The gap between advantaged and disadvantaged students in science achievement in South African secondary schools

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South Africa's education system is still deep in the throes of reform under its third Minister of Education since 1994. Poor communities, in particular those of rural Africans, bear the brunt of the past inequalities. The challenge was to explore the extent of the ''gap'' in students' scores by comparing the advantaged and disadvantaged communities in this context. The TIMSS-Repeat 1999 data were explored and 3 categories of students were ultimately identified: advantaged, semi-advantaged, and disadvantaged groups. Partial least squares analysis was applied to explore the science performance but very few factors were found that consistently predicted performance across and within these groups. However, one dominant factor emerged in these models and that was the students' performance in the locally developed English test that provided a measure of students' proficiency in English, the language in which more than 70% of the students wrote the science tests. Students who had a higher score on the English test also performed better in the science test, despite their backgrounds.

Keywords: South African science factors; South African science achievement; location of school; advantaged students; disadvantaged students

Introduction

South Africa's education system is still deep in the throes of reform under its third Minister of Education since 1994. However, it is marked by underachievement of students at each level of the system. Poor communities, in particular those of rural Africans, bear the brunt of the past inequalities, and these continue to be reflected in the national results of the final year examinations in Grade 12. Equity and access top the South African government's priority list for the country's education system, which accommodates approximately 12.3 million students (50.5% female). Access to education has improved to the extent that primary education is almost universal. However, only 86% of South African students are enrolled in secondary school, even though education in South Africa is compulsory and supposed to be free for Grades 1 to 9 (Grade 8 is the first grade of most secondary schools). Students are expected to pay fees only for Grades 10 to12, but educational user fees are widespread across all the grades.

South Africa participated in TIMSS 1995, 1999, and 2003. Secondary analyses of these studies have revealed the large inequities in the education system, with 55% of the variance in students' mathematics scores explained by differences between schools (Howie, 2002). This variance, in turn, is mostly explained by the historical inequities imposed on communities and schools over the 40 years prior to 1994. The challenge is to explore the extent of the ''gap'' in students' scores by comparing the advantaged and disadvantaged communities in this context. The former include well-resourced, largely urban schools; the latter include largely underresourced, mostly African rural schools. Previous work conducted for mathematics performance pointed to crucial student-level factors such as language, socioeconomic status, perceptions of mathematics, attitudes towards mathematics, and self-concept (see Howie, 2002). In this paper, the focus is on performance in science and the predictors of this performance across three groups. The three groups of students, classified on the basis of their background characteristics, are advantaged, semiadvantaged, and disadvantaged.

The paper aims to ascertain the extent to which the previously mentioned factors (for mathematics) in the TIMSS-R (1999) (from here on known as TIMSS 1999) data may also have an effect on science achievement and to what extent other factors play a role. The aim is to identify prominent relationships between science factors and science achievement. Specifically, the following research questions are addressed:
(1) To what extent does the location of the school have an effect on the performance of students in science?
(2) How do students from advantaged and disadvantaged backgrounds compare in their science performance?
(3) What other factors have an effect on the performance of South African students in science?

The paper is structured in the following manner. The next section provides an overview of previous research on the topic. The third section presents the conceptual framework for this research. The fourth section provides a brief description of the research design and methods. The main findings are presented in the fifth section, and this is followed by conclusions and implications for further research.

Previous research conducted on factors related to science performance

The 21st century beckoned a new era with many possibilities. However, it was estimated that at the end of the 20th century about 140 million people in sub-Saharan Africa could not read or write. Amongst the 47.4 million people (South Africa.info, 2006) of South Africa's multicultural society, approximately 4.5 million adults older than 20 years have received no education (Statistics South Africa, 2001), which can be attributed to the decades of Apartheid – abolished in 1994 – policies implemented under the nationalist government of South Africa. These separatist policies forced cultural groups apart under the guise of separate development. The education system became divided, with children of each race group attending schools separated on the basis of these racial groupings. Schools for White children received more funding than others, had better facilities, were better equipped, and had better qualified teachers (Alexander, Badenhorst, & Gibbs, 2005). Therefore, today, in addition to the other challenges facing the rest of Africa and other developing worlds, South Africa has to deal with a set of special circumstances.

However, the complexity and peculiarities of schools in general can be magnified by highly disadvantaged settings such as those evident in South Africa and other developing countries. There is a need to explore and disentangle the multiple associations and divergent outcomes derived from the same set of input variables. For example, qualifications and experience of the teacher relate to the quality of learning taking place, and inexperienced teachers and poorly qualified teachers tend to concentrate in certain geographic areas or schools serving students of particular socioeconomic backgrounds (Mabogoane, 2004).

Cross-national research at the student level indicates that many antecedent factors, such as students' home background and their age, religion, and gender, in addition to the type of school they attend and the locality of that school, affect student achievement in science, particularly in Trinidad and Tobago (Kutnick & Jules, 1988). Lockheed and Zhao (1993) found, after keeping constant students' socioeconomic status (SES), age, and gender, significant differences in achievement among students attending different types of schools in the Philippines. Young (1998) found that the location of schools in Western Australia had a significant effect on the performance of students attending them. Students from rural areas performed less well than their counterparts in urban areas. Research by Van der Berg and Burger (2003) found the achievement of students from poor schools in the Western Cape (a province in South Africa) to be worse than that of students from other SES groups and population groups. A similar result emerged from the analysis of the TIMSS 1999 data as Martin, Mullis, Gonzales, et al. (2000) report, in that schools that were better resourced tended to obtain higher average achievement scores. The students attending the Western Cape schools were predominantly African and to a lesser degree Colored (of mixed race). Clearly, schools located in and drawing pupils from more affluent communities have more advantaged pupils attending the school and Martin, Mullis, Gregory, Hoyle, and Shen (2000) contend that home background and affluence in particular remain powerful predictors of science achievement.

There appears to be a consensus within the literature of racial/ethnic differences in students' science performance (see also Bacharack, Baumeister, & Furr, 2003; Ikpa, 2003; Von Secker, 2004). The literature also shows a relationship between racial/ethnic origin and SES.

Studies comparing the science achievement of students from different SES groups in the United States of America show that students from high-SES groups tend to outperform students from lower SES groups (see, e.g., Von Secker, 2004). The same picture emerges in South Africa, where students from lower SES groups obtain significantly lower scores than those from higher SES groups (National Department of Education, 2005). Here, SES is associated with possessions in the home and the expanded opportunities which the home environment provides to students (Von Secker, 2004; Yang, 2003). Parents' level of education, their occupations, and their aspirations for their children are also linked to SES (Tamir, 1989; Young & Fraser, 1990).

Many inconsistencies have been reported with regard to the effect of parental involvement on science achievement (see, e.g., McNeal, 2001). As McNeal shows, parental involvement is more effective for higher SES students than it is for lower SES students, but the mother's perception of her child's ability does affect the self-efficacy of the child (Bleeker & Jacobs, 2004). Parents' reinforcement of educational expectations and family involvement in educational activities has also been linked to performance in science (Onocha & Okpala, 1987). Parental involvement in educational activities includes taking an interest in school work and helping with homework.

Students who regularly have homework tend to perform better in science in the upper grades of school (Van Voorhis, 2003). Opportunities to learn and motivation have also been linked to science performance (Tamir, 1989). In an analysis of the Longitudinal Study of American Youth, Young, Reynolds, and Walberg (1996) found that attitudes towards science affect the performance of pupils in science. A similar result was obtained in a secondary analysis of the Cypriot TIMSS 1995 data conducted by Papanastasiou and Zembylas (2002). Finally, the literature suggests that gender influences science achievement, with boys generally performing better than girls in this subject (Bacharack et al., 2003; Dimitrov, 1999; Martin, Mullis, Gonzales, et al., 2000; Von Secker, 2004).

Conceptual framework

The conceptual framework for this study is based on one used by Howie (2002), who adapted it from a model developed by Shavelson, McDonnell, and Oakes (1987). The framework also draws on thinking in relation to the mathematics and science curriculum by the International Association for the Evaluation of Educational Achievement (IEA) (Travers & Westbury, 1989). The framework used in this study (and depicted in Figure 1) includes a number of adaptations to the original frameworks to better suit this secondary analysis of the TIMSS 1999 data.

The model shown in Figure 1 presents the education system in terms of inputs, processes, and outputs. The curricula for academic subjects play a central role in an education system. The IEA also considers curricula to be the key feature of any evaluation of educational achievement. This is reflected by their inclusion of curriculum-based, explanatory designs (IEA, 1998, p.32). The organization differentiates between the intended, the implemented, and the attained curriculum. The central positioning of the three curricula and their links between and among elements within the model illustrate this key role. The model also provides an important theoretical and conceptual basis for analysis of the TIMSS 1999 data. Because the data were collected at a number of education levels, namely, school, classroom, and student, the model also serves as a means of exploring, identifying, and/or confirming the reasons for differences in student achievement in science.

Research design and methods

This study is a secondary analysis of the South African data from the IEA's Third International Mathematics and Science Study–Repeat (TIMSS 1999), collected in 1998 (as was the case in all Southern Hemisphere countries). The data were explored to determine if there were significant differences among groups of students classified in terms of the relative advantage of their background and in order to provide possible explanations for the students' performance. The analysis identified factors that had a direct or indirect effect on science achievement of South African students.

Sample

The TIMSS 1999 sample for South African students was used for the analysis. A national sample of schools, stratified according to province, type of education (government or private), and medium of instruction (English and Afrikaans) was drawn. The data were obtained from 8,142 student achievement tests administered in English and Afrikaans and questionnaires, as well as from 189 school principals.

Instruments

The instruments included the TIMSS 1999 science achievement test, the student questionnaire, and the principal's questionnaire, although the only information considered for the analysis from the principal's questionnaire was school location. In addition to the TIMSS 1999 test and questionnaires, a locally developed English language test was also included. The English language test consists of multiple choice questions seeking to assess the sequencing and coherence skills with regard to sentences as well as spelling and basic grammar (Howie, 2002).

Data analysis

Descriptive statistics were generated to provide descriptive results and to prepare the data for further analysis. Further steps entailed preparing a correlation matrix in order to identify variables that were related, conducting reliability analysis to investigate the reliability of certain scales and building constructs for inclusion in a Partial Least Squares (PLS) analysis. Finally, in order to prepare a number of models for the purpose of comparison, indices were constructed for advantaged, semi-advantaged, and disadvantaged learners based on the socioeconomic status of each student, the possessions in the student's home (including number of books), and the language(s) used in the student's home. The limitation of analyzing subgroups is that the variance amongst the factors that could be important is reduced.

The PLS employed the software PLSPATH to explore and analyze those student-level factors (together with one variable from the school-level data, namely the location) that had an effect on students' achievement in science. For more details on the PLS, see Howie (2002).

Results

In this section, the main findings of the research are presented first in terms of the overall South African sample and thereafter for each of the groups classified in terms of their relative advantage in background.

Description of students in advantaged, semi-advantaged, and disadvantaged groups

The sample was divided into subsamples according to the criteria specified below. These were the advantaged group (n ¼ 225), the semi-advantaged group (n ¼ 3,656), and the disadvantaged group (n ¼ 4,151).

The majority of the South African sample was African (71%), and the ethnic/racial group with the lowest number of students in it was Indian (3%). None of the African students was in the advantaged category, and just over half of this group was Colored. The majority of the African students were classified as disadvantaged (86%), a finding consistent with the impact of South Africa's political history on this group (refer to Table 1).

Students in the advantaged group all spoke the language of the test in contrast to the 9% only of students from the disadvantaged group who spoke the language of the test (Table 2). More than 20% of students in the semi-advantaged and disadvantaged groups never spoke the language of the test.

Overall, as Table 3 shows, 40% of this sample achieved scores of 200 or below (out of 800 points), which is very low. Of the disadvantaged group, 44% scored in this range in contrast to 8% of the advantaged group. Sixty percent of the advantaged group attained scores between 401 and 500 out of 800, while the other groups performed substantially below this level (only 20% of the semi-advantaged and 6% of the disadvantaged groups attained scores higher than 400 points).

Predictors of science achievement for South African students

The students performed well below the international average for the science test (488 (SE .07)) (as well as for mathematics 487(SE 0.7)). They achieved an average score of 249 out of 800 points. There was a considerable difference in the mean ages of the students between the participating countries and the South African sample. The South African students were also the oldest in TIMSS 1999, with an average age of 15.5 years. However, after the TIMSS 1999 data were cleaned to investigate specific factors, it was found that the average age of the sample analyzed in this paper was actually 16 years.

As mentioned earlier, the South African students also wrote an English language proficiency test. The overall average score was 17 out of 40. Those students whose first language was English (n ¼ 533) or Afrikaans (n ¼ 1,281) achieved the highest marks on this test (means of 25 (SE 0.4) and 21 (SE 0.2) respectively out of 40). Children speaking indigenous African languages (n ¼ 5,496) achieved very low scores, with an average of 15 marks out of 40 (SE 6.5) on the test. Overall, the scores on this test showed the students, as a group, had low proficiency in English.

The overall statistics for the univariate analysis conducted for this paper are set out in Table 4. Originally, 22 factors were considered for inclusion in the student model. However, after trimming the model, only 18 factors (latent variables) remained, reflecting 19 manifest variables (see Appendix 1 for details). These factors were included in four models: the overall science model, the advantaged group model, the semi-advantaged group model, and the disadvantaged group model. However, in the final trimming, the location variable had no effect in any of the paths tested and was therefore removed from the overall model. This was not the case in the other three models, and therefore that variable remained in those models. The overall model is discussed below; the other three models are discussed in the following sections. The same variables were included for all four models and with the same patterns in order to explore the effects of the same variables overall and within different groups on performance in science.

The inner model results for the South African sample, including the direct, indirect, correlation, and total effects, are presented in Table 5. These inner model results provided the direct effects for the overall model.

Predicting the performance of advantaged students

The subsample of advantaged students was very small and comprised only 225 students (see Appendix 2). The performance of the advantaged students was significantly above that of both the other groups and of the overall performance (422 points (SD 144) compared to 248 points). The performance, however, of the students in the advantaged group on the English proficiency test was below expectation (23 out of 40 marks). This group, at 14.9 years, was also younger than the average for the South African sample (compared to 16 years).

Students in this group had many books at home and tended to speak English or Afrikaans at home, and they were also more likely to be Indian or White. They had most of the possessions listed for the index of SES.

The outer model results of the PLS analysis revealed that these results fell within the recommended parameters set for the loading, communality and tolerance. A number of relationships for the loading and communality were statistically significant providing confirmation of the strength of the model. To evaluate the strength of the inner model (see Table 6), 0.08 was regarded as the minimum acceptable coefficient to reveal a relationship. Any coefficient found below this was not regarded as having a relationship (see Howie, 2002).

Overall, 66% of the variance of the science score for this group could be explained by 14 factors. Of these factors, three had a direct effect on the science score. These factors were SES (7.35), self-concept in science (7.11), and (the most dominant factor) the English test score (.49). Several factors had an indirect effect, namely age (.10), language spoken at home (.14), and books in the home (7.09). SES, in addition to the direct effect, also had an indirect effect (7.17). Factors that had no effect, although tested, were ‘‘if science is important’’, language of learning, and location of the school.

The strength of the English test score far surpassed that of any other predictor and therefore was examined more closely than were the other predictors. Forty-eight percent of the variance of the English test score was explained by seven factors, of which five had direct effects. These were age, language spoken at home, SES, aspirations of students, and books in the home. The strongest predictor was SES and the only indirect effect observed was that of SES. The number of parents in the home and the location of the school had no effect on the English test score.

Predicting the performance of semi-advantaged students

The semi-advantaged students (n ¼ 3,656) achieved a score on the science test (264 points) that was above the national average (248 points). The score achieved for the English test was 17 marks (out of 40). Many of these students spoke an indigenous African language at home (by definition of the classification). The semi-advantaged students, on average, had more listed possessions than those in the disadvantaged group. They were also more likely to live in towns and cities.

The results of the PLS outer model met the criteria for all the parameters (refer to Table 6). The model explained 63% of the variance in the science score. Fourteen factors were included in the model, of which seven were tested for direct effects. Only four proved to have a direct effect (language spoken at home, SES (greater than .20), language of learning (.08), and (again the strongest effect) the English test score (.37). Language spoken at home and SES also had an indirect effect on the science score. No other factors had an indirect effect.

A closer look at the English test score revealed that 48% of the variance in the students’ English test score could be explained by seven factors in this model. Five factors had a direct effect (age, language spoken at home, SES, location of the school, and aspirations of students), with the strongest being SES (7.22). No indirect effects were found.

Predicting the performance of disadvantaged students

The disadvantaged students (n ¼ 4,151) achieved the lowest scores for science (224.5 out of 800) (see Appendix 2). This was also the case for the English test score (16 out of 40). These children tended to be older (15.6) than the mean age for the South African sample (15.5). By definition (of the classification), their home language differed from the medium of instruction and therefore was most likely to be one of the African languages. Children in this group were also more likely to come from rural areas than were the students in the other groups. They also had fewer books in the home and had fewer listed possessions in the home than the children in the other groups had.

As with the advantaged group, the PLS outer model results for the disadvantaged students proved to be similar and conformed to the set parameters (refer to Table 6).

The model for the disadvantaged students explained only 35% of the variance in the science score – much less than the variance explained in the other two groups. Of the 14 factors included in the model, seven had a direct effect (language spoken at home, SES, science is important, language of learning in the classroom, location of the school, selfconcept in science, and the English test score). Only one of these, the English test score, had a strong effect (.40). Age, language spoken at home, and location of the school had weak indirect effects on the science score.

It is worthwhile to examine the paths explaining the variance in the English test score, given the strength of its effect on the students' science achievement. Twenty-three percent of the variance was explained by the above seven factors, of which five had direct effects on the English score (age, language spoken at home, location of the school, aspirations of students, and books in the home). SES and number of parents in the home had no effect on the English score and no indirect effects were found for these factors.

Conclusions

The results from the mathematics-related data from TIMSS 1999 analyzed previously for South Africa (Howie, 2002) showed a strong relationship with location, English language proficiency, language of the home, SES, self-concept of the student (in terms of having difficulty with mathematics), and the importance that mathematics held for the student (according to mother, friends, and the student). The analysis in this paper revealed a similar pattern for science.

The performance of South African students in science, as in mathematics, was very low. The heavy reliance on text in the science test could have further exacerbated the poor performance in South Africa. This conclusion is based on the strong relationship between the English language proficiency test and the science scores. The pattern evident suggests a strong relationship between levels of advantage and performance in terms of the more advantaged the students, the better they tended to perform in science and on the English language proficiency test (see Table 7).

In terms of the predictors of science, the models that were applied uniformly across the groups revealed interesting differences among the groups (see Table 8). The models were able to explain high levels of variance for each model (above 50%), except for the disadvantaged group. In the case of the latter, it is clear that the factors that were included are too limited for this group, although there could also be a bottom effect due to the extremely low scores attained by this group. Further exploration of this group is needed to fully understand which factors predict achievement in conditions that are most disadvantaged. However, one factor remains consistent across all groups, and that is the English test score. It has been suggested previously that the strength of this factor could be a result of measuring intelligence or aptitude rather than language ability (Howie, 2002), although disentangling these factors could be rather difficult.

Given the language policy of and challenges in South Africa, the strength of the relationships found is not surprising. If children's access to science knowledge is denied through inadequate communication and comprehension skills, then poor conceptual understanding is inevitable and has disastrous consequences. However, this finding may in part explain the very low performance of South African students in science, particularly those students from disadvantaged backgrounds (as defined in this paper). The finding may also suggest that part of the solution in developing the sound knowledge and skills base of students in South Africa lies in interventions related to language at both the student level and the teacher level.

Final words

Few nationally representative studies (Tshabalala, 2007, is one of them) have been conducted in South Africa that have the aim of analyzing differences in rural–urban performance. The identification of predictors of science achievement is critical given the paucity of nationally generalizable data in South Africa. It is crucial to identify factors beyond the obvious inheritance of the Apartheid era that could significantly contribute to the advancement of science teaching and learning and that may also be invaluable to those involved in teacher education and development in the country.

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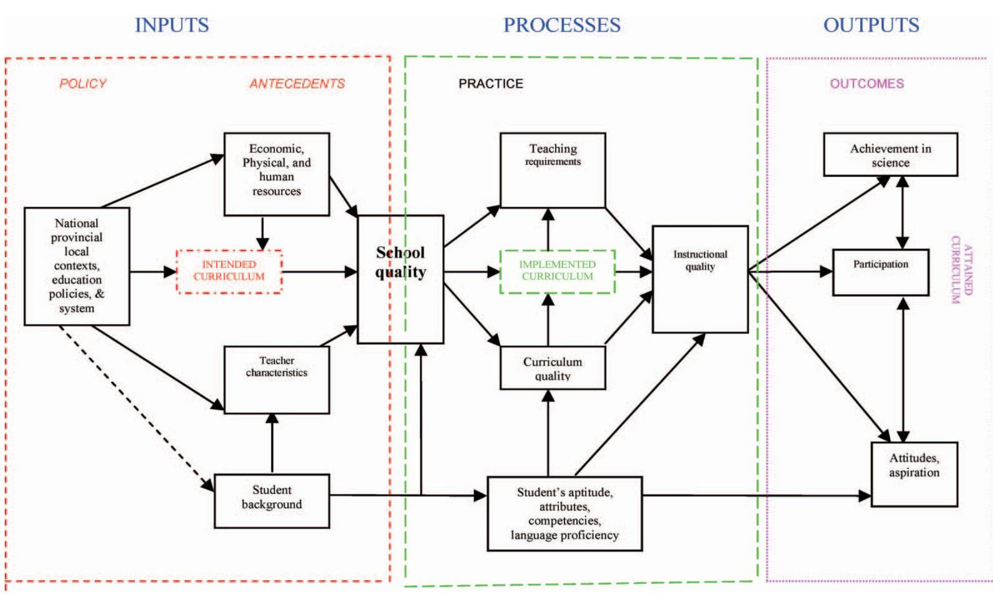

Figure 1. Factors related to science achievement.
Note: This model was used to explain mathematics achievement in Howie (2002), who adapted it from a framework developed by Shavelson et al., (1987).

Table 1. Distribution of students in advantaged, semi-advantaged, and disadvantaged groups by racial grouping.

Category	African	Asian	Colored	Indian	White
Advantaged	0%	0%	53%	4%	44%
Semi-advantaged	59%	1%	24%	4%	13%
Disadvantaged	86%	2%	5%	1%	6%
Overall percentage	**71%**	**1%**	**15%**	**3%**	**10%**

Note: The figures have been rounded off and in some cases may exceed 100%.

Table 2. Percentage of students and the frequency of students speaking the language of the test at home.

	Language of the Test Spoken at Home (%)		
Category	Never	Sometimes	Always or almost always
Advantaged	0	0	100
Semi-advantaged	23	38	39
Disadvantaged	22	68	9
Overall percentage	**22**	**52**	**26**

Table 3. Performance of the students by category.

	Achievement in Science within a Group (%)					
Category	0–200	201–300	301–400	401–500	501–600	601–800
Advantaged	8	13	19	27	25	8
Semi-advantaged	38	29	14	11	7	2
Disadvantaged	44	35	16	5	1	0
Overall percentage	**40**	**31**	**15**	**8**	**5**	**1**

Table 4. Univariate statistics for manifest variables included in the student model ($N = 8,142$).

Variable description	Variable	M	SD	Minimum	Maximum
Science score	bsssci01	248.82	132.24	5.00	775.40
English score	totscore	17.01	6.40	0.00	40.00
Dictionary	diction	1.25	0.43	1.00	1.00
Age	age_1	15.52	1.80	9.42	28.80
Extra lessons	lesson_1	1.21	1.10	0.00	4.00
Aspirations	selfed_1	3.90	1.42	1.00	5.00
Books in home	books	2.02	1.16	1.00	5.00
Success attribution	luck	1.99	0.99	1.00	4.00
Home language	homelang	1.31	0.60	0.00	3.00
Race of student	race_1	1.80	1.36	1.00	5.00
Language on radio	ralang_1	1.58	0.86	1.00	3.00
Maths is boring	bores_1	2.86	1.04	1.00	4.00
Possessions in home	posses10	14.44	2.48	10.00	20.00
No of Parents at home	parent	1.08	1.00	0.00	2.00
Self-concept in science	difsci	11.03	2.88	4.00	16.00
Attitude to science	sciimpt	10.22	1.98	3.00	12.00
Language of learning	lanlearn	5.10	1.45	2.00	7.00
Location of school	sccom_1	2.80	0.90	1.00	4.00
Attendance at school	attend	2.46	0.61	0.00	6.00
Student activities	studact	1.78	2.79	0.00	24.00

Table 5. The inner model that provided the direct effects for the overall model.

Latent Variable	Description of Variable	Direct	Total	Indirect	R-squared
ASPIRE	**Aspirations for future**				**0.02**
AGE	Age of student	−0.15	−0.15	–	
LANLEARN	**Language of learning**				**0.24**
LANG	Language spoken at home	0.49	0.49	–	
ATTEND	**Attendance at school**				**0.02**
AGE	Age of student	0.08	0.09	0.01	
ASPIRE	Aspirations for future	−0.08	−0.08	–	
SUCATTRB	**Attributions for success**				**0.50**
LANG	Language spoken at home	0.17	0.17	–	
SES	Socioeconomic status	–	−0.08	−0.08	–
ATTITUDE	**Attitude to science**				**0.02**
AGE	Age of student	−0.13	−0.14	−0.01	
ASPIRE	Aspirations for future	–	0.01	0.01	
ATTEND	Attendance at school	−0.07	−0.07	–	
SELFCNPT	**Self-concept in science**				**0.19**
AGE	Age of student	–	0.04	0.04	
ASPIRE	Aspirations for future	–	0.00	0.00	
LANG	Language spoken at home	0.06	−0.06	–	
SES	Socioeconomic status	–	0.03	0.03	
ATTEND	Attendance at school	–	0.02	0.02	
SUCATTRB	Attribution for success	−0.32	−0.32	–	
ATTITUDE	Attitude to science	−0.27	−0.27	–	
BOOK	**Books in the home**				**0.11**
SES	Socioeconomic status		−0.33	−0.33	–
ENGTEST	**English test score**				**0.38**
AGE	Age of student	−0.16	−0.18	−0.01	
ASPIRE	Aspirations for future	0.10	0.10	–	
LANG	Language spoken at home	0.39	0.39	–	
SES	Socioeconomic status	−0.19	−0.22	−0.02	
HOME	Number of parents at home	0.02	0.02	–	
BOOK	Number of books in home	0.08	0.08	–	
SCISCR	**Science score**				**0.54**
AGE	Age of student	–	−0.08	−0.08	
ASPIRE	Aspirations for future	–	0.04	0.04	
LANG	Language spoken at home	0.21	0.43	0.22	
SES	Socioeconomic status	−0.14	−0.24	−0.09	
HOME	Number of parents at home	–	0.01	0.01	
SCIIMPT	Science is important	0.03	0.03	–	
LANLEARN	Language of learning	0.11	0.11	–	
ATTEND	Attendance at school	–	0.00	0.00	
SUCATTRB	Attribution for success	–	0.03	0.03	
ATTITUDE	Attitude to science	–	0.02	0.02	
SELFCNPT	Self-concept in science	−0.09	−0.09	–	
BOOK	Number of books in home	–	0.03	0.03	
ENGTEST	English test score	0.42	0.42	–	

Note: Beta coefficients equal to and above .08 are regarded as significant relationships.

Table 6. Inner model for the subgroups of students.

Variable	Advantaged ($n = 225$)				Semi-advantaged ($n = 3{,}656$)				Disadvantaged ($n = 4{,}151$)			
	Direct	Total	Indirect	R-squared	Direct	Total	Indirect	R-squared	Direct	Total	Indirect	R-squared
LANLEARN				**0.02**				**0.37**				**0.06**
LANG	0.15	0.15	–		0.61	0.61	–		0.23	0.23	–	
ASPIRE				**0.02**				**0.02**				**0.03**
AGE	−0.14	−0.14	–		−0.13	−0.13	–		−0.15	−0.15	–	
LOCATION	0.04	0.04	–		0.04	0.04	–		0.05	480.00	–	
SUCATTRB				**0.10**				**0.08**				**0.12**
LANG	0.11	0.11	–		0.13	0.13	–		0.05	0.05	–	
SES	−0.23	−0.23	–		−0.16	−0.16	–		−0.03	−0.03	–	
LOCATION	0.04	0.04	–		0.02	0.02	–		0.07	0.07	–	
ATTEND				**0.08**				**0.02**				**0.01**
AGE	0.23	0.25	0.02		0.08	0.09	0.01		0.07	0.08	0.01	
LOCATION	–	−0.01	−0.01		–	0.00	0.00		–	0.00	0.00	
ASPIRE	−0.13	−0.13	–		−0.08	−0.08	–		−0.08	−0.08	–	
ATTITUDE				**0.01**				**0.02**				**0.03**
AGE	−0.10	−0.10	0.00		−0.12	−0.13	−0.01		−0.14	−0.15	−0.01	
LOCATION	–	0.00	0.00		–	0.00	0.00		–	0.00	0.00	
ASPIRE	–	0.00	0.00		–	0.01	0.01		–	0.01	0.01	
ATTEND	0.00	0.00	–		−0.07	−0.07	–		−0.08	−0.08	–	
SELFCNPT				**0.21**				**0.20**				**0.16**
AGE	–	0.02	0.02		–	0.03	0.03		–	0.04	0.04	
LANG	–	−0.04	−0.04		–	−0.04	−0.04		–	−0.02	−0.02	
SES	–	0.08	0.08		–	0.05	0.05		–	0.01	0.01	
LOCATION	–	−0.02	−0.02		–	−0.01	−0.01		–	−0.02	−0.02	
ASPIRE	–	0.00	0.00		–	0.00	0.00		–	0.00	0.00	
SUCATTRB	−0.35	−0.35	–		−0.33	−0.33	–		−0.29	−0.29	–	
ATTEND	–	0.00	0.00		–	0.02	0.02		–	0.02	0.02	
ATTITUDE	−0.25		−0.25		−0.28	−0.28	–		−0.26	−0.26	–	
BOOK				**0.84**				**0.17**				**0.16**
SES	−0.92	−0.92	–		−0.44	−0.44	–		−0.39	−0.39	–	
LOCATION	−0.01	−0.01	–		−0.05	−0.05	–		0.04	0.04	–	
ENGTEST				**0.48**				**0.48**				**0.23**

(continued)

Table 6. (*Continued*).

Variable	Advantaged (n = 225)				Semi-advantaged (n = 3,656)				Disadvantaged (n = 4,151)			
	Direct	Total	Indirect	R-squared	Direct	Total	Indirect	R-squared	Direct	Total	Indirect	R-squared
AGE	−0.17	−0.19	−0.02		−0.12	−0.14	−0.01		−0.20	−0.21	−0.02	
LANG	0.27	0.27	–		0.39	0.39	–		0.21	0.21	–	
SES	−0.49	−0.33	0.16		−0.22	−0.22	0.00		−0.07	−0.11	−0.04	
HOME	0.05	0.05	–		0.01	0.01	–		0.02	0.02	–	
LOCATION	0.07	0.07	0.01		0.10	0.10	0.00		0.19	0.20	0.01	
ASPIRE	0.15	0.15	–		0.09	0.09	–		0.10	0.10	–	
BOOK	−0.18	−0.18	–		0.01	98.00	–		0.10	0.10	–	
SCISCR				**0.66**				**0.63**				**0.35**
AGE		–			–	−0.05	−0.05		–	−0.09	−0.09	
LANG	−0.02	0.12	–		0.20	0.40	0.20		0.09	0.20	0.11	
SES		−0.35	–		−0.22	−0.30	−0.09		−0.10	−0.14	−0.04	
HOME	–	0.03	–		–	0.00	0.00		–	0.01	0.01	
SCIIMPT	−0.01	−0.01	–		0.00	0.00	–		0.08	0.08	–	
LANLEARN	0.05	0.05	–		0.08	0.08	–		0.09	0.09	–	
LOCATION	0.04	0.08	–		0.03	0.06	0.04		0.09	0.17	0.08	
ASPIRE	–	0.07	–		–	0.04	0.04		–	0.04	0.04	
SUCATTRB	–	0.04	–		–	0.02	0.02		–	0.03	0.03	
ATTEND	–	0.00	–		–	0.00	0.00		–	0.00	0.00	
ATTITUDE	–	0.03	–		–	0.02	0.02		–	0.03	0.03	
SELFCNPT	−0.11	−0.11	–		−0.07	−0.07	–		−0.11	−0.11	–	
BOOK	–	−0.09	–		–	0.00	0.00		–	0.04	0.04	
ENGTEST	0.49	0.49	–		0.37	0.37	–		0.40	0.40	–	

Table 7. Performance in science and English overall and within groups.

	Advantaged		Semi-advantaged		Disadvantaged		Overall	
	Score	*SD*	Score	*SD*	Score	*SD*	Score	*SD*
Science score out of 800	422	144	264	145	224.5	107	249	132
English score out of 40	23.5	7.8	17	6.9	16	5.5	17	6.4

Table 8. Predictors of science score overall and within groups.

	Advantaged	Semi-advantaged	Disadvantaged	Overall
***R*-squared**	0.66	0.63	0.35	0.54
Language spoken at home	X	0.20	0.09	0.21
SES	−0.35	−0.22	−0.10	−0.14
Science is important	X	X	0.09	X
Language of learning	X	0.08	0.09	0.11
Location of school	X	X	0.09	X
Self concept in science	X	X	- 0.11	0.09
English test	0.49	0.37	0.40	0.42

Note: X indicates that no relationship was found.

Appendix 1. Latent and manifest variables included in the student-level PLS analysis.

Latent variables	Manifest variables	TIMSS-R variables	Description	Scoring
SCISCR	SCIEN	BSSSCI01	Student mean score on TIMSS-R science test	Score out of 800 points
ENGTEST	TOTSCORE	N/a	Student mean score on English language proficiency test	Score out of 40 points
RACE	RACE_1	POPULAT	Race of student: African, Asian, Colored, Indian, White	1. African 2. Asian 3. Colored 4. Indian 5. White
AGE	AGE_1	BSGAGE	Age of student	Number of years
	RALANG_1	RADIO	Language on favorite radio station	1. All other languages 2. Afrikaans 3. English

(*continued*)

Appendix 1. (*Continued*).

Latent variables	Manifest variables	TIMSS-R variables	Description	Scoring
LANG	HOMELANG	INGUA	Language spoken most often at home	0. Other languages 1. African languages 2. Afrikaans 3. English –
HOME	PARENT (COMPOSITE)	GENADU1, 2, 5, 6	Whether students have two parents	0. no 1. yes
	BOOKS	BSBGBOOK	Number of books in the home	1. 0–10 2. 11–25 3. 26–100 4. 101–200 5. more than 200
BOOK	DICTIONARY	BSBGPS04	Availability of dictionary in home	0. no 1. yes
SES	POSSES10 (COMPOSITE)	BSBGPS02, 5–14	Computer, electricity, tap water, TV, CD player, radio, own bedroom, flush toilets, car (9 items)	0. no 1. yes
LANLEARN	LANLEARN (COMPOSITE)		Extent to which both student and teacher speak language of instruction in science class	1. Language spoken at home if not English/ Afrikaans 2. Sometimes English/ Afrikaans 3. Most of the time English/ Afrikaans 4. Always English/ Afrikaans
SCIIMPT	SCIIMPT (COMPOSITE)	BSBGMIP2 BSBGSIP3 BSBGFIP2	Extent to which students, mother, friends think that science is important (3 items)	Scale of (+) 1–4 (−) strongly agree to strongly disagree
ASPIRE	SELFED_1	GENEDSE	Aspirations to education	1. Some secondary 2. Finished secondary 3. Finished technikon

(*continued*)

Appendix 1. (*Continued*).

Latent variables	Manifest variables	TIMSS-R variables	Description	Scoring
				4. Some university 5. Finished university
ATTEND	ATTEND (COMPOSITE)	BSBGSSKP BSBGFSKP	Extent to which student or students' friends bunk school (2 items)	Scale of 0–4 (−) never, once or twice, three or four times, five or more. Recoded to 0–6.
SELFCNPT	DIFSCI	SCIMYT_1–5	The extent to which student reports having difficulty with science (5 items)	Scale of (−) 1–4 (+) Strongly agree to strongly disagree
SUCATTRB	LUCK	MATHDOW2	If the student attributes success to luck	Scale of (−) 1–4 (+) Strongly agree to strongly disagree
ATTITUDE	BORES	SCIBORE	If student finds science boring	Scale of (−) 1–4 (+) Strongly agree to strongly disagree
LOCATION	LOCATION	BCBGCOMM	Type of community	1. A geographically isolated area 2. Village of rural (farm) area 3. One on the outskirts of a town/city 4. One close to the centre of a town/city
EXTRA LESSONS	LESSON_1	BSBSEXTR	Extra science lessons outside school	1. No time 2. Less than 1 hour 3. 1–2 hours 4. 3–5 hours 5. More than 5 hours
ACTIVITIES	STUDENT ACTIVITIES (COMPOSITE)	BSBSTEST BSBSPROJ BSBSWSHT BSBSHWTC BSBSHWFC BSBSHWDS BSBSEVLF BSBSSGRP	Student active in group or class non-traditional	Scale of (+) 1–4 (−) never, once in a while, pretty often, almost always. Combined scale of 0–24

Appendix 2. Univariate statistics of factors from PLS models per subgroups.

Variable	Advantaged ($n = 225$)		Semi-advantaged ($n = 3,656$)		Disadvantaged ($n = (4,151)$)	
	M	*SD*	*M*	*SD*	*M*	*SD*
bsssci01	421.81	144.18	264.02	145.32	224.51	106.67
totscore	23.55	7.86	17.50	6.92	16.17	5.46
diction	1.11	0.31	1.30	0.46	1.22	0.41
age_1	14.92	1.06	15.44	1.75	15.63	1.87
lesson_1	0.52	0.87	1.11	1.10	1.32	1.08
selfed_1	4.21	1.27	3.90	1.41	3.83	1.45
books	3.78	1.60	2.27	1.30	1.66	0.76
luck	2.61	1.00	2.03	1.01	1.87	0.95
homelang	2.17	0.37	1.45	0.65	1.14	0.47
race_1	3.91	0.98	2.11	1.46	1.40	1.07
ralang_1	2.57	0.56	1.68	0.87	1.43	0.80
bores_1	3.10	0.86	2.83	1.02	2.85	1.07
posses10	13.13	3.16	15.31	2.89	13.74	1.64
parent	1.52	0.85	1.11	0.99	1.02	1.00
difsci	9.43	2.98	10.94	2.91	11.22	2.80
sciimpt	1.75	3.00	10.21	1.90	10.23	2.05
lanlearn	6.64	0.91	5.28	1.53	4.82	1.30
sccomm_1	3.22	0.85	2.67	0.90	2.89	0.89
attend	1.52	1.50	1.43	1.50	1.43	1.48
studact	14.08	5.12	15.35	5.08	16.12	5.19