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The Influence of Optimism and Pessimism on Student Achievement in Mathematics

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Students' causal attributions are not only fundamental motivational variables but are also critical motivators of their persistence in learning. Optimism, pessimism, and achievement in mathematics were measured in a sample of primary and lower secondary students on two occasions. Although achievement in mathematics was most strongly related to prior achievement and grade level, optimism and pessimism were significant factors. In particular, students with a more generally pessimistic outlook on life had a lower level of achievement in mathematics over time. Gender was not a significant factor in achievement. The implications of these findings are discussed.

The influence of attitudes, values, and personality characteristics on achievement outcomes and later participation in the learning of mathematics are important considerations for mathematics educators. Teachers not only want students to learn mathematics but also want to be able to enjoy and be confident about the subject (Kloosterman, 1990; Reyes, 1984). They strongly believe that affective variables such as motivation and self-esteem facilitate or hinder students' learning and achievement in mathematics (Fennema & Peterson, 1985). Furthermore, affective goals are included in statements of educational objectives for mathematics curricula (e.g, see the *National Statement on Mathematics for Australian Schools*, Australian Education Council, 1991, and the *Curriculum and Evaluation Standards for School Mathematics*, National Council of Teachers of Mathematics, 1989).

Affective issues play a central role in mathematics learning and instruction (McLeod, 1989; 1992). Reviews of research in mathematics education cite several studies in which the formation of various attitudes and beliefs about mathematics and their influences on mathematics achievement have been investigated (see, Leder, 1987; McLeod, 1992; Reyes, 1984). These studies have encompassed attitudes, beliefs, and emotions about mathematics learning and teaching as well as mathematics itself, in both teachers and students (McLeod, 1992). Studies have also considered students' self-confidence, self-efficacy, mathematics anxiety, learned helplessness, and causal attributions for the causes of success and failure in mathematics, and the influences of these individual differences on students' motivation and achievement in mathematics (Kloosterman, 1990; McLeod, 1992). Gender differences have also been an important focus of research (see, Leder, 1992; Meyer & Fennema, 1988; Reyes, 1984).

Research directed at increasing understanding of the development of affective variables in learners, and of their influence on mathematical learning, is vital for mathematics education (Fennema, 1989). A theoretical model of Autonomous Learning Behavior (ALB) (Fennema & Peterson, 1985; Fennema, 1989) has been advanced to facilitate the planning and direction of this research. In its original formulation a relationship between external/societal influences and students' internal belief system was postulated (Fennema & Peterson, 1985). Together these two variables were hypothesised to have an effect on students' performance on high level cognitive tasks in mathematics through their autonomous learning

behaviours of engagement, persistence, and success. In the later more generic formulation of the ALB model, the term affect was substituted for internal belief system, mediating learning activities for autonomous learning behaviours, and mathematics education outcomes for high level tasks (Fennema, 1989). While differences exist in the use of the term affect (Hart, 1989; McLeod, 1992), the concept in both the original and generic model included confidence, perceived usefulness of mathematics, and causal attributional style (Fennema, 1989).

Much of the research into affect in mathematic education has been conducted from a cognitive science perspective (Hart, 1989; McLeod, 1992). Students' beliefs and attitudes are developed over a relatively long period of time (McLeod, 1989; 1992). Affective factors have been found to exert a considerable influence on students' motivation and learning in mathematics (Kloosterman, 1990). In particular, students' beliefs about themselves and the causes of their successes and failures in mathematics have important implications for their educational outcomes (Kloosterman, 1988; McLeod, 1992; Middleton & Spanais, 1999).

Studies of students' causal attributions for success and failure in mathematics have found relationships between specific attributions to ability, effort, task difficulty, luck, and achievement related behaviours such as persistence, effort, and choice of challenging tasks (Bar-Tal, 1978; Covington & Berry, 1976; Dweck & Goetz, 1978; Weiner, 1972, 1976, 1979). These studies have been conducted within Weiner's (1974) attributional theoretical framework which has three dimensions of internal or external locus, stability (ability versus effort), and controllability (see, Reyes, 1984). There is, however, a more generalised attributional theory of explanatory style (Peterson & Seligman, 1984) that has significance for mathematics education. This theory is concerned with the optimistically or pessimistically oriented explanations that people make for everyday events in their lives, particularly when these events are negative and occur under ambiguous circumstances (Seligman, 1990). Like the specific attributions to ability, effort, task, and luck, these more general explanations are considered to influence behaviour (Seligman, 1990).

The reformulated learned helplessness theory (Abramson, Seligman, & Teasdale, 1978), referred to as a theory of explanatory style (Peterson & Seligman, 1984), proposes that people have a predisposition to analyse and interpret events, attributing them to causes which vary across permanent, personal and pervasive dimensions (Peterson & Seligman, 1984). Optimists typically attribute good events to permanent, personal, and pervasive causes, and bad events to causes that are unstable, external, and specific. By contrast, pessimistically oriented people attribute bad events to stable, internal, and global causes, and good events to transitory, exterior, and specific factors (see, Peterson & Bossio, 1991; Seligman, 1990; 1995). Optimism and pessimism can be conceptualised best as poles on a continuum (Shatté, Reivich, Gillham, & Seligman, 1999).

Studies have established that the differences between optimistic and pessimistic attributional explanations encompass significant aspects of personal adjustment and influence health, motivation and learning (Peterson & Bossio, 1991; Schulman, 1995). In particular, explanatory style interacts with achievement to create self-fulfilling prophecies, that either enhance or undermine performance (Seligman, 1990; Schulman, 1995). Explanations that individuals habitually make for their successes and failures lead to expectations that affect their reactions to future successes and failures. In turn, these expectations affect performance through a variety of behaviours. Individuals with a more optimistic explanatory style are more likely to take the initiative, persist under adversity, take risks, be

decisive, engage in quality problem-solving strategies, and be more assertive (Schulman, 1995). In short, optimism is associated with action (Peterson & Seligman, 1984).

Optimistic and pessimistic tendencies are formed during childhood (Nolen-Hoeksema & Girgus, 1995; Yates, 1998a) from the myriad of everyday experiences (Peterson & Bossio, 1991) and impact on children's health, motivation, and achievement (Seligman, 1990, 1995). Significant moderate correlations have been found between children's explanatory style and concurrent measures of general academic achievement ($r = 0.26$, $p < 0.05$), as assessed by the *California Achievement Test* (California Testing Bureau, 1982) (Nolen-Hoeksema, Girgus & Seligman, 1986). In a five year longitudinal study, a weak relationship was found between explanatory style and academic achievement measured six months later in Grade 4 and Grade 5 students ($r = 0.11$, $p < 0.10$ and $r = 0.14$, $p < 0.05$, respectively) (Nolen-Hoeksema, Girgus, & Seligman, 1992). Children with a pessimistic explanatory style were less successful on the *California Achievement Test* than optimistic children (Nolen-Hoeksema & Girgus, 1995). Boys were consistently more pessimistic than the girls, particularly in terms of their explanations for negative events (Nolen-Hoeksema et al., 1992).

Students who have developed pessimistic cognitive frameworks are at risk of doing less well academically (Seligman, 1995). The deleterious effects of a pessimistic style have been implicated in studies of tertiary students' general academic performance (Peterson & Barrett, 1987) and grades in algebra (Pierce & Henry, 1993). In primary school-aged children, relationships between explanatory style and achievement in mathematics were explored in a pilot study of 145 students (Yates, Yates, & Lippett, 1995). Significant correlations were found between students' optimistic or pessimistic explanatory style and concurrent achievement in mathematics. Pessimism also correlated significantly with students' achievement in mathematics two and three years previously. Girls were significantly more optimistic and less pessimistic than the boys.

In the present study, relationships between students' optimism, pessimism, and achievement in mathematics were explored over a period of almost three years. Although explanatory style was implicated as a determinant of mathematics performance in the pilot study (Yates et al., 1995), it was unclear whether this relationship was stable or predictive. More substantive, extensive data were therefore collected, using a longitudinal approach so that these relationships could be investigated more fully. In order to examine relative rather than absolute change over time, and to identify some of the factors that influence this relative change, two student measurement points were planned. An objective measure of achievement in mathematics and student self-report indices of explanatory style were collected on both occasions.

The Study

The fundamental hypothesis of this study is that possessing a pessimistic explanatory style leads to decreased achievement levels in mathematics over time. Thus pessimistic children in primary and lower secondary school are more likely to show less gain in their relative mathematical achievement levels over time. The aims of this study therefore are:

1. to examine the direction and magnitude of the relationships between students' optimism, pessimism, and achievement in mathematics over time; and

2. to consider the influence of students' Grade level and gender on these relationships.

Participants

The study commenced with a sample of 335 students in Grades 3 to 7 in two government primary schools in South Australia (Time 1). These two schools differed slightly in their socioeconomic status, although both were located in the upper socioeconomic classification categories employed within the government system. Almost three years later, 243 of these students were traced to 26 primary and 24 lower secondary schools in the government and non-government sectors in South Australia (Time 2). The Grade level and gender of the final sample of 243 students at Time 2 are presented in Table 1.

Research Measures

Students' achievement in mathematics was measured with Form A of the *Progressive Achievement Tests in Mathematics* (*PATMaths*) (Australian Council for Educational Research, 1984). *PATMaths* consists of three timed multiple choice format tests, calibrated for use with Australian students. All three tests contain items measuring number, computation, measurement, money, statistics, spatial relations, and graphs. Fractions are included in Tests 1 and 2, logic and sets are introduced in Test 2 and relations and functions are added to Test 3. The advantage of choosing *PATMaths* was that the tests could be administered to students from Grades 3 to 9, and their performance across grades and across time could be located on a single Rasch calibrated scale (ACER, 1984). In addition, many students were already familiar with the tests through their annual use in school. Students were administered Test 1, 2, or 3 on both occasions in accordance with the recommendations made in the *Teachers Handbook* (ACER, 1984) and advice from their mathematics teachers.

Table 1
Numbers of Students by Grade Level and Gender at Time 2

Gender	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Total N
Male	8	28	21	28	24	109
Female	10	34	22	38	30	134
Combined	18	62	43	66	54	243

Students' optimistic or pessimistic explanatory style was measured by the *Children's Attributional Style Questionnaire* (CASQ) (Seligman, Peterson, Kaslow, Tanenbaum, Alloy, & Abramson, 1984). The pencil and paper questionnaire consists of 48 hypothetical statements about positive and negative events, covering a number of different domains including schoolwork, peer relationships, family relationships, and extracurricular activities. Students chose between two possible explanations for each event.

Procedure

The *PATMaths* and the CASQ were administered to students in their own schools in Term 1 in the first year of the study, and again in Term 4 almost three years later. Students' results for the *PATMaths* were placed on the single standard scale of achievement (*The Progressive Achievement Tests in Mathematics Teacher Handbook*, 1984), irrespective of the level of the test or the time at which it was taken. Rasch analysis of the CASQ indicated that it contained two separate scales of positive explanatory style (referred to as optimism) and negative explanatory style (referred to as pessimism) (Yates & Afrassa, 1994; Yates, Keeves, & Afrassa, in press). For the purposes of analyses in this study optimism and pessimism were therefore considered separately. Students' results for the Time 1 and Time 2 optimism and pessimism scales were equated concurrently (Yates, 1998a).

Results

Relationships between students' optimism, pessimism, and achievement in mathematics at Time 1 and Time 2, grade level and gender were examined with correlational statistics, as presented in Table 2. Strong correlations were evident between achievement in mathematics at Time 1 and Time 2 and between Grade level and achievement on both occasions. Gender was correlated significantly with pessimism in both years, and with optimism at Time 1 but not with achievement. The negative correlations between gender and pessimism at both Time 1 and Time 2 indicated that boys (coded as 1) were more pessimistic than girls (coded as 2). The positive relationship between gender and Time 1 optimism signified that girls were more optimistic than the boys at the primary school level. However, optimism declined across the grade levels as indicated by the weak but significant negative correlation between Grade level and Time 1 optimism.

Table 2
Correlations Between Mathematics Achievement, Optimism and Pessimism in Time 1 and Time 2, Grade Level and Gender (N = 243)

Variables	2	3	4	5	6	7	8
1. Time1 Maths achievement	0.73***	–0.18**	–0.17**	–0.14*	•	0.62***	•
2. Time 2 Maths achievement	–	–0.19**	–0.17**	–0.21***	•	0.43***	•
3. Time 1 Optimism		–	0.35***	•	–0.15*	–0.15*	0.13*
4. Time 2 Optimism			–	•	•	•	•
5. Time 1 Pessimism				–	0.32***	•	–0.19**
6. Time 2 Pessimism					–	•	–0.19**
7. Time 1 Grade level						–	•
8. Gender							–

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, • correlation not significant

Weak but significant negative correlations were also evident between the measures of optimism and achievement in mathematics at Time 1 and Time 2. These negative relationships reflected the gradual decrease in optimism and

increase in students' achievement across the grade levels (Yates, 1999). While pessimism at Time 1 was negatively correlated with concurrent achievement in mathematics at a significant but weak level, and with achievement at Time 2 at a moderate level, the Time 2 pessimism scores did not correlate with the *PATMaths* scores at either Time 1 or Time 2. As the pessimism scale had been scored by reversing the 24 negative CASQ items (Yates & Afrassa, 1994; Yates, Keeves & Afrassa, in press), the negative relationships between the Time 1 pessimism and achievement in both years indicated that pessimistic students had lower achievement in mathematics.

The nature and extent of the negative relationships between the optimistic and pessimistic explanatory style measures at Time 1 and subsequent achievement in mathematics were of particular interest since it had been hypothesised that a pessimistic explanatory style would predispose students to poorer achievement in mathematics. These relationships were therefore tested with direct entry multiple regression analyses (SPSS; Norusis, 1993). As achievement in mathematics at Time 2 was correlated strongly with prior achievement and with Grade level, it was necessary to control for these factors in separate analyses.

In the regression analysis presented in Table 3, the influences of achievement, optimism and pessimism measured at Time 1 on achievement in mathematics at Time 2 were examined.

Table 3
Regression Analysis: Predicting Mathematics Achievement at Time 2 by Achievement in Mathematics, Optimism and Pessimism at Time 1

Time 2 Mathematics Achievement Variable (N = 243)	r	β	t
Time 1 Achievement in Mathematics	0.74	0.70	15.90***
Time 1 Optimism	-0.19	-0.09	-2.00*
Time 1 Pessimism	-0.21	-0.12	-2.73**

Multiple $R = 0.75$, $R^2 = 0.56$, $F = 100.46$***. *Note:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$

Although Time 2 achievement in mathematics was most strongly related to prior achievement, there were also significant negative relationships with the Time 1 optimism and pessimism measures (t = -2.00, $p < 0.05$ and t = -2.73, $p < 0.01$, respectively). When the influences of Grade level, gender, Time 1 optimism and pessimism on achievement in mathematics at Time 2 were considered, as shown in Table 4, the pessimism score was strongly negatively related to subsequent mathematics achievement (t = -4.81, $p < 0.005$), as was the Time 1 optimism score (t = -2.58, $p < 0.01$). Grade level was also significantly related to achievement (t = 7.66, $p < 0.005$). The latter strong correlation was not unexpected as it was not only evident in Table 2 for both Time 1 (r = 0.62, $p < 0.001$) and Time 2 (r = 0.43, $p < 0.001$), but also had been found in correlation and regression analyses reported elsewhere (Yates, 1998). Over time students show incremental increases in achievement as they are exposed increasingly to the mathematics curriculum in schools (*The Progressive Achievement Tests in Mathematics Teacher Handbook*, 1984). Gender was not a significant variable.

Table 4
Regression Analysis: Predicting Mathematics Achievement at Time 2 by Optimism, Pessimism and Grade Level at Time 1 and Gender

Time 2 Mathematics Achievement Variable N = 243	*r*	Beta	*t*
Time 1 Optimism	-0.19	-0.15	-2.58**
Time 1 Pessimism	-0.21	-0.27	-4.81***
Time 1 Grade level	0.43	0.43	7.66***
Gender	-0.06	-0.08	-1.47

Multiple $R = 0.52$, R square = 0.27, $F = 22.47$***. *Note:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.005$

Summary of the Results

Positive and negative explanatory style at Time 1 were both related negatively to achievement in mathematics at Time 2. As this study commenced when all of the students were in primary school, it is evident that those who held a more pessimistic explanatory style at Time 1 experienced a lower relative level of achievement almost three years later, as measured by the *Progressive Achievement Test in Mathematics*. While boys were significantly more pessimistic than girls at both Time 1 and Time 2, gender was not a significant factor in relation to achievement in mathematics. Students' prior achievement and the Grade level were also significant factors in their later achievement in mathematics.

Discussion

This study clearly demonstrated that the explanatory style students had developed with respect to everyday events in their lives was significantly related to their achievement in mathematics. Notwithstanding the strong relationships between prior achievement and Grade level, it was evident that students' optimism or pessimism played a part in their achievement in mathematics. In particular, the hypothesis that pessimism would be associated not only with lower concurrent achievement but also with subsequent achievement measured almost three years later was affirmed. Pessimism was identified in students at the primary school level and influenced their achievement in mathematics at that level and as they became older and moved into lower secondary schools.

The relationship between pessimism and lower achievement demonstrated by this study has significance for mathematics teachers and learners. Students with a pessimistically oriented explanatory style habitually view the causes of bad events as stable in time, global in effect and internal to themselves (Nolen-Hoeksema et al., 1986). Pessimism is maladaptive (Abramson, Seligman, & Teasdale, 1978) and becomes a self-fulfilling prophecy, setting in train behaviours that are deleterious for achievement (Schulman, 1995; Seligman, 1990). In particular, when pessimistic students encounter negative events they are likely to exhibit a constellation of helpless behaviours including cognitive deficits, passivity, sadness, lowered self esteem, lowered assertiveness and competitiveness (Nolen-Hoeksema et al., 1986). These behaviours have been clearly identified by classroom teachers (Fincham, Hokoda, & Saunders, 1989; Nolen-Hoeksema et al., 1986) and

mathematics teachers (Yates, 1998b) and are associated with lower achievement (Fincham et al., 1989; Nolen-Hoeksema et al., 1986, 1992; Yates, 1999, 2000). The ALB model has proposed that affective beliefs influence achievement in mathematics through mediated learning activities (Fennema & Peterson, 1985; Fennema, 1989). These findings suggest that these beliefs may emanate from negative attributions about the causes of events in life in general and not just from specific attributions about success and failure in mathematics. In addition, it is the primary school years that are crucial, as during this time students' pessimistic explanatory style is established, and influences achievement in mathematics, an effect that continues on into the lower secondary school years.

One of the more interesting aspects of this study for mathematics education was the concurrent and predictive negative relationship between optimism and achievement. Although students became less optimistic as they became older, they continued to make gains in achievement in mathematics. Younger children are generally optimistic (Seligman, 1990), but there is a trend for students as they mature to use increasingly external, unstable, and specific attributions for positive events (Nolen-Hoeksema, Girgus, & Seligman, 1991). As students progress through school they develop more realistic attributions based on the feedback that they receive about their abilities and limitations (Nolen-Hoeksema et al., 1991). Optimism is believed to be associated with positive mastery-oriented learning behaviours including engagement, persistence, utilisation of appropriate problem-solving strategies, and assertiveness (Schulman, 1995). Students in the early primary school years who view positive events as being long-lasting, under internal control and generalised, and negative events as of short duration, external and specific are more likely to develop task oriented behaviours which lead to higher achievement (Seligman, 1990; Yates, 1997). Thus, while optimistic explanations for common life events decreased as the students in this study approached adolescence, the level of their achievement in mathematics increased over time as a result of the instruction they received, the goals that they had set and the constructive work habits acquired in the earlier years.

Conclusions and Future Research

Mathematics educators share a common concern that students have positive experiences in mathematics both in terms of learning outcomes and attitudes towards mathematics. As affect is an integral part of mathematics education, studies of students' attitudes, beliefs, and emotions have the potential to improve the teaching and learning of mathematics (Fennema, 1989). The ALB model (Fennema & Peterson, 1985; Fennema, 1989) has directed attention to the importance of affective variables in exploring factors that influence students' achievement in mathematics. Previous studies have focussed on students' beliefs about themselves and about mathematics, as well as their specific attributions for success and failure in mathematics (McLeod, 1992). This study adds to that body of knowledge and understanding about affect, with the finding that students' beliefs about the causes of general events in their lives has an influence on achievement in mathematics. Students bring to the learning of mathematics characteristic explanatory styles and interpret the causes of events from optimistic or pessimistic perspectives. These explanatory styles are established early in the primary school years, with pessimism associated with lower achievement in mathematics. Moreover, boys are more pessimistic than girls.

Failure and success are highly salient in mathematics (McLeod, 1992), with

both playing an important role in learning and mastery (Seligman, 1995). Teachers have been exhorted to provide successful learning experiences for students (Berliner, 1987), but the attributions that students make are equally important. Students with a pessimistic explanatory style regard success as transitory, specific and external, and failure as a generalised, permanent state over which they have little or no control. For them, mistakes, errors, and faults are not viewed as part of the fabric of learning, but are likely to be recast, leading them to expect further negative outcomes and setting up a vicious circle of learned helplessness (Yates, 1999). Pessimistic students need to be identified as early as possible in their primary school years, so that their self-defeating negative explanatory styles and trajectory towards lower achievement in mathematics can be interrupted and reversed (Nolen-Hoeksema et al., 1986). Explanatory style is learned and is changeable (Seligman, 1990, 1995). Intervention studies have been conducted for pessimistic adolescents (Jaycox, Reivich, Gillham, & Seligman, 1994; Peterson, 1988; Shatté, Reivich, Gillham, & Seligman, 1999) and college students (DeRubeis & Hollon 1995). This study would suggest that such interventions should begin when students are in primary school and should target attributions in specific subject areas, particularly as attributions have been found to be subject specific (Marsh, 1986).

Within mathematics education, comparatively little research has been conducted within the affective component of the ALB model (Fennema, 1989; Hart, 1989; McLeod, 1992). This study has indicated that students' explanatory style is a significant aspect of this component, with pessimism associated with deleterious behaviours and lower achievement. Previous studies have demonstrated that as students get older their beliefs about mathematics change (Kouba & McDonald, 1987), as do their beliefs about the self (Dossey, Mullis, Lindquist, & Chambers, 1988). Relationships between younger and older students' optimism, pessimism, and specific attributions for success and failure in mathematics need to be examined in future studies, as do relationships between explanatory style and other beliefs about the self. Differences between the genders have been the focus of many studies in mathematics education (see, Afrassa & Keeves, 1997; Fennema & Leder, 1990; Leder, 1992). While gender was not associated with achievement in this study, the differences in pessimism in boys and girls is worthy of more careful scrutiny. More representative samples with larger numbers of students at the earlier grade levels would also be advantageous. Future research should be directed at the measurement of optimism and pessimism as it is operationalised in the regular classroom. Interviews with teachers, students, and their peers could not only be used to investigate their own explanatory styles but also that of each other. Such data would shed some light on factors that influence the development of optimism and pessimism, and their relationships with achievement in mathematics.

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