A STUDY OF THIRD LEVEL STUDENTS' BELIEFS ABOUT MATHEMATICS

Sinead Breen, St Patrick's College, Drumcondra
Joan Cleary, Institute of Technology, Tralee
Ann O'Shea, National University of Ireland, Maynooth

In 2006 and 2007, first year students in three third level institutions in Ireland were surveyed in order to gauge their attitudes to mathematics. In particular students were asked whether they believed that mathematical ability could be improved and were asked to rate their confidence in approaching mathematics. Dweck (1986) maintains that a student's theory of intelligence (as to whether intelligence is fixed or malleable) and confidence in his/her present ability combine to influence the student's behaviour when presented with an unfamiliar task. Bandura (1977 and 1993) postulated that self-confidence has a major influence on whether a person will attempt a task and with what determination and perseverance. As part of the survey the mathematical literacy of the students was also measured (Breen et al 2007) and the data collected will be used to investigate both of these theories. Moreover, the responses of the students with regard to theories of intelligence are contrasted with the responses of mathematics teachers to similar questions as part of the TIMSS (Beaton et al, 1996) and PISA (Cosgrove et al, 2004) studies. Gender and age differences in confidence levels and theories of intelligence are also explored.

Introduction

For many years, third level Mathematics Departments in Ireland have been using diagnostic tests to identify 'at-risk' students and to construct support systems for these students. These diagnostic tests usually seek to identify any gaps in students' basic mathematical skills. The authors felt that more insight into the problems faced by students as they make the transition to third level education could be gained by a broader investigation of students' mathematical literacy and their mathematical attitudes or experiences. It was hoped that the data collected might help to identify ways in which these transition problems could be addressed. Most lecturers have encountered students who have very little belief in their ability to learn new mathematics, and this lack of confidence acts as an obstacle to progress. As part of this study, students were asked questions about the nature of mathematical ability and about their confidence in approaching the subject. We will investigate how these beliefs affect students' mathematical performance and perseverance.

Bandura (1977) introduced the term self-efficacy to describe a person's judgement of his/her own ability to successfully take part in a specific activity. He claims that self-efficacy influences the goals that people set for themselves, how much effort they expend, how long they persevere in the face of difficulties, and their resilience to failure (Bandura 1993, p 131). He claims that people with a strong sense of self-efficacy are more likely to view challenges in a positive light, and will recover quickly from setbacks. On the other hand, people with low self-efficacy will avoid challenges, and any failures will cause them to lose confidence. Hackett and Betz

(1989) investigated the relationship between mathematical performance and mathematics self-efficacy. They studied over 200 students at a US university and found that performance and self-efficacy were correlated and that self-efficacy was a better predictor of whether a student would choose a mathematics-related major than mathematical performance. They had previously postulated that female students had unrealistically low levels of mathematics self-efficacy compared to male students but were unable to find evidence to support this theory.

Dweck (1986) claims that a student's goal-setting is influenced by his/her theory of intelligence. She claims that students who believe that intelligence is fixed tend to have performance goals, their aim is to receive positive feedback and to avoid negative judgements of their ability. Students who believe that intelligence is malleable, however, have learning goals and aim to increase their competence. She claims that these goals, along with confidence, have a strong influence on behaviour in the following way: students with learning goals will enjoy challenges and display perseverance whether their confidence is high or low; however, students with performance goals will behave in this way only if their confidence is high and otherwise will avoid challenges and will give up easily. Elliott and Dweck (1988) experimentally tested the latter hypothesis with 101 fifth-grade children by manipulating the children's beliefs about their current levels of ability and the relative values of the two goals. They report that the results obtained confirmed their expectations. Dweck (1986) also reported differences between males and females, she reported that girls (especially bright girls) have less confidence in their abilities and tend to avoid challenges.

Carmichael and Taylor (2005) conducted a study of 129 students to test the hypothesis that motivation was a key factor in determining the success of students on a tertiary preparatory mathematics course in Queensland. They found student beliefs on intelligence did not appear to influence their confidence or performance. Initial findings indicated that specific measures of confidence (that is, confidence in ability to succeed on a specific question) can predict student performance, but it was remarked that any such effect is far more complex than originally thought.

In a study of US college students, Sax (1992) found significant differences between the levels of confidence in mathematical ability between males and females. She followed the students for four years and found that mathematical confidence actually decreased over this time and that the decrease was larger for women. She also found that even after four years of college, students' mathematical confidence was most strongly predicted by second level experiences.

Attitudes of Irish mathematics teachers have been investigated as part of two international studies. In the 1995 TIMMS study (Beaton et al, 1996) and in the 2003 PISA study (Cosgrove et al 2004), teachers were asked whether they agreed with the statement 'Some students have a natural talent for mathematics and others do not'. In TIMMS it was found that 90% of students were taught by teachers who agreed with this statement and this was supported by the results of the PISA survey where 92.4% of teachers agreed or strongly agreed with the statement. Lyons et al (2003) asked the ten teachers taking part in their intensive study of ten post-primary mathematics classes in Ireland the same question: all 10 agreed. However, they found that the students, especially the girls, taking part did not view innate ability as important as the teachers. It was also observed in this study that the boys' assessment of their own ability was slightly higher than the girls, though this difference was not significant.

The Study

In February 2006 and 2007, first year students at IT Tralee (ITT), St Patrick's College, Drumcondra (SPD), and the National University of Ireland, Maynooth (NUIM) participated in a one hour survey which comprised of a PISA-style test and a questionnaire. The PISA-style test aimed to measure the students' mathematical literacy and the questionnaire was used to gather their opinions and experiences of mathematics and their mathematical education. The survey was carried out early in the second semester of the students' first year at third level and was anonymous.

Participants

In 2006, this survey was administered to first year students in the Engineering Department at ITT, the Arts faculty at NUIM and the Humanities and Education faculties of SPD. In 2007, the test was again administered to first year students in the Engineering Department at ITT, the Arts faculty at NUIM, and two groups of first year Science students at NUIM. In total, 316 students took part in the study. There were 60 students in the ITT group, 33 students in the SPD group, 131 students in the NUIM Arts group, and 81 students in the NUIM Science group. This Science group is split into separate mathematics classes called Standard (N=36) and Quantitative Methods (QM) (N=45). The main difference between these two classes is that the Standard group have mostly taken Higher Level (HL) mathematics at Leaving Certificate and the QM students have mostly taken Ordinary Level (OL) mathematics. The ITT students and the NUIM Science students are required to study mathematics in first year at third level while the SPD students and the NUIM Arts students have chosen to study mathematics. The full group was made up of 184 females (58.2%) and 132 males (41.8%). There were 29 mature students (9.2% of the total sample). 142 students (44.9%) took mathematics at HL at Leaving Certificate, 169 students (53.5%) took OL and 5 students did not report their Leaving Certificate level. Table 1 below shows the spread of Leaving Certificate results for the group. Nine students (2.8% of group) did not report their Leaving Certificate Mathematics grade. 52% of the female students and 36% of the male students studied mathematics at HL.

Table 1: Leaving Certificate Mathematics Grades

Grade	HA	HB	HC	HD	HE	OA	OB	OC	OD	OE
Number	15	54	58	13	1	62	66	28	9	1
% of Gp	4.7%	17.1%	18.4%	4.1%	.3%	19.6%	20.9%	8.9%	2.8%	.3%

Instrument

The PISA-style test used test items released from the PISA 2000 and PISA 2003 studies (OECD 2004a). The PISA studies aim to measure how well 15-year-old students are equipped to deal with mathematics in real-life situations as opposed to how well they have mastered particular curricula. PISA questions are classified into four content subdomains (Space and Shape, Quantity, Uncertainty, and Change and

Relationships), and three competency clusters (Reproduction, Connections, and Reflection). Each item is assigned a difficulty level and students are awarded scores which reflect the difficulty of items they could answer. Thus student scores and item difficulties are measured on the same scale (OECD 2004b). In PISA 2003, scores were standardised so as to have a mean of 500 and a standard deviation of 100. Furthermore, six proficiency levels were identified in PISA 2003. Level 1 students succeed only on the most basic tasks whereas level 6 students are able to handle complex problems and have advanced reasoning skills. The PISA-style test used in this survey contained 13 questions to be completed in 30 minutes. The questions were spread across the four content subdomains, the three competency clusters, and the six proficiency levels in such a way as to make it comparable to a single PISA question-cluster. Item Response Theory was used to convert the raw scores (out of 13) to a score on the PISA scale and this score was then used to assign a proficiency level to each student (OECD 2004b). Table 2 below shows the percentage of students who participated in this study in each literacy level. For an analysis of how Irish students performed on PISA 2003 see Cosgrove et al (2005). Breen at al (2007a) describes in detail the PISA-style test administered and subsequent results for first year students at ITT, SPD and NUIM in 2006. Previously, Corcoran (2005) used a PISA-style test to study the mathematical literacy of a group of pre-service primary teachers.

Table 2: Mathematics Literacy Levels

Literacy Level	Below Level 1	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Percentage	0.9	0.9	5.1	16.5	38.6	15.2	22.8

Once they had completed the PISA-style test, students were asked to fill in a questionnaire. The questions could be grouped into the following categories: second level experience of mathematics; third level experience of mathematics; attitudes to mathematics; study habits. Findings from the 2006 study relating to students' experiences of mathematics at second and third level are reported elsewhere (Breen at al 2007b). This paper will be concerned with the students' responses to two questions relating to the nature of mathematical ability and their confidence in approaching mathematics.

Motivational Factors

Improving Mathematical Ability

Students were asked whether it is possible to improve natural mathematical ability. Of the 303 students who answered this question, 82% answered yes, 14% said no and 4% were unsure.

Of the students who commented further, 58% said that practice and hard work can help improve ability. About 10% expressed opinions like 'you either have it or you don't'. One student said 'Everyone has a limit to how much they understand. Maths requires a lot of understanding, if you don't have this initially it is hard to develop it'. It should be noted that 17% (N=55) of students did not offer any comments. As noted earlier, in TIMSS 1995, 90% of Irish second year students were taught by teachers who agreed that some students have a natural talent for mathematics while others do not (Beaton et al, 1996). In a survey of Irish mathematics teachers in schools participating in PISA 2003, more than 90% held a similar opinion, (Cosgrove et al, 2004). Moreover, Irish teachers interviewed by Lyons et al (2003) agreed. This illustrates a stark contrast in the views held by teachers and adult learners.

It is interesting to look at the comments in this section. Many of the 58% who think practice makes perfect say that you need to work hard, do lots of examples, or learn formulas in order to improve. Some typical comments were: ‘maths is about practice’; ‘do loads of questions’; ‘you can see trends in problems the more you repeat them’. This attitude seems to stem from the view of mathematics as a series of procedures rather than a series of concepts. It also reflects the study methods that many students employ. Not all students felt like this however, for example, one said ‘A deeper understanding of maths instead of mechanically memorising would improve natural skills’. Many of the responses expressed opinions similar to ‘you can always improve any skill’ or ‘if you have an open mind or challenge yourself then you can improve’. These echo findings of Carmichael and Taylor (2005), who concluded from their study of 129 students on a Tertiary Preparatory Mathematics Course, that most adult learners subscribe to an incremental view of intelligence (intelligence is malleable) rather than an entity view (that is, the interpretation of smartness as a static entity or fixed trait).

Dweck (1986) cites a study of bright junior high school students that showed there was a greater tendency for the girls surveyed to subscribe to an entity theory of intelligence than the boys. This is not the case here: theories of intelligence are independent of gender (p=0.222, Fisher Exact Test (FET)) with 83.1% of males and 81.6% of females subscribing to the idea of malleable intelligence. No age differences or differences between HL and OL students were found in the responses to this question. The view of intelligence held by students is not independent of the compulsory nature of their third level mathematics courses (p=0.038, FET). Of those who have chosen to study mathematics at third level 9.8% believe mathematical ability cannot be improved while 18.6% of those for whom third-level mathematics is compulsory share this belief.

Confidence

The students were asked whether they felt confident in approaching mathematics, they were asked to answer on a 5 point Likert scale. Of the 314 students who answered this question 123 (or 39%) said that they were confident or very confident. There was no significant difference between the students at the three different colleges. There is a difference (p=0.000, FET) however, when looking at the whole sample, grouped by Leaving Certificate Mathematics level, as shown below in Table 3 with HL students being more confident as might be expected. 58% of HL students said they were confident or very confident but only 24% of OL students did. There was also a difference in confidence between the students who had chosen to study mathematics and those for whom it is compulsory (p=0.001, FET). 48% of students who had chosen mathematics said that they were confident or very confident while only 29% of the compulsory group said this.

Table 3: Confidence and Leaving Certificate Level.

		Confidence in Approaching Mathematics					
		1	**2**	**3**	**4**	**5**	**Total**
LC Level	**Higher**	5	17	37	67	15	141
	Ordinary	28	48	52	39	1	168
Total		33	65	89	106	16	309

In the sample as a whole, 46% of males classed themselves as confident (choosing 4 or 5 on the Likert scale) compared with 34% of females which shows that there is a significant gender difference (p=0.03, Chi-squared). If LC Level is kept fixed, then gender and confidence are not independent (p=0.000, FET). Just over half (50.5%) of HL females said they were confident or very confident whereas 74% of HL males felt confident or very confident. To see if there was a gender difference in confidence within each Leaving Certificate grade a Cochran test was used. It was found that confidence and gender are not independent when Leaving Cert grade is kept fixed (p=0.000). As before, males were more likely to be confident than females. A 95% confidence interval for the common odds ratio is (0.193, 0.598). This means that the odds of a female being confident are no more than 60% of the odds for a male with the same Leaving Cert grade. For example, at OA1 grade, 77% of males rated themselves as confident but only 23% of females did. These results are similar to the findings of the PISA 2003 study (p.119 Cosgrove et al, 2005), where it was found that Irish male students were more confident about their mathematical abilities and also less anxious about mathematics than female students. Moreover, it echoes the results of a study of Carmichael and Taylor (2005) who also found that females consistently reported lower levels of confidence in relation to mathematics than males, although there were no significant differences in their prior knowledge or subsequent academic performances.

Surprisingly there was no significant difference between the proportions of mature and non-mature students rating themselves as confident when approaching mathematics, although a higher proportion of mature students felt confident or very confident (44.8% as opposed to 38.5% of the non-mature group). This contrasts with the results of Carmichael and Taylor (2005) who found that students for whom there had been a longer period of time since studying reported lower levels of confidence. Possible explanations may be that only 29 of the 316 students in the Irish study were mature or that not as much time had elapsed for the Irish students since last undertaking formal study in mathematics.

For the group as a whole, confidence and PISA score (categorised by literacy level attained) are not independent (p=0.000, FET). 53% of confident students achieved a mathematical literacy level of 5 or 6 but only 28% of the less confident students scored at these levels. However we have seen that HL students are more confident than OL students and it would be expected that HL students would perform better on the PISA test so HL and OL students were considered separately. If HL students are considered as a group then PISA score and confidence level are not independent (p=0.002, FET) with students with higher confidence levels doing better on the PISA test. For OL students PISA scores and confidence levels are independent (p=0.146, FET). It may be that OL students underestimate their mathematical ability.

Adaptive and Maladaptive Behaviour Patterns

Dweck (1986) focuses on psychological factors, other than ability, that characterise adaptive and maladaptive behaviour patterns in students, which in turn determine how effectively these individuals obtain and use skills. The adaptive pattern of achievement behaviour can be identified by the challenge-seeking behaviour and high persistence of those who display it, while maladaptive patterns are recognised by the challenge-avoidance and low persistence of its carriers in the face of difficulty. Dweck maintains that a child’s tendency towards adaptive or maladaptive behaviour is intrinsically linked with the class of goal motivating his sense of achievement and that, furthermore, a child’s theory of intelligence orients him towards a certain class of goal. In particular, children subscribing to an entity theory of intelligence, in which intelligence is believed to be fixed, tend towards performance goals (through which favourable judgements of their competence are sought) whereas those believing intelligence is malleable, or supporting an incremental view of intelligence, tend towards learning goals (by which they seek to increase their competence).

According to Dweck, for a child with performance goals, the entire choice and pursuit of a task revolves around the child’s own concerns about his ability. If he is to obtain a positive judgement of his ability then he needs to be confident in his present ability at the outset in order to seek challenges on a certain task and persist when obstacles are encountered. However, if his confidence in his present ability is low then he will try to conceal his ability and protect it from unfavourable evaluation (see Figure 1). On the other hand, a child with learning goals will always choose challenging tasks that foster learning and is willing to risk displays of ignorance in order to acquire knowledge.

Figure 1: Achievement Behaviour Patterns (Dweck, 1986)

Theory of Intelligence	Goal Orientation	Confidence in present Ability	Behaviour Pattern
Entity Theory □	Performance Goal	If high □	Seeks challenge High persistence
		If low □	Avoids challenge Low persistence
Incremental Theory □	Learning Goal	If high □	Seeks challenge High persistence
		If low □	

In order to investigate this theory using the data collected for students in ITT, SPD and NUIM, students with an incremental theory of intelligence are deemed to be those who agreed that mathematical ability can be improved and those who disagreed are taken to subscribe to a fixed theory of intelligence. As before, students exhibiting high confidence in their own abilities are those who chose 4 or 5 on the Likert confidence scale, while the remainder are said to be of low confidence. Table 4 illustrates the division of participants into the four categories that result.

Table 4: Theories of Intelligence and Confidence

		Confidence in Present Ability		Total
		Low Confidence	***High Confidence***	
Theory of Intelligence	***Entity Theory***	27 8.5%	15 4.7%	42 13.2%
	Incremental Theory	145 45.9%	103 32.6%	248 78.5%
Total		172 54.4%	118 37.3%	290 91.7%

The placement of a student in one of these categories is not independent of the level at which LC Mathematics was studied (p=0.000, FET): this is largely due to the confidence factor. Placement in a category is independent of gender (p=0.075, FET) and of 'maturity' (p=0.827, FET).

Transfer of Knowledge

Dweck (1986) goes on to state that one of the hallmarks of effective learning is the tendency to apply or transfer knowledge to novel tasks. In a 1985 study with Farrell, the relationship between children's goal orientation and transfer of learning was examined. The results showed that children with learning goals rather than performance goals (a) attained significantly higher scores on the transfer test (regardless of pretest performance) and (b) produced about 50% more work on their transfer test (suggesting a greater level of activity in the process).

The PISA-style test administered in the ITT, SPD and NUIM study represented an unfamiliar or novel task for the students in question and required the transfer of mathematical knowledge and skills learned previously. If Dweck's findings were to be replicated by this study, the students supporting an incremental theory of intelligence should score more highly on the test than those who believe intelligence is fixed. However, the theory of intelligence supported by students was found to be independent of the PISA level of literacy attained (p=0.215, FET). In fact, 38.2% of those who believe in the incremental nature of intelligence, and 42.9% of those who don't, performed at levels 5 or 6.

The PISA test presented students with 13 items or questions. One student attempted as few as 4 of these. Details on the number of questions attempted are given in Table 5.

Table 5: Number of Test Items Attempted

No. of items attempted	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**4**
No. of students	176	84	25	20	7	1	2	1
% of Students	55.7	26.6	7.9	6.3	2.2	0.3	0.6	0.3

The number of questions attempted by students was taken as a measure of the level of activity they exerted on the test. To enable statistical tests to be carried out, the number of items attempted was divided into three categories: all 13 items, exactly 12 items, 11 or fewer. An analysis of the number of questions attempted together with the theory of intelligence supported by a student shows them to be independent (p=0.807, FET). Again the results obtained disagree with those of Dweck, with 61.9% of students who believe intelligence is fixed attempting all 13 items compared with 55.4% of students who agree with an incremental theory. Furthermore, comparing the number of level 6 questions (that is, the most difficult items) attempted by students with the theory of intelligence supported shows these too to be independent (p=0.341, FET) as is the students' performance on these level 6 items (p=0.880, FET). In both cases, the results again contradict Dweck's findings with students who believe intelligence is fixed being more inclined to attempt the more difficult questions and scoring more highly when they do so.

High or Low Persistence

The level of confidence reported by students was incorporated, in order to investigate whether the behaviour patterns suggested by Dweck (see Figure 1) were exhibited by this group of students. Dweck's categories will be labelled as follows in reporting the results: EL (entity theory of intelligence, low confidence), EH (entity theory, high confidence), IL (incremental theory of intelligence, low confidence), IH (incremental theory, high confidence).

The number of questions attempted by students on the PISA test was not independent of the latter categories (p=0.003, FET). In fact, the following pattern of behaviour was noted:

Table 6: Persistence Behaviour

Category	% of students attempting all 13 items
EH	80.0
EL	51.9
IH	68.9
IL	45.5

It is true to say that, within the entity theory of intelligence categories, students of lower confidence showed less persistence than those of higher confidence. However, these are not the least persistent group and Dweck's suggestion that students holding a view of intelligence as malleable will always persist in the face of obstacles is not borne out by the data collected here. In fact, confidence was seen to be the influential factor when determining a students' persistence as measured by number of questions attempted: these are not independent (p=0.001, FET). Likewise, the number of level 6 questions attempted by students was not independent of confidence displayed (p=0.009, FET) nor was the students' performance on level 6 questions (p=0.000, FET). Students with high confidence in their present ability tended to attempt more level 6 questions and performed better on them than students with low confidence. (The relationships between the students' theories of intelligence and these measures of persistence have been commented on in the previous section.) These results support Bandura's assertion that students with high confidence are more likely to attempt difficult problems, will display greater perseverance, and so ultimately will be more likely to succeed.

Another interesting observation is that the number of questions attempted is not independent of the level at which mathematics was studied for the Leaving Certificate (p=0.002, FET) with 64.8% of HL students and 49.1% of OL attempting all 13 items. In fact, a Cochran test provides some evidence of a relationship between confidence and the attempting of all test items, even when the students' Leaving Certificate grade is kept fixed (p=0.066). This would indicate that the relationship between confidence and perseverance on the PISA-style test cannot be explained purely in terms of previous mathematical performance.

Effect of Gender on Behaviour Patterns & Persistence

Although the appearance of students in the categories suggested by Dweck is independent of gender (as remarked above), splitting the group into males and females shows some differences in their category placements as illustrated by Table 7.

Table 7: Theories of Intelligence and Confidence by Gender

Category	No. & Percentage of Males	No. & Percentage of Females
EH	9 6.8%	6 3.3%
EL	10 7.6%	17 9.2%
IH	51 38.6%	52 28.3%
IL	52 39.4%	93 50.5%

Once again, this is largely due to the confidence factor and it has already been remarked that levels of confidence displayed are not independent of gender. Thus, the behaviours of males and females, in terms of their persistence on the PISA test, were investigated separately.

For the male group, the number of questions attempted (13, 12, 11 or less) is not independent of the categories inhabited (p=0.007, FET) (see Table 8 below), neither is the number of level 6 questions attempted (p=0.002, FET). While some relationship can be observed between the categories of Table 7 and a student's performance on the more difficult level 6 test items, this is not significant (p=0.067, FET).

The results are somewhat different for the female group with the categories inhabited in this case being independent of the number of questions attempted (p=0.521, FET), the number of level 6 questions attempted (p=0.931, FET) and performance on the level 6 questions (p=0.210, FET).

Table 8: Persistence Behaviour by Gender

Category	% of students attempting all 13 items	
	Males	Females
EH	77.8%	83.3%
EL	50%	52.9%
IH	72.5%	65.4%
IL	36.5%	50.5%

Again it can be seen, contrary to Dweck's assertion, that those students showing the least inclination to persevere with a difficult task are those who subscribe to an incremental theory of intelligence but have low confidence in their present abilities: this is more pronounced in the male group than the female group.

Separating the students into two subgroups based on whether or not they obtained an above average score on the PISA test (corresponding to a raw score of 9 or above), results in a grouping that is not independent of Dweck's suggested behaviour categories for males (p=0.001, FET) or for females (p=0.048, FET). Details for each of the four categories of the percentages of students who obtain above average PISA scores are shown in Table 9.

Table 9: Achievement by Gender

Category	% of students obtaining above-average score	
	Males	Females
EH	88.9%	100%
EL	50%	35.3%
IH	74.5%	51.9%
IL	42.3%	55.9%

In the case of the males, it can be seen that confidence is the influential factor with males who display higher confidence being more likely to obtain an above-average score (p=0.000, FET). This is not the case for females (p=0.876, FET) and indeed, the picture is a lot less clear in this case.

Dweck (1986) states that a number of previous studies have found that girls, and particularly bright girls, display greater tendency towards challenge avoidance and debilitation in the face of obstacles. (However, Elliott and Dweck (1988) did not report any observations on gender difference in their study of 57 girls and 44 boys.) This may go some way to explain the relatively poor performance of the confident females here who believe intelligence to be incremental in nature. In fact, Dweck (1986) suggests these differences in behaviour patterns between girls and boys may be an important factor in the discrepancies in mathematical achievement often reported between the sexes and may prevent females from choosing to study mathematics at more advanced levels.

As remarked earlier, some of the students participating in this study are required to study mathematics at third level while others have chosen to do so. For 69.4% of the males surveyed, mathematics courses are compulsory and the view of intelligence held by males is independent of the compulsory nature of their mathematics courses ($p=0.475$, FET). Only 30.2% of the females involved have not chosen to study mathematics and while it is also true in this case that the view of intelligence they hold is independent of the compulsory nature of their courses ($p=0.073$, FET), this result is less significant.

Discussion

It has long been accepted that factors other than ability influence whether students use and develop their skills effectively, and how they do so. The study reported here found the level of confidence incoming third-level students have in their mathematical ability to be an important factor in how they approach, persevere and perform on unfamiliar tasks. This follows Bandura's (1977, 1993) findings on self-efficacy. However, it should be noted that Bandura measured self-efficacy in terms of an individual's conviction of his ability to execute the behaviour required to succeed on a particular task, whereas the level of confidence measured here dealt with the student's confidence in approaching mathematics in general.

On the other hand, students' beliefs about the nature of mathematical ability do not seem to influence the behaviour patterns adopted by these students when presented with the task described. This runs contrary to the theory outlined by Dweck (1986). Perhaps this is due to the difference in age and level of previous academic achievement of the subjects: the participants of the ITT, SPD, NUIM study are essentially adult learners and, by their presence at third-level, can be assumed to be towards the high-achieving end of the general population for the age cohort to which they belong. Also the survey described here asked participants only to respond to a single question on the nature of mathematical intelligence and it is likely this was not sufficient to give a consistent, robust picture of the students' beliefs.

Alternatively, it may be that goal-orientation influences student learning behaviour as described by Dweck (1986) but that theory of intelligence does not play as important or integral a role as the model suggests.

Broadly speaking, there was no difference in the views held by female and male students on the nature of mathematical intelligence, but there were significant differences in the levels of confidence displayed. A full picture of the gender differences uncovered is much more complex.

Finally, it was found that the views of participants as to the nature of mathematical intelligence greatly contrasted with the views of Irish teachers (Beaton et al, 1996; Lyons et al, 2003; Cosgrave et al, 2004). There has been some concern expressed (Dweck, 1986; Lyons et al, 2003, p.270) that teachers' views of students' ability can actually affect students' performance, leading to a 'self-fulfilling' prophecy. Thus, the overwhelming agreement among students (82% of respondents) that mathematical ability can be improved is to be welcomed.

The authors hope to undertake a more comprehensive survey on third-level students' beliefs about the nature of mathematical intelligence and the level of confidence felt in approaching mathematical tasks and courses in order to investigate these issues further.

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