specificity that assessed student confidence in mathematics topics (Mathematics self-efficacy scale). One of the purposes of this study was to assess the predictive strengths of self-efficacy in mathematics at three levels of specificity:

- self-efficacy at the course level ('I am confident I can succeed in this course');
- self-efficacy at the topic level ('I am confident I can solve a problem using algebra'); and
- self-efficacy at the question level ('I am confident I can solve the equation $y = x + 2$').

Pajeres and Miller [12] make the point that self-efficacy is task specific. They argue that items asking students to provide an assessment of their confidence in mathematics in general are not assessing self-efficacy but mathematics self-concept. We regard this argument as academic. The purpose of this study was to assess the motivational aspects of students in a tertiary preparatory context. We believe that in this context confidence towards mathematics (whether it is towards specific tasks or is more general) will provide significant motivation for our students to adopt positive learning behaviours and to ultimately achieve. We will use the term mathematics confidence to describe student beliefs regarding their confidence to succeed in mathematics at both the general and the specific level.

3. Background to the study

The Tertiary Preparatory Program (TPP) at the University of Southern Queensland (USQ) was established in 1989 and is one of the largest access and equity initiatives in the Australian higher education sector [18]. 'Mathematics Level A' (TPP7181), a core TPP mathematics course, aims to provide students entering 'non-mathematical' undergraduate courses with pre-requisite mathematical knowledge and skills. The course includes topics on numeracy, descriptive statistics, introductory algebra and some preliminary work on functions (primarily linear). Details of the content and curriculum design are described in Taylor and Mohr [19].

Students enrolled in the preparatory program (median age 29 years) are generally older than students enrolled in the University's undergraduate courses (median age 25.5 years). Many students entering the program come from sub-populations that are not traditionally represented at university, they have not studied formal mathematics for many years and often have a history of lack of success in school mathematics. These students are reported to have reduced levels of enjoyment of mathematics compared with traditional recent school leavers [19]. The TPP is regarded by the University as an important mechanism for addressing access and equity problems in the community, with approximately 30% of successful students subsequently enrolling in a USQ award programme and 19% in other tertiary programmes [18]. Many students, however, fail to meet the expectations required of

them and withdrawal rates are quite high. In the mathematics course TPP7181 an average of 30% of enrolled students withdraw from the programme each semester and of those who remain between 40% and 45% do not receive a passing grade.

4. Research design and methodology

A self-report questionnaire was developed with items adopted (in most cases) from existing validated scales. Items from the popular MSLQ [4] were used to assess student confidence in their ability to succeed in mathematics at the course level. The Mathematics Self-efficacy Scale [17] was used to assess student confidence in their ability to succeed in mathematics topics. A scale was written to assess students' confidence in a sample of 10 specific mathematics questions. Items to assess students' beliefs about intelligence were adopted from the 'Entity related Beliefs and Effort Scale' [20]. The final instrument thus consisted of five hypothesized scales:

- Scale C–confidence in ability to succeed in the course (8 items).
- Scale T–confidence in ability to succeed in a specific mathematical topic (12 items).
- Scale Q–confidence in ability to succeed in a specific mathematical question (10 items).
- Scale E–measure of entity beliefs on intelligence (6 items).
- Scale I–measure of incremental beliefs on intelligence (6 items).

After a small pilot study involving a prototype questionnaire and interviews, final questionnaires were sent out to all students enrolled in Tertiary Preparatory Mathematics Level A (TPP7181) for semester 1, 2005. In all 364 were posted and 129 were returned (50 were male and 79 female). In 50% of cases, more than 10 years had elapsed since the students had last undertaken formal studies in mathematics (in 25% of cases this was more than 20 years). The final questionnaire included the five above scales as well as demographic data on age, gender, years since study, and was accompanied by a routine mathematics readiness test.

Factor analysis was used to assess the factorial structure of the instrument. The concurrent validity of scale Q was evaluated through a comparison of responses with the validated scales C and T. Internal consistency was assessed using Cronbach's alpha.

Student results in their first course assignment, which was due soon after the commencement of the semester, provided an initial measure of their performance in the mathematics course. Of the original 129 respondents, 20 had withdrawn prior to completing their first assignment. In this initial analysis it was felt appropriate that these students be awarded zero for their performance in the first assignment.

5. Initial results

5.1. *Assessment of the hypothesised scales*

Factor analysis of scales C, T and Q indicated the presence of one underlying factor in each case that accounted for 57%, 57% and 61% of the variance respectively. These factors were then used in subsequent analyses under the titles

'course confidence', 'task confidence' and 'question confidence' respectively. The factorial structure of the remaining scales was less evident and no attempt was made to retrieve an underlying factor that explained student beliefs regarding the nature of intelligence. Internal consistency for the scales C, T, and Q was 0.85, 0.94, and 0.87 respectively.

5.2. *Correlations between self-efficacy scales, existing knowledge and performance*

Correlations were calculated between the three self-efficacy scales, student results in their maths readiness test (M-test) and student performance in their first mathematics assignment. These are shown in table 1.

Course, topic and question confidence measures were strongly correlated with each other. These measures were also correlated with prior knowledge (M-test), with the more specific measures (Question confidence) correlating more strongly than the less specific measures. Only prior knowledge (M-test) and question confidence correlated (and this was weakly) with academic performance.

5.3. *The effect of age and gender on confidence*

Females consistently reported lower levels of confidence than males. This difference was more pronounced for the more specific measures of confidence. There were no significant differences in prior knowledge for females and males nor were there in academic performance.

Similarly, students who had spent a longer period of time since last studying mathematics reported lower levels of confidence. This relationship was strongest between task confidence and time ($r = -0.330^{**}$). There was no evidence of a relationship between this time and actual student performance.

5.4. *Student beliefs on the nature of intelligence and their confidence towards mathematics*

As previously reported, the factorial solution for the 6 items that assessed an entity view of intelligence and the 6 items that assessed an incremental view of intelligence was inconclusive. Nevertheless, very few students strongly adhered to an entity view of intelligence. Based on a sum of raw scores (each one ranging from 1 to 5) for these six items, only 8.5% of students scored a total of 18 or more out of a possible 30. In other words these students tended to agree with statements such as 'it doesn't

Table 1. Study correlations.

	Scale C	Scale T	Scale Q	M-test	Assign. 1
Scale C	1	0.58**	0.58**	0.25**	0.07
Scale T	–	1	0.72**	0.39**	0.12
Scale Q	–	–	1	0.45**	0.20*
M-test	–	–	–	1	0.33**
Assign. 1	–	–	–	–	1

*Significant at the 5% level of confidence.
**Significant at the 1% level of confidence.

matter how you study mathematics, you either have the ability or you don't'. It would seem that most adults subscribe to an incremental view of intelligence, and this issue is probably not relevant in an adult education context.

6. Summary and conclusion

The primary purpose of this study was to investigate motivational effects on the performance of students in a Tertiary Preparatory Mathematics Course. At this stage in the study, only performance data for one assignment were available. Using the first assignment as a measure of performance it was found that significant correlations occurred between prior academic knowledge (as measured by a mathematics pre-test), confidence to solve specific mathematics questions, and performance. In other words the evidence suggests that students' assessments on their confidence to successfully undertake mathematics questions is based, in part, on their current level of knowledge and skills, and that this will influence their ultimate performance. Although these results are not surprising, the small effects obtained are of interest. They seem to indicate that either a much larger sample might be required, or that such effects may not be so pronounced for the students enrolled in this preparatory mathematics course.

Female students reported lower levels of confidence in all three scales used – their actual performance, however, was not significantly different from that of male students. Similarly students who had spent some years away from study expressed lower levels of confidence than those who studied mathematics more recently. Yet the performance of both groups was not significantly different. It is likely that some students gain motivation from their lack of confidence, and this may be the case for females and mature aged students. Students with a lower prior knowledge of mathematics were less confident and less likely to outperform students with a high prior knowledge. In fact, of the twenty students who withdrew from the course prior to the first assignment, 18 obtained scores less than the median in the mathematics pre-test.

Students are able to assess their mathematics confidence to a greater degree of precision when they are familiar with the material on which they base this judgment. Consequently results from the question confidence scale were more precise, in that they correlated with performance, and more clearly demonstrated the effects of gender and age. However, it is course performance that is the ultimate concern and it is difficult to comment at this stage on the usefulness of any of these measures in predicting course achievement. Student beliefs on intelligence did not appear to be a factor that influenced their confidence or their performance. The majority of respondents indicated that they believed intelligence was incremental and that there was value in hard work.

As teachers we are only too aware of the importance of motivation on mathematics achievement. However, actually identifying this motivation to the degree that we can measure its effect is not an easy task. It is obvious from the initial findings of this study that more data need to be obtained in order to have the statistical power to identify such motivational effects. Certainly the initial results suggest that the effect of mathematics confidence on student performance in a tertiary preparatory context is far more complex than first thought. Older students who lack confidence and indeed adequate prior knowledge and skills, may have gained through life's experiences a determination (as opposed to a confidence) to overcome these and

succeed. Further research on student beliefs on the value they place on learning and their enjoyment of such learning may be needed in order to clarify the role of motivation on performance for tertiary preparatory mathematics students.

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