Exploring the role of confidence, theory of intelligence and goal orientation in determining a student's persistence on mathematical tasks

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We consider Dweck's (1986) theory on the relationships between students' beliefs concerning the nature of intelligence, their learning goal orientation, their confidence, and their willingness to seek challenges and to persist when faced with difficulties. Dweck's theories have been studied for the past 20 years, for example by Stipek and Gralinski (1996) among many others. In this study the beliefs and behaviour of 182 third level students were investigated. These students had all chosen to pursue an undergraduate course in a numerate subject. It was found that the relationships between theories of intelligence and goal orientations were more complicated than those postulated by Dweck, and in particular seem to differ between the male and female students. We also found that a student's theory of intelligence, goal orientation, and confidence in his mathematical ability influenced his persistence at difficult mathematical tasks. However, once again, differences were found between the male and female groups.

Keywords: Confidence, goal orientation, theory of intelligence, persistence

Introduction

Dweck (1986) conjectured that a student's theory of intelligence and confidence in his/her present ability combine to influence the student's behaviour when presented with a mathematical task, particularly a challenging or unfamiliar task. A preliminary study by the authors (Breen, Cleary and O'Shea 2007) failed to endorse this theory and found that an individual's level of confidence but not his theory of intelligence played an important role in how he approached, persevered with and performed on a task. A more comprehensive study, using an instrument specially constructed for this purpose (Breen, Cleary and O'Shea 2009), was undertaken and initial findings are presented here.

Figure 1 overleaf summarises and illustrates Dweck's theory. The theory asserts that children's theories of intelligence seem to orient them towards different goals, which then appear to set up different behaviour patterns. We will focus, like Dweck, on performance and learning goals. Students who display performance goals wish to receive positive feedback on their abilities from themselves or others, and to avoid demonstrating a lack of ability. Students with learning goals however, wish to increase their competence and acquire new understanding. Those who believe intelligence is a fixed trait tend to display performance goal behaviour, with their entire process of task choice and pursuit built around their concerns about their ability. If their perceptions of their own ability are low, they tend towards defensive strategies, avoiding and withdrawing from challenge. On the other hand, children who believe intelligence is malleable focus on progress and mastery through effort in both their choice and pursuit of tasks. Even children whose assessment of their present ability is low will choose challenging tasks that foster learning.

Theory of Intelligence	Goal Orientation	Confidence in present Ability	Behaviour Pattern
Entity Theory → (Intelligence is fixed)	Performance Goal	If high →	Seeks challenge High persistence
		If low →	Avoids challenge Low persistence
Incremental Theory → (Intelligence is malleable)	Learning Goal	If high →	Seeks challenge High persistence
		If low ↗	

Figure 1: Achievement goals and behaviour patterns (following Dweck 1986)

Dweck and her colleagues have continued to study and refine her theories. For example, Grant and Dweck (2003) describe 5 studies concerned with the impact of achievement goals. They found evidence that learning goals have a positive influence on performance and motivation in challenging situations. Performance goals were also found to have positive effects when major difficulties were not encountered but they were found to have negative effects in the face of challenges. Mangels, Butterfield, Lamb, Good and Dweck (2006) studied the manner in which theory of intelligence beliefs influence how students respond to negative feedback and their ability to learn from mistakes. Students were asked general knowledge questions, they were told whether their answer was right or not and were immediately shown the correct answer. The study found that entity theorists were less likely to focus their attention on the correct answer and were less likely to recall it later. The authors postulate that their results may explain how theory of intelligence beliefs influence learning and achievement.

Middleton and Spanias, in their 1999 review of mathematics education research on motivation, contend that students who are intrinsically motivated engage in academic tasks because they enjoy them and their motivation tends to focus on learning goals, whereas students who are extrinsically motivated engage in academic tasks to obtain rewards and their motivation is centred on performance goals. They support Dweck's belief that those who are intrinsically motivated exhibit adaptive or pedagogically desirable behaviour such as selection of more difficult tasks, persistence in the face of failure and selection of deeper learning strategies. They also observed goal orientation to be a strong predictor of achievement, with students with an orientation toward learning (or mastery) goals tending to perform better than those with performance (or ego) goals regardless of the learning situation. Middleton and Spanias (1999) explain how, by the middle grades, many students begin to believe that success and failure are attributable to ability and that effort seldom results in a change in their success patterns. Those who continue to conceive of ability as amenable to augmentation through effort tend to expend more effort and thus are better achievers than those who believe ability is fixed. Findings show that a belief in effort as a mediator of ability and failure as an acceptable stage in the learning of mathematics also increases students' confidence in relation to the subject.

Stipek and Gralinski (1996) also studied the relationships between children's goal orientations, theories of intelligence, and achievement. They found than an entity theory of intelligence was associated with performance goals and that an incremental

theory of intelligence was associated with learning goals, although they note that the relationships are not strong.

Yet other studies have not fully supported Dweck's theory. Dupeyrat and Mariné (2005) found that theories of intelligence did not seem to influence goal orientation. But they did find that students with learning goals were more likely to put effort into their studies and that this had a positive impact on learning and achievement, whereas performance goals seemed to have a negative impact on effort and achievement. Carmichael and Taylor (2005) found, in a study of 129 students (with median age 29) enrolled in a tertiary preparatory mathematics course, that most subscribed to an incremental theory of intelligence, and concluded that the issue of theory of intelligence is probably not relevant in an adult education context.

Dweck (1986) also 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. Dweck and Leggett (1988) found that girls were more likely than boys to subscribe to an entity theory of intelligence. However, in a study of secondary school pupils in England, Ahmavaara and Houston (2007) did not find a link between theory of intelligence beliefs and gender. Middleton and Spanias (1999) found that boys tend to be more confident in learning mathematics than girls and while boys' confidence is robust to failure, girls' insecurities tend to be resilient in the face of success.

In this study, our aim is to search for evidence for Dweck's theory as outlined in Figure 1. We will consider the theory of intelligence beliefs, goal orientation and confidence of a group of third level students enrolled in mathematics modules. We will look for relationships between these variables and study their influence on persistence on difficult mathematical tasks. We will also investigate the role of gender in Dweck's model.

Survey instrument & administration

The study was conducted in the second semester of the 2007/2008 academic year and the participants were all in the first year of their respective programmes at one of three third level institutions: namely St Patrick's College, Drumcondra (BEd or BA (Humanities) programme), the National University of Ireland, Maynooth (BA or BA (Finance)) and the Institute of Technology, Tralee (Higher Certificate in Engineering or BSc). All students were enrolled in mathematics modules taught by the authors. The survey was administered during class and students were invited to participate in the study. 182 students agreed to participate and of these 73 (43.2%) were male.

The students completed a 20-minute questionnaire in which they were asked to respond to sets of rating scale items addressing Confidence, Theory of Intelligence, Goal Orientation (Learning or Performance) and Persistence. The items used a 5-point Likert scale (with 1 representing 'disagree strongly', 2 representing 'disagree', 3 'not sure', 4 'agree' and 5 'agree strongly') and were gathered from a number of sources but modified to render them relevant to third-level students in Ireland (for full details see Breen, et al 2009). The Learning Goal rating-scale items are displayed in figure 2 for illustrative purposes. Personal information (including gender, age, level of mathematics achievement at post-primary school) was also collected from the participants.

Learning Goals
1. I work at maths because I like finding new ways of doing things.
2. I work at maths because I like learning new things.
3. I work at maths because I like figuring things out.
4. I work at maths because I want to learn as much as possible.
5. I work at maths because it is important for me that I understand the ideas.

Figure 2: Rating-scale items for Learning Goal trait

When undertaking a study of attitudes and opinions, it is important to ascertain that the instrument of inquiry used provides valid, reliable and interpretable information that addresses the specific question of interest. The validity and reliability of the survey instrument used here were determined using Rasch analysis (Bond and Fox 2007) by means of the computer software Winsteps (Linacre 2009). Full details can be found in Breen et al (2009). Rasch analysis is a means of constructing an objective fundamental measurement scale from a set of observations of ordered categorical responses (to assessment items or rating-scale items). The scale produced is an interval one centred at 0. Following the assumption that useful measurement involves the consideration of a single trait or construct at a time, the Rasch model was applied to each set of rating-scale items separately. This gave rise to five measures, namely, Confidence, Theory of Intelligence (TOI), Learning Goal (LG), Performance Goal (PG) and Persistence measures. (The questions on the performance goal scale were reverse coded so that a high (or positive) score on this scale indicates a low level of performance goal orientation.) For statistically stable measures to be computed from the data, it is recommended that at least 10 observations per category of reasonably targeted items should be collected (Linacre 2009). Each item used here offered 5 categories of response (disagree strongly – agree strongly) and as the participants, despite their voluntary nature, were appropriate targets for the instrument (as evidenced by Item-Person maps produced by Winsteps (Breen et al 2009)), the size of the sample (182) was deemed sufficient.

Results

Participants were recategorised on the basis of being assigned positive or negative scores on each scale for an initial exploration of the data. Each trait was considered individually using these (crude) binary measures before the interactions were explored further using chi-squared tests (unless stated otherwise).

Theory of intelligence

Items here included “You have to be smart to do well in maths” and “You can succeed at anything if you put your mind to it”. A positive score on the Theory of Intelligence (TOI) scale indicates that a student subscribes to an incremental view of intelligence, while a negative score means that the student has an entity view. More extreme scores in either case represent stronger views. Only 27.2% of the participants in this study attained a negative score on the scale (indicating an entity view) and their views on the nature of intelligence, using this binary measure, were independent of gender ($p=0.862$).

Confidence

Broadly speaking, positive scores on the Confidence scale are awarded to those who feel confident in relation to mathematics, while negative scores are awarded to those who do not. 66.3% of the respondents here achieved positive scores, and this classification of 'confident' or 'not confident' is independent of gender (p=0.871). Confidence items presented to the students included "I learn mathematics quickly" and "I have trouble understanding anything with mathematics in it".

Goal Orientation

Learning goal items were shown already in Figure 2. Performance Goal items included "I work at maths because it is important to me that the lecturer/tutor thinks I do a good job" and "I work at maths because it is important to me to do better than the other students".

The data here showed very few students reporting a tendency towards performance goals, with only 21.3% falling into this category (that is, exhibiting a negative score on the scale). On the other hand, 62.7% exhibited a tendency toward learning goals, attaining a positive score on the LG scale. Orientation towards learning goals is independent of gender (p=0.873 using the binary measure) with 61.6% of males and 63.5% of females displaying evidence of this orientation. However, there is some evidence that males are more inclined towards performance goals than females with 26% of males and only 17.7% of females displaying this tendency, though this is not statistically significant (p=0.255).

Dweck's theory postulates that a student's goal orientation follows from his theory of intelligence. Thus, it may seem reasonable to expect a strong inverse relationship between LG and PG. However, the classification of students as having positive or negative LG scores is independent of their classification as having positive or negative PG scores (p=0.244).

Persistence

Students were invited to respond to a number of statements relating to persistence including "when presented with a choice of mathematical tasks, my preference is for a challenging task" and "when presented with a mathematical task I cannot immediately complete, I increase my efforts". Only 44 students (26%) were awarded a negative score on the persistence scale. The allocation of a positive or negative Persistence score was independent of gender (p=1.000).

Relationships between confidence, theory of intelligence, goal orientation and persistence

Dweck (1986) asserts that a student's level of confidence, combined with his goal orientation, determines his behaviour pattern (either adaptive or maladaptive) and the level of persistence he will employ on mathematical tasks. The binary measure of Persistence created was found not to be independent of the binary measures of Confidence ($p<0.001$), TOI ($p<0.001$) or LG ($p<0.001$) but independent of PG (p=0.287) using chi-squared tests. Of 125 students with a positive score for persistence, 96 (76.8%) are confident, 102 (81.8%) subscribe to an incremental theory of intelligence, 94 (75.2%) hold learning goals, and 24 (19.2%) hold performance goals. This can be contrasted with the attitudes of the 44 students who are assigned a negative persistence score: 16 (36.4%) are confident, 21 (47.7%) subscribe to an

incremental theory of intelligence, 12 (27.3%) hold learning goals, and 12 (27.3%) hold performance goals.

In an effort to understand more clearly the interplay between these traits, further analysis was carried out using the original interval measures constructed using Rasch analysis. Pearson correlations between these measures were computed and are displayed in Table 1.

	TOI	**LG**	**PG**	**Persistence**
Confidence	0.352 ($p<0.001$)	0.587 ($p<0.001$)	0.222 ($p=0.004$)	0.628 ($p<0.001$)
TOI	1	0.383 ($p<0.001$)	0.274 ($p<0.001$)	0.452 ($p<0.001$)
LG		1	0.155 ($p=0.044$)	0.659 ($p<0.001$)
PG			1	0.249 ($p=0.001$)

Table 1: Correlations between the measures

Note that the correlation between LG and PG was computed to be 0.155 (significant at the 0.05 level). Moreover, the correlation between TOI and LG was found to be 0.383, while that between TOI and PG was computed as 0.274 (both significant at the 0.001 level). Also, the relatively strong correlations of 0.352 between Confidence and TOI and 0.587 between Confidence and LG indicate a more complex situation than that portrayed by Dweck (1986). As seen in Figure 1, Dweck suggests that orientation towards a particular type of goal follows from the theory of intelligence held by a subject, and that level of confidence contributes to the determination of behaviour patterns at a later stage.

In order to see how students' persistence on mathematical tasks depends on their confidence, theory of intelligence and goal orientation, a regression with the Persistence measure as the dependent variable and gender, Confidence, TOI, LG and PG measures as independent variables was performed. The regression analysis revealed that Confidence ($p<0.001$), TOI ($p=0.005$) and LG ($p<0.001$) were indeed significant predictors of Persistence. PG and gender were not. The model had an adjusted R^2 value of 0.543, which suggests that these three variables account for 54.3% of the variation in the persistence measure.

Gender Effects

Gender seems to play an important role in the relationships under investigation. For instance, consideration of male and female students separately shows the correlation between TOI and LG to be 0.197 for males (not significant at the 0.05 level) and 0.504 for females (significant at 0.01 level). Looking at this from another perspective, by means of chi-squared tests on the binary (positive/negative) measures of TOI and LG, shows them to be independent for males ($p=0.696$) but not for females ($p=0.015$). However, when the sample is split by gender, positive scores on PG are independent of positive scores on TOI for both males and females.

Using gender to subdivide the sample and performing a regression using the interval measures of Persistence, Confidence, TOI, LG and PG with Persistence as the dependent variable yields TOI ($p=0.003$) and Confidence ($p<0.001$) as significant predictors of Persistence for males, with an adjusted R^2 value of 0.505. The goal orientation variables were not significant predictors of persistence. However, for females, the significant predictors are LG ($p<0.001$), Confidence ($p=0.008$) and PG ($p=0.015$) but not TOI. The adjusted R^2 value of the latter model is 0.644.

Conclusions

The majority of the students surveyed here portrayed themselves as confident, as subscribing to an incremental theory of intelligence (in agreement with the findings of Carmichael and Taylor 2005), as aspiring to learning goals and as persisting on challenging or unfamiliar mathematical tasks, while only a minority reported a tendency towards performance goals. We did not see a strong inverse relationship between the goal orientation measures. Hannula (2006) comments that learning and performance goals should not be seen as mutually exclusive. The binary measures of confidence and persistence used failed to provide evidence to support Middleton and Spanias' (1999) comment that boys tend to be more confident than girls or Dweck's (1986) remarks that girls are less persistent than boys in relation to learning mathematics. We found no evidence that TOI beliefs are related to gender, mirroring Ahmavaara and Houston's (2007) results.

When considering the low levels of performance goals exhibited by our sample, as with any self-reporting measure, caution should be employed: it may be that students do not like to think of themselves in this way and so have not responded 'honestly'. Alternatively, it may be that third level students are mature enough not to have these kinds of goals. Corroborating evidence is needed. We do have corroborating evidence for one of our self-reporting measures however. This survey was administered at the same time as a PISA-type test of mathematical literacy. Thus we were able to consider students' persistence on unfamiliar mathematical tasks. Preliminary analysis showed that our persistence measure correlated well with the evidence provided by the PISA-type test.

Let's consider Dweck's assertion that TOI determines goal orientation. The correlations between TOI and LG and TOI and PG are both statistically significant but seem to be weaker than we might have expected following Dweck's theory. This finds resonance with Stipek and Gralinski's (1996) acknowledgement that the proposed relationships between TOI and goal orientation are not strong.

In our study, entity theories of intelligence were not associated with performance goals, echoing the findings of a study of adult learners by Dupeyrat and Mariné (2005). We did see that female students with incremental views of the TOI were likely to have learning goals but the same was not true for males. However Blackwell, Trzeniewski and Dweck (2007) found that teenagers who subscribed to an incremental theory of intelligence were more likely to exhibit learning goals and also employ more effort in studying.

The second part of Dweck's theory asserts that persistence is determined by confidence and theory of intelligence (through goal orientation). We found that the TOI, LG and confidence measures were significant predictors of the persistence measure for the group as a whole, providing support for the finding of Dupeyrat and Mariné (2005) in relation to the positive impact of learning goals on effort but not in relation to a negative impact of performance goals. Some differences were evident when gender was taken into account: for the female group TOI was not a significant predictor of persistence, while for the male group goal orientation was not a significant predictor of persistence. Grant and Dweck (2003) assert that it is only when faced with difficult situations that performance goals impact negatively on persisitence. In future work, we hope to investigate this phenomenon further by examining the behaviour of students on challenging PISA-type questions.

In summary, it seems that there is evidence for Dweck's theory in certain groups of students but not in others. In particular, it seems to be that gender has a role

to play in the relationship between TOI and LG and in how confidence, TOI and goal orientation influence persistence.

Information about students' previous mathematical achievements was also collected and further analysis will be carried out to determine if this affects the relationships studied here.

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