
STUDENTS' OPTIMISM, PESSIMISM AND ACHIEVEMENT IN MATHEMATICS: A LONGITUDINAL STUDY

Shirley M. Yates

The Flinders University of South Australia

shirley.yates@flinders.edu.au

Optimism, pessimism and achievement in mathematics in primary and lower secondary students were measured on two occasions separated by almost three years. The students' Grade level and gender were also considered. The hypothesis that, relative to more pessimistically oriented students, those with a more generally optimistic outlook on life would evidence a higher level of achievement in mathematics was confirmed. Students' Grade level and gender were also significant variables. The implications of these findings for mathematics education are discussed.

INTRODUCTION

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. The *National Statement and Profile on Mathematics for Australian Schools* (AEC, 1990) stresses attitudes and appreciations. The development of optimism is included in the second significant educational aim for all students in the 1989 *National Goals for Australian Schooling* (The Hobart Declaration).

For centuries optimism, the belief that positive events outweigh the negative, has been regarded as a natural, normal and healthy personality attribute. Differences between optimists and pessimists abound within popular culture, literature and humour. Recently, studies have established that these differences encompass significant aspects of personal adjustment and influence motivation, learning and health (Peterson & Bossio, 1991). Optimistic and pessimistic tendencies, referred to as an explanatory style, are formed during childhood (Nolen-Hoeksema & Girgus, 1995; Yates, 1998) and impact on children's health, motivation and achievement (Seligman, 1990). In the present study, relationships between students' optimism, pessimism and achievement in mathematics were explored over a period of almost three years. In a pilot study, explanatory style was implicated as a determinant of mathematics performance (Yates, Yates & Lippett, 1995), but 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.

Explanatory style has been defined as the trait-like characteristic way in which people explain the causes of events in their lives, particularly when these events are negative and occur under ambiguous circumstances (Seligman, 1990). Optimists attribute good events to permanent, personal and pervasive causes and bad events to unstable, external and specific causes. For pessimistically oriented people, bad events are attributable to causes which are universal, unchangeable and due to their ineptitudes and good events to factors that are transitory, specific and due to outside factors such as luck. Explanatory style interacts with achievement to create self-fulfilling prophesies, which 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).

Since 1980, research has supported the theory that explanatory style is related to achievement in various domains including education, work, and sports (Schulman, 1995). In the workplace people with an optimistic explanatory style have greater productivity than

pessimists (Seligman & Schulman, 1986). The deleterious effects of a pessimistic style have been implicated also in studies of athletic performance and illness (see Seligman, 1990) and academic performance, with Peterson and Barrett (1987) reporting a correlation of 0.36 between tertiary academic grades and negative attributional style. In mathematics, a small but significant correlation was found between college students' pessimistic style and final grade in algebra ($r = 0.08$, $p < 0.05$) (Pierce & Henry, 1993).

Peterson, Maier and Seligman (1993) have asserted that after depression the best known influence of explanatory style is on achievement. However, surprisingly few studies have actually examined this phenomenon in school-aged students. Two studies have investigated relationships between explanatory style and general academic achievement. Significant moderate correlations were found between concurrent measures of academic achievement, as assessed by the *California Achievement Test* (California Testing Bureau, 1982) and explanatory style ($r = 0.26$, $p < 0.05$) (Nolen-Hoeksema, Girgus & Seligman, 1986). In a five year longitudinal study, a weak relationship was found between primary school children's explanatory style and academic achievement measured six months later, with pessimistic children being somewhat less successful on standardised achievement tests (Nolen-Hoeksema, Girgus & Seligman, 1992; Nolen-Hoeksema & Girgus, 1995). Boys were consistently more pessimistic than the girls, particularly in terms of their explanations for negative events. Relationships over the longer term were not examined.

Relationships between explanatory style and achievement in mathematics has been explored in a single pilot study of 145 primary school-aged students (Yates, Yates and Lippett, 1993; 1995). Significant correlations were found between students' optimistic or pessimistic explanatory style and concurrent achievement in mathematics ($r = 0.20$, $p < 0.05$ and $r = -0.30$, $p < 0.01$ respectively). Pessimism also correlated significantly with students' achievement in mathematics two and three years previously ($r = -0.29$, $p < 0.05$ and $r = -0.35$, $p < 0.05$ respectively). The girls were significantly more optimistic ($F(1, 130) = 4.31$, $p < 0.05$) and less pessimistic ($F(1, 130) = 13.66$, $p < 0.001$) than the boys.

Children develop characteristic patterns of explaining causes of events from the myriad of experiences of their lives (Peterson and Bossio, 1991). In their everyday interactions in the classroom all students encounter successes and failures. Students who have developed pessimistic cognitive frameworks are at risk for doing less well in school (Seligman, 1995) as they are likely to view failure as being a permanent state over which they have no control. Furthermore, failure in a subject area is likely to pervade all other aspects of their schooling. For such students, failure is not seen as part of the fabric of learning but is likely to be recast, leading them to expect further negative outcomes, thus setting up a vicious circle. This is particularly likely to occur in mathematics where such strong views about the nature of the subject matter abound.

In Western cultures people often hold very strong negative views of mathematics, with many considering it a subject to be feared. Studies in the United States have reported repeatedly that people believe that they cannot do mathematics, as the subject is too difficult (McLeod, 1992), a belief more commonly espoused by females. People not only admit readily to failure in mathematics, but also see it part of a familial pattern and therefore outside of their personal control (McLeod, 1992). Furthermore, failures in school mathematics are often interpreted as a confirmation of a lack of ability, with the very fact of having to make an effort to master mathematics further proof of this lack of accomplishment. Many students in the United States prefer to not try than to try and fail (Covington & Omelich, 1979).

In a longitudinal study over a period of 12 months, in a causal model earlier attitudes towards mathematics were related to later achievement in mathematics (Keeves, 1972; 1986). Clearly beliefs that students hold about themselves and about mathematics play an

important role in their achievement in mathematics in the United States, particularly when these perceptions lead students to expect to do well (McLeod, 1992). While there has been some indication that in comparison with males, female students are more likely to attribute their success to effort and their failure to lack of ability, gender differences in attributions in mathematics have not been clear cut (McLeod, 1992).

These equivocal findings between gender differences in the United States in selected internal belief variables and gender differences in learning mathematics suggest the need to consider gender in this study. If boys in primary school are more pessimistic than girls, and if girls become more pessimistic as they enter their teenage years, as suggested by Nolen-Hoeksema and Girgus (1995), then this might have differential effects on their achievement. Of particular interest in this study therefore, is not only whether the findings of Nolen-Hoeksema *et al.* (1986) would be affirmed for the concurrent measures of achievement in the specific subject area of mathematics, but also whether explanatory style would be related to subsequent achievement in mathematics. In general, attitudes towards mathematics appear to be related to age (Fraser, 1980), so Grade level too is an important variable.

The use of a longitudinal design facilitates the examination of relative gain over time and the factors that are hypothesised to influence both this gain as well as change over time. In order to investigate 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, with an objective measure of achievement in mathematics and student self-report indices of explanatory style collected on both occasions.

METHOD

The fundamental hypothesis of this study is that possessing an optimistic explanatory style leads to enhanced achievement levels in mathematics. Thus optimistic children are more likely than pessimistic children to show increases in their relative mathematical achievement levels over time. The aims of this study therefore are:

1. to examine the relationships between students' optimism, pessimism and achievement in mathematics over time; and
2. to consider the influence of student's gender and Grade level on these relationships.

Subjects The study commenced in Term 1, 1993 with a non-random, non-representative sample of 335 students in Grades 3 to 7 in two government primary schools in South Australia. In Term 4, 1995, 243 of these students were traced to 26 primary and 24 lower secondary schools in the government and non-government sectors. The Grade level and gender of the 243 students in 1995 is presented in Table 1.

Table 1
Numbers of Students by Grade Level and Gender in 1995

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

Mathematics Achievement Test Students' achievement in mathematics was measured with Form A of the *Progressive Achievement Tests in Mathematics (PATMaths)* (ACER, 1984) which consisted of three timed standardised multiple choice format tests. In 1993 students were administered Test 1, 2 or 3 in accordance with the recommendations made in the *Teachers Handbook* (1984). In 1995 students in Grades 5, 6 and 7 were administered Test 1 or 2, Grade 8 Test 2 or 3 and Grade 9 Test 3.

Explanatory Style Questionnaire Students' optimistic or pessimistic explanatory style was measured by the *Children's Attributional Style Questionnaire (CASQ)*, (Seligman,

Peterson, Kaslow, Tanenbaum, Alloy, & Abramson, 1984). The questionnaire consisted of 48 hypothetical statements about good and bad events, with students choosing between two possible explanations for each event.

Procedure The *PATMaths* and the CASQ were administered to students in their own schools in Term 1, 1993 and again in Term 4, 1995.

RESULTS

As the *PATMaths* had been Rasch scaled (ACER, 1984) the results for all students could be placed on the single standard scale of achievement (*Teachers Handbook*, ACER, 1984), irrespective of the level or the time at which the students took the test. Rasch analysis of the CASQ indicated that it contained two separate scales of optimism (CASQCP) and pessimism (CASQCN). Students' results for the 1993 and 1995 CASQCP and CASQCN were equated concurrently (Yates, 1998).

Relationships between students' optimism, pessimism and achievement in mathematics in 1993 and 1995 were examined with correlational statistics with the Grade level and gender variables initially included and then omitted. In Table 2, weak but significant negative correlations were evident between the measures of optimism in 1993 and 1995 and achievement in mathematics in 1993 and 1995. While pessimism in 1993 was negatively correlated with concurrent achievement in mathematics at a significant but weak level, the 1995 CASQCN did not correlate with *PATMaths* in either 1993 or 1995. Gender was correlated significantly with pessimism in both years, but not with achievement.

Table 2
Correlations Between Mathematics Achievement, CASQCP and CASQCN in 1993 and 1995, Grade Level and Gender

N = 243	2	3	4	5	6	7	8
1. 1993 Maths achievement	0.74***	-0.18**	-0.17**	-0.14*	•	0.62***	•
2. 1995 Maths achievement	-	-0.19**	-0.17**	-0.21***	•	0.43***	•
3. 1993 CASQCP		-	0.35***	•	-0.15*	-0.15*	0.13*
4. 1995 CASQCP			-	•	•	•	•
5. 1993 CASQCN				-	0.32***	•	-0.19**
6. 1995 CASQCN					-	•	-0.19**
7. 1993 Grade level						-	•
8. Gender							-

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

The nature and extent of the relationships between the 1993 optimistic and pessimistic explanatory style measures and subsequent achievement in mathematics were of particular interest since it had been hypothesised that a pessimistic explanatory style in 1993 would predispose students to poorer achievement in mathematics in 1995. These relationships were therefore tested with multiple regression analysis, with the Grade level and gender variables initially retained as presented in Table 3.

Table 3
Regression Analysis: Predicting Mathematics Achievement in 1995 by 1993 CASQCP, 1993 CASQCN, Grade Level and Gender

1995 Mathematics achievement					
Variable	N = 243	r	Beta	t	Significance of t
1993 CASQCP		-0.19	-0.15	-2.58	0.01
1993 CASQCN		-0.21	-0.27	-4.81	0.00
1993 Grade level		0.43	0.43	7.66	0.00
Gender		-0.06	-0.08	-1.47	NS
Multiple R = 0.52		F = 22.47			
R square = 0.27		Significance of F = 0.00			

The 1993 CASQCN score was strongly related to subsequent mathematics achievement ($t = -4.81, p < 0.000$), as was the 1993 CASQCP ($t = -2.58, p < 0.01$). Grade level was also significantly related to achievement ($t = 7.66, p < 0.000$). This strong correlation was not unexpected as it was not only evident in Table 2 for both 1993 ($r = 0.62, p < 0.001$) and 1995 ($r = 0.43, p < 0.001$), but also had been found in correlational 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 (ACER, 1984). Gender was not a significant variable.

In order to consider the influence of the prior measures of explanatory style on subsequent achievement in mathematics, it was necessary to control for the influence of Grade level on achievement with partial correlation. Table 4 shows the negative correlation between the 1993 CASQCN and the 1995 achievement in mathematics ($r = -0.27, p < 0.000$) at a moderate level. The 1993 CASQCP was correlated also with achievement in mathematics in 1995, but this correlation was weaker ($r = -0.14, p < 0.05$) than that of the 1993 CASQCN.

Table 4
Partial Correlations between 1993 CASQCP and CASQCN and 1995 Achievement in Mathematics Controlling for 1993 Grade Level

Variables	Df = 240	2	3
1. 1995 Mathematics achievement		-0.14*	-0.27***
2. 1993 CASQCP			-0.09
3. 1993 CASQCN			-

* $p < 0.05$ *** $p < 0.000$

The relationship between the 1993 CASQCP and CASQCN and achievement was then examined with direct entry multiple regression analysis, as shown in Table 5, with the Grade level and gender variables omitted. Both of the 1993 CASQ measures were related to mathematics achievement in 1995.

Table 5
Regression Analysis: Predicting Mathematics Achievement in 1995 by 1993 CASQCP and 1993 CASQCN

1995 Mathematics achievement				
Variable	N = 243	r	Beta	t
1993 CASQCP		-0.19	-0.22	-3.50
1993 CASQCN		-0.21	-0.23	-3.72
Multiple R = 0.30		F = 11.82		
R square = 0.09		Significance of F = 0.000		

Summary of the Results

Both positive and negative explanatory style in 1993 were related to achievement in mathematics in 1995. 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 in 1993 experienced a lower rate of achievement in 1995, as measured by the *Progressive Achievement Test in Mathematics*. While boys were significantly more pessimistic than girls in both 1993 and 1995, gender was not a significant factor in relation to achievement in mathematics. Grade level was a significant factor in achievement.

DISCUSSION

Schulman's (1995) assertion that explanatory style was related to achievement in a number of domains including achievement in school was borne out in this study. The finding of Nolen-Hoeksema *et al.* (1986; 1992) that explanatory style was related to achievement was not only confirmed, and extended to the specific subject area of mathematics, but it

was also clearly linked, particularly for negative explanatory style, with subsequent achievement. While the pilot study had indicated a relationship between students' explanatory style and concurrent achievement in mathematics (Yates *et al.*, 1995), this study affirmed this relationship over time. Both the CASQCP and CASQCN in 1993 were significantly related to achievement in mathematics in 1995, with the CASQCN measure showing a slightly stronger effect than the 1993 CASQCP.

Seligman and other researchers have frequently claimed that optimistic children achieve more at school, and that conversely pessimistic children achieve less. While these claims were substantiated with correlational and regression analyses in this study, achievement in mathematics was strongly related to prior achievement in mathematics. Notwithstanding the magnitude of this relationship, explanatory style, particularly the CASQCN, was related to achievement in mathematics. Students who reported a pessimistic explanatory style experienced a lower rate of achievement, with boys consistently more pessimistic than girls over time.

Implications for Mathematics Education

While attitudes towards mathematics have been found to be related to achievement in mathematics (Keeves, 1972), the nature of the relationship between attitude and achievement remains largely unexplored. Explanatory style is a motivational characteristic that might conceivably impact upon a disposition to maintain effortful responding over extended time sequences. Skill development in the area of mathematics is likely to demand a continuing level of high motivation. The deleterious effects of a pessimistic explanatory style on academic performance at the tertiary level (Peterson & Barrett, 1987), and general achievement at school (Nolen-Hoeksema *et al.* 1986; 1992) were linked clearly with achievement in mathematics in this study.

Failure and success are considered to be highly salient in mathematics classrooms (McLeod, 1992). Students bring to the classroom a rich range of experiences which influence how they account for their successes and failures. While teachers have been exhorted to provide successful learning experiences in mathematics for their students (Berliner, 1987), the attributions that students make are equally important. In particular, pessimistic students who believe that their failures are likely to be long-lasting, to pervade all aspects of their work and to be due to their own ineptitudes need to be identified as early as possible in their primary school years, so that their trajectory towards poorer achievement can be interrupted and reversed. Intervention studies have been conducted for pessimistic adolescents (Peterson, 1988; Jaycox, Reivich, Gillham & Seligman, 1994) and college students (DeRubeis & Hollon 1995). This study would suggest that such interventions should begin when students are in primary schools and should target attributions in specific subject areas, particularly as attributions have been found to be subject specific (Marsh, 1986).

Mathematics teachers need to be cognisant of the attributions that they make about students' work, particularly in relation to failures. Seligman (1990) has suggested that teachers, together with parents and coaches, have an important part to play in children's development of an optimistic or pessimistic explanatory style. Since mathematics is a subject which is likely to have negative connotations for many students, teachers need to be aware of pessimistic students who attribute their mistakes and errors to permanent, personal and pervasive factors. Explanatory style is learned and is therefore changeable.

Future research could 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 light on some of the factors that influence the development of optimism and pessimism and its relationship with achievement in mathematics .

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