Attitudes To Science: Part Of The Puzzle To Improve Educational Achievement?

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ABSTRACT

This paper examines the relationship between attitudes to learning science and science achievement in South Africa. TIMSS 2011 science achievement data and science attitudinal indices of enjoyment, valuing science and self-confidence in ability to learn science, are used to examine this. All three indices were found to contribute significantly to the science performance of Grade 9 learners. The findings highlight the need to focus on the non-cognitive aspects in educational interventions in order to improve science achievement in the country.

INTRODUCTION

This paper investigates the association between South African students' attitudes towards science and their science achievement. The 2011 Trends in International Mathematics and Science Study (TIMSS) highlighted that South African Grade 9 students perform poorly in science, with 75% of students achieving below the minimum achievement levels (Reddy et al., forthcoming). This has serious implications for the potential production of human capital in the country, as poor performance at this level prevents students from pursuing science related subjects and occupations in the future. Globally, there is a growing body of research which seeks to identify the factors that affect educational achievement in general; and science achievement in particular (Case and Dean, 1999; Carnoy and Arends, 2012). The focus of the majority of the research has been on the cognitive domain (intelligence); however the research agenda has expanded to include non-cognitive aspects, which encompass personality, social and emotional traits (Heckman, 2000; Cunha et al, 2010). This paper expands on the research focusing on non-cognitive aspects by determining whether attitudes can explain the variance in the science achievement of South African Grade 9 students.

LITERATURE REVIEW

Research into the factors that affect academic achievement reveals a mixed set of results. Amongst the most important predictors of achievement are factors such as gender; socio-economic status (SES); age; home, parental and peer groups; and schools, teachers and school curricula. Gender has been associated with differences in achievement. This relationship, however, differs internationally and has been attributed to cultural variations in opportunity structures for females (Else-Quest et al, 2010). In addition, gender differences have been found when considering attitudes and achievement jointly (Steinkamp and Maehr, 1984). Socio-economic differentials play a role in the educational outcomes of South African students, as students in the richest quintile of schools outperform schools in the other four quintiles substantially (van der Berg, 2008). Parental involvement and attitudes are further important factors, as students from family environments where their parents highly value science are more likely to demonstrate higher achievement in science (Perera et al, 2014).

In addition to the extensive research that highlights the importance of cognitive skills, or intelligence, in producing educational success, research is emerging which demonstrates the importance of non-cognitive skills. Most research emerges from education and social psychologists studying individuals' motivation, values, interests and attitudes (Chang and Cheng, 2008; Hassan, 2008). Economists (Heckman, 2000; Borghans et al, 2008) have also analysed large datasets to explore the relationship between the cognitive and the non-cognitive domains.

Evidence suggests that while both cognitive and non-cognitive traits evolve over the lifecycle, non-cognitive skills can be influenced successfully later in life (Borghans et al, 2008). Social policy focusing on non-cognitive traits, such as attitudes, may therefore be effective in addressing low educational achievement. Policy makers and researchers recognise that fostering positive attitudes of students toward science could be a crucial component in developing their science ability (George, 2006).

Students' commitment and motivation to learn science can be affected by whether they enjoy the subject, place value on the subject in terms of its use to themselves and society, and by their self-confidence in their own ability to perform a particular task (Hassan, 2008). A review of the achievement-attitude literature reveals a mixed set of results: some finding positive (moderate) correlations between achievement and attitudes (George, 2006;

Hattie 2009), while others have concluded that there is no definitive relationship between the two, or that they are weakly correlated (Abu-Hilal, 2000). A number of studies have also acknowledged that the relationship between achievement and attitudes is bi-directional with each mutually affecting the other (Chang and Cheng, 2008).

METHODOLOGY

Forty seven countries participated in the TIMSS 2011 assessment at the Grade 8 or 9 level (Martin et al, 2012). For South Africa, previous rounds of TIMSS at the Grade 8 level produced estimation errors at the lower achievement levels. To reduce the proportion of students with scores that are too low for estimation, and to increase the validity and reliability of the measures, South Africa participated at the Grade 9 level from 2002. The 2011 sample consisted of 11,969 students in 298 schools using stratified random sampling. Achievement was measured out of a possible 1000 scale points, with a centre point set at 500 (SD=100). A number of items included in the instruments relate to student attitudes to science. Students were scored according to their agreement with specific statements. These items were used to construct three attitudinal indices: enjoyment of science; value of the utility of science and self-confidence in ability to learn science. These scores were converted to scale scores with a centre point set at 10. These values were converted to z scores (i.e., zero mean, unit variance, Gaussian distributions) for the purposes of this study. Multiple regression analysis was used to investigate the effects that exhibiting a particular attitude towards science has on the performance of Grade 9 students in science. The aim was to identify and investigate the quantitative effect of independent variables upon science performance as the dependent variable, while controlling for age, sex, parental involvement and socio-economic status. Appendix 1 describes the variables used in the analysis.

RESULTS

Table 1 sets out the range, mean and standard deviations of the constructed indices. On average, the most positive attitude is associated with valuing science (M=10.69, SD=1.95). Students exhibited lower levels of self-confidence in their ability to learn science than the other attitudinal indices (M=10.08, SD=1.67). This index also exhibited the widest range of scores.

Table 2 represents the results of the multiple regression analysis conducted to test if attitudes significantly predict overall science performance. This model accounted for 31% of variance in science achievement (adjusted r^2 = 0.31). After controlling for all the variables in the model, achievement scores were 0.4 of a SD below the TIMSS centre point.

It is evident that all three attitudinal indices contributed significantly to the dependent variable. With regards to overall achievement, enjoyment had the largest positive relationship as each scale score point increase in enjoyment of science was associated with a 24 point increase in the science achievement score (ß= 24.6, p< 0.01). This was followed by self confidence in learning science, where the corresponding increase in self-confidence was associated with a 10 point science achievement increase (ß=10.76, p< 0.01). Interestingly, each scale score point increase in valuing science was associated with a 15 point decrease in achievement (ß=-14.92, p< 0.01).

DISCUSSION

The findings indicate that although students exhibited a more positive attitude in terms of valuing science, this did not translate into better science achievement. This may be a result of weaker students being made aware of the value of science, with a view to encouraging better achievement or perseverance in the subject. This ties in with the large negative association between parental involvement and achievement; as the parents of weaker students are more likely to be involved in their children's school work. This may also indicate that valuing science alone is not enough to inspire students to strive for better science achievement.

Despite the finding that students show lower levels of confidence in their ability to learn science, self-confidence was found to be positively associated with achievement, indicating that students are aware of their academic abilities. Higher levels of enjoyment, which had the highest association with science achievement, and self-confidence, may therefore translate into more effort being put into learning and understanding school science.

IMPLICATIONS

The link between attitudes (non-cognitive aspects) and achievement (cognitive aspect) is evidently complex, and the South African results for enjoyment and self-confidence corroborate the

Table 1: Descriptive statistics of attitudes towards science

	Min	Max	Mean	SD	SE
Enjoyment	4.51	12.94	10.37	1.83	0.04
Value	4.13	13.10	10.69	1.95	0.05
Confidence	3.09	14.97	10.08	1.67	0.03

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Table 2: Results of multiple regression analysis on the effects of attitudes on science achievement

Regression variable	Regression coefficient (ß)	Regression coefficient SE	Regression coefficient (t-value)	Standardized coefficient	Standardized coefficient SE	Standardized coefficient (t value)	p
Enjoyment	24.6	1.58	15.59	.22	.01	16.62	<0.01
Value	-14.92	1.96	-7.62	-.13	.02	-7.53	<0.01
Confidence	10.76	1.66	6.49	.09	.01	6.49	<0.01
Sex	-10.7	3.42	-3.13	-.05	.01	-3.16	<0.01
Age	111.89	28.11	3.98	1.18	.28	4.15	<0.01
Age^2	-4.27	.87	-4.92	-1.47	.28	-5.21	<0.01
Socio economic status	17.87	1.37	13.04	.29	.02	14.45	<0.01
Parental involvement	-49.07	5.07	-9.68	-.15	.01	-10.00	<0.01
Constant	-456.9	229.58	-1.99				

international literature, finding a positive relationship. The preceding discussion indicates that value alone is not a strong enough attitude to ensure that students perform well in science; highlighting the need to focus on encouraging the enjoyment of science, as well as building students self-confidence in their ability to learn science.

While the paper reports on the measures of attitudes and its relationship to achievement, these are blunt measures and do not indicate how such attitudes were developed in students and how they can be changed. In order to formulate social policy focusing on non-cognitive traits, such as attitudes, to address low educational achievement, deeper analysis is required which takes into account the inequality in the South African education system. This would then provide the means to design the appropriate policy interventions to change learning behaviours in order to improve science achievement in South Africa.

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Appendix 1: Description of variables

Variable	Description
Enjoyment	Index created from the following statements: "I enjoy learning science"; "I wish I did not have to study science"; "Science is boring"; "I learn many interesting things in science" and "I like science." Scale scores were converted to z scores.
Value	Index created from the following statements: "I think learning science would help me in my daily life"; "I need science to learn other school subjects"; "I need to do well in science to get into the university of my choice"; "I would like a job that involves using science"; "I need to do well in science to get the job that I want" and "It is important to do well in science." Scale scores were converted to z scores.
Confidence	Index created from the following statements: "I usually do well in science"; "Science is more difficult for me than for many of my classmates"; "Science is not one of my strengths"; "I learn things quickly in science"; "I am just not good at science"; "My teacher tells me that I am good at science" and "Science is harder for me than any other subject." Scale scores were converted to z scores.
Sex	Indicated by "male= 0" or "female= 1"
Age	Measured in years and months
Age^2	Age squared to account for the non-linear relationship between age and science achievement.
Socio economic	Index created from the following variables: parental education level, number of books in the home, the presence of study supports.
Parental Involvement	Indicated by: "parents check homework=1" or "parents do not check homework=0"

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