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The relationships among previous achievement, effort, and performance in high school Mathematics and English

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Abstract

Data obtained from a sample of New South Wales high school students were used to investigate the relationships among standardised Year 7 numeracy and reading tests, a measure of general schoolwork effort taken at Year 10, and Mathematics and English scores in a state-wide, compulsory Year 10 examination. A correlation analysis showed that all the measures were positively and significantly related. Multiple regression analyses demonstrated that the relevant Year 7 test result contributed to a considerable amount of the explained variance in the two Year 10 examination scores. Effort also contributed significantly to the explained variance in the Mathematics score. Implications for researchers, as well as school personnel, are considered.

Introduction

A full or even cursory reading of Georgiou's (2008) article published in *Educational Psychology* would lead the reader to conclude that both ***ability*** and ***effort*** are central to any investigation of achievement but especially so in a study of the factors influencing school achievement.

Ability

Previous studies have demonstrated that the achievements of both primary school and high school students are greatly influenced by ability and/or a proxy measure of ability referred to as prior achievement. To exemplify, Spinath, Spinath, Harlaar, and Plomin (2005) showed that a measure of general mental ability was the main predictor of achievement in a large sample of nine-year-old British students. Aubrey, Dahl, and Godfrey (2006) also concluded from their analysis of British longitudinal data that early mathematical abilities and skills were vital for future mathematical success at school.

Hemmings (1996) showed that prior school achievement in English, mathematics, and science, based on standardised Year 10 examination results in New South Wales, (NSW), Australia, was significantly related to Year 12 Tertiary Entrance Rank (TER). Strikingly, a Year 10 composite measure of these three subjects accounted for over 60 percent of the explained variance in the TER. Yates' (2000) research, also undertaken in Australia, found that prior achievement in mathematics was highly predictive of later achievement in mathematics. This study was conducted in South Australia and drew on the results of students aged between 8 and 12 years.

Similarly, Aiken's (1972) research in the United States of America showed that language abilities impact on the mathematical achievements of primary school students. Reynolds (1991) found that previous achievement was a chief predictor of Grade 8 mathematics and science knowledge. And, Thomas (2002) has pointed to the significance of previous results in English and how these affect reading results in Grades 7 and 8.

Effort

Terms such as academic engagement, self-worth, and causal attributions abound in the research literature and these terms are commonly associated with the construct of effort (see, for example, Covington, 2000; Slavin, 1994; Yates, 2000). However, few references are made to effort, and its measurement, in the research literature. This is

especially so with studies which relate to school achievement. One notable work was conducted by McInerney and his colleagues (see, for example, McInerney & Sinclair, 1991; Ali & McInerney, 2005), who devised a measure of general effort with regard to schoolwork. Forming part of the Inventory of School Motivation (see, for example, Ali & McInerney, 2005), this 'Effort' scale has been validated in a number of Australian settings, as well as trans-nationally. When used as an independent variable the scale has been found to be a good predictor of English results with Australian and American high school students. The measure has also been shown to relate significantly to Grade Point Average for these same students; however, it did not have a significant effect on mathematics achievement.

Relationship between numeracy and literacy

Not much information has been reported in the research literature about the relationship between numeracy and literacy measurements and their various components, despite the extensive use of standardised numeracy and literacy tests in schools. The information that has been relayed tends to be marked by three general features: the vast majority of the work is based on North American data; the datasets tend to be built on primary school results; and, a reliance on quite dated sources. Both Aiken (1972) and Thomas (2002), for example, reported correlations between reading scores and mathematics achievement of the order of .40 to .80. These researchers used large USA elementary school datasets drawing on information from the 1960s through to the late 1980s.

Research denoting the relationships between numeracy and literacy test scores in Australian schools is very limited. In fact, only two studies have reported on the relationships. Marks and Ainley's (1997) work investigated data across a 20-year period and the only correlation coefficient noted in their work was that numeracy and reading comprehension had a correlation of .60 for a sample of 13- to 15-year-olds. More recent research by Hemmings and Kay (2009) examined the relationships between and among the four Literacy and Numeracy National Assessment (LANNA)[1] tests taken by non-government students. They showed that the correlations between the numeracy and reading tests, for a number of relatively small student cohorts, were of a similar magnitude to the Marks and Ainley (1997) result.

It is remarkable that an Australia-wide testing program, namely, LANNA, has been in place from 1999 to 2007, yet almost no analysis of these data, with the exception of Hemmings and Kay (2009), has been reported in the research literature. Given that about 80 000 students enrolled in Years 3, 5, and 7 in non-government schools across Australia would have sat these tests, this is even more surprising. A clear gap exists in the research literature, requiring Australian publications detailing correlations or more sophisticated statistical analyses involving LANNA and other basic skills testing schemes.

Aims of this study

The present study had two aims. Firstly, it sought to explore the relationships among the two Year 7 LANNA tests of numeracy and reading, a measure of general schoolwork effort, and performance in Year 10 Mathematics and English. Secondly, and as an extension of the previous aim, the study sought to examine the predictive capacity of numeracy and reading, together with the effort measure, in relation to Year 10 Mathematics and English scores.

Method

The participants for the study were Year 10 students (in 2007) in a co-educational, regional high school with a drawing population of middle- to high-income families. Nearly all of the participating students had sat Year 7 LANNA tests during 2004 and then continued their schooling to Year 10. The age of the students at the beginning of Year 10 varied from 15.4 to 16.9 years. A breakdown by gender indicated that the students were approximately evenly split between males and females. During Year 10 these students sat state-wide School Certificate (SC) examinations in both Mathematics and English. Before these examinations were held, the participants completed a short questionnaire. This was administered during normal lesson time by a school representative. Following this administration, the representative added LANNA scores and SC examination results and deleted the names of the participants so as to maintain

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[1] Literacy is comprised of three tests – reading, writing, and spelling – and numeracy is assessed by one test examining number, space, measurement, and chance and data.

the anonymity of these participants. The completed questionnaire was then returned to the researcher for coding and analysis.

The questionnaire was divided into two sections. Section one sought demographic information as well as being designed to allow the school representative to add LANNA test and SC examination results. The second section of the instrument consisted of items that asked participants to indicate their level of agreement or disagreement with a statement, using a 5-point scale. Seven of the items were drawn from The Inventory of School Motivation (see, for example, Ali & McInerney, 2005) and were devised to tap into an *effort* dimension. These items are listed in the Appendix. An effort measure was then derived from a scale analysis (using SPSS, Version 16.0 and the *Reliability* program), with a Cronbach alpha of .83. This is consistent with results reported by Ali and McInerney (2005). A summary of the various measures, including the mean values recorded, is given in Table 1.

Table 1
Description of measures

Measure	Description
Numeracy	Highest score=178, Benchmark score=110, Mean=129.85
Reading	Highest score=155, Benchmark score=99, Mean=115.10
Effort	Highest score=5, Lowest score=1, Mean=3.63
SC Maths	Highest score=100, Lowest score=30, Mean=74.10
SC English	Highest score=100, Lowest score=30, Mean=77.78

Results

The results of the correlation analysis appear in Table 2. These results were produced by using the *Correlate* program in SPSS, Version 16.0. An inspection of the correlation coefficients revealed that all the measures were positively and significantly related. In fact, all were significant at the 5% level and most reached significance at the 1% level. The correlation coefficients ranged from .338 to .661. The strongest relationships were found between Reading and the two SC measures.

Table 2
Correlation matrix

Measure	1.	2.	3.	4.	5.
1. Numeracy	1				
2. Reading	.490**	1			
3. Effort	.348*	.338*	1		
4. SC Maths	.593**	.639**	.443**	1	
5. SC English	.360**	.661**	.394**	.633**	1

*p<.05; **p<.01 (2-tailed)

Several multiple regression analyses were performed using the *Regression* program in SPSS, Version 16.0 to determine the predictive capacity of the different LANNA tests, Effort, and the results in Year 10 Mathematics and English. Because the sample sizes involved were relatively small, it was decided to set a limit on the number of independent variables in each regression equation. As a result, only variables with a strong conceptual tie were included in the equations.

In the first equation with SC Maths as the dependent measure, only Numeracy and Effort were included. Numeracy on its own contributed 38.9% of the variance and when Effort was added to the model a further 13.3% was contributed (see Table 3). In other words, a student's performance in the LANNA Numeracy and a measure of the effort

expended in his/her schoolwork were significant predictors of his/her performance in Year 10 Mathematics.

In the second equation when SC English was the dependent measure, both Reading and Effort contributed to the total explained variance, explaining 51.5% of the variance (see Table 4). However, Effort did not make a significant contribution (*p*=.066). Once again, the chief contribution came from the single Year 7 LANNA test.

Table 3
Multiple regression model of predictors of SC Maths (N=44)

Step	R^2	R^2 change	Standard error of estimate	F- change	Significance of F- change
1. Numeracy	.389	.389	6.641	27.359	.000
2. Numeracy, Effort	.552	.133	5.944	11.669	.001

Table 4
Multiple regression model of predictors of SC English (N=45)

Step	R^2	R^2 change	Standard error of estimate	F- change	Significance of F-change
1. Reading	.475	.475	5.762	39.743	.000
2. Reading, Effort	.515	.040	5.602	3.555	.066

Discussion

This study had two aims. The ***first aim*** centred on the relationships among the two LANNA tests, a measure of general schoolwork effort, and performance in the two standardised Year 10 examinations, namely, Mathematics and English. All measures were significantly and positively related to each other ($p<.05$), with the correlation coefficients ranging from .34 to .66. The correlation between LANNA Reading and Numeracy was .49 and significant at the 1% level. This result is in accord with previous Australian research reported by Marks and Ainley (1997). Although Reading had the strongest correlation with Year 10 English it also correlated highest with Year 10 Mathematics. This latter result was unexpected but is consistent with the view that there is a strong literacy base for mathematical tasks (see, for example, Aiken, 1972; Thomas, 2002). As anticipated, Numeracy was also highly related to Year 10 Mathematics.

The correlation analysis also revealed that Effort had a relationship with the two Year 7 test results but, more importantly, was associated with Mathematics and English SC examination scores. These correlation coefficients were .44 and .39 respectively. What this finding suggests is that not only does ability (or a proxy for previous achievement) influence current performance in Mathematics and English, but general schoolwork effort can affect one's school performance at Year 10, the last year of compulsory schooling in NSW.

The ***second aim*** of the study was to examine the predictive capacity of the Year 7 tests and Effort, in relation to Year 10 Mathematics and English. Because the size of the

sample was small, only two independent variables were entered into the respective regression models. This meant that the ratio between the number of cases and the number of variables could remain greater than 20 to 1 (see, for example, Hair, Anderson, Tatham, & Black, 1998). Entry occurred using the hierarchical method and was linked to the predicted conceptual influence of the variables. As a consequence, Numeracy was entered initially in the first regression analysis and Reading was entered initially in the second regression analysis. It was evident in the results that the measures taken at Year 7 in Numeracy and Reading were clearly the main predictors of Year 10 achievement. To elaborate, Numeracy contributed 38.9% of the explained variance in SC Mathematics; whereas, Reading contributed 47.5% of the explained variance in SC English.

The contribution of Effort in the respective regression models varied. With relation to SC Mathematics, Effort explained over 13% of the total variance. This was a significant contribution indicating that the perceived effort expended by students during Year 10 can impact positively or negatively on their performance in the state-wide Mathematics examination. However, the finding with respect to SC English is not so encouraging. The contribution to the total explained variance was 4% and not significant. Taken together, these findings are at odds with the results reported by Ali and McInerney (2005) who found that the same measure of Effort had a significant effect on English rank across a mix of student cohorts but a non-significant relationship with mathematical attainment. Clearly, comparisons of this form can be misleading especially when the English and Mathematics test results used by Ali and McInerney spanned a number of school years and drew on data from other jurisdictions outside NSW.

The general schoolwork effort measure used in this study, and validated previously by Ali and McInerney (2005), has potential as an indicator of current and future school performance. The measure in this study had a moderate relationship with test results obtained a number of years earlier and some predictive capability with one compulsory Year 10 subject. On the basis of the results reported here, the measure could be utilised by mathematics teachers, learning support teachers, or school counsellors to appraise student effort levels. This appraisal could then feed into an individualised intervention for those identified as lacking in general schoolwork effort. Teachers might also be more confident in emphasising the importance of effort when talking to parents about their child's achievement.

There are two obvious limitations inherent in the current study. One, an observation of student effort, or information from teachers regarding student effort, was not included. In hindsight, a verification of the self-reported data would have improved the study's design. Two, only one school was sampled and the overall sample size was restricted. However, it was determined using Cohen's (1988) statistical power tables that there was adequate statistical power in the design to permit the use of multiple regression analyses. Future studies need to replicate and build on the current research by using government school students and students from other jurisdictions.

This present study is one of a few that has reported on the relationships between specific LANNA tests at any year level and, in addition, the relationship of these tests to later school achievements. It is critical that studies of this kind are undertaken as 'basic skills tests' across Australia have now become compulsory and any research information that has relevance to the new testing regime known as The National Assessment Program – Literacy and Numeracy (NAPLAN) needs to be widely available. Such research will be critical in evaluating the extent to which current information about schools, now available through the government's My School website, is a reliable predictor of student performance.

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Appendix

Effort Items:

1. I am always trying to do better in my schoolwork.
2. I work hard to try and understand new things at school.
3. I try hard at school because I am interested in my work.
4. I try to make sure that I am good at my schoolwork.
5. The harder the problem, the harder I try.
6. When I am improving in my schoolwork I try even harder.
7. I don’t mind working a long time at schoolwork that I find interesting.