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The Big-Fish-Little-Pond Effect on Grade 9 Leaners in South Africa

Chad Fourie[1] and Debra Shepherd[2]

Abstract

Effective schooling remains a challenge in many countries, including South Africa. In addressing this challenge, a focal area is often neglected: student emotional wellbeing. Self-concept is defined as the perception of one's ability, as well as motivation and academic enjoyment, and is a multi-dimensional concept used in studies of individual's behaviour. One such dimension is academic self-concept (ASC), the process by which students perform social and academic comparison within and between classrooms. ASC is associated with the social context and comparative nature embedded in schools and classrooms. It is for this reason that ASC is often used to explain the Big-Fish-Little-Pond effect (BFLPE). The BFLPE hypothesizes that higher-achieving students' academic self-concept can be negatively influenced when surrounded by similarly high-achieving peers, but positively influenced when surrounded by lower-achieving peers. This paper adds to the literature on the BFLPE in assessing the relationship between ASC and South African Grade 9 achievement in mathematics and science using the 2015 wave of the Trends in International Mathematics and Sciences Study (TIMSS). This dataset was chosen as it makes use of standardized assessments in mathematics and science, with the addition of a student questionnaire making use of Likert-type response questions related to student perceptions on relative standing and ability, subject enjoyment, as well as student motivation. These responses were captured using polychoric principal component analysis (PCA) to allow for the construction of three separate self-concept constructs: subject self-concept, extrinsic motivation, and subject-specific enjoyment. A multilevel modelling approach was adopted to capture the relationship between self-concept and achievement at a within- and across-classroom level. In addition to estimating random intercept and slope models, a cross-level interaction model was estimated to allow for the within-classroom relationship to differ by school socio-economic status. The results of the model indicate moderate-to-strong positive correlations between the three constructs, with all three were being positively related to achievement in mathematics and science. Concurrent with existing findings, this paper finds that each of the three constructs present varying degrees or relation to academic achievement in the wealthier and poorer subset of schools.

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1. Introduction

Education is fundamental to the development and welfare enhancement of an economy. Furthermore, it plays a crucial role in securing social progress and improving the distribution of income. However, the universal provision of quality education and effective schooling remains a challenge in many countries, including South Africa. In addressing this challenge, focal areas for educational development have centred around curriculum, the expansion of school resources, and teacher development and training. And, whilst these areas are justifiably important for academic development, a focal area is often neglected: student emotional wellbeing. In a country such as South Africa, where the divide in performance is highly correlated along racial, geographical and socioeconomic lines, students' poor performance could be attributed to a lack of motivation and enjoyment in an environment that fails to address these inequalities.

The perception of one's ability and, relatedly, motivation and academic enjoyment play a key role in determining individual success. This perception is often termed as self-concept, which Baumeister (1990) defines as "the individual's belief about himself or herself, including the person's attributes and who and what the self is". Although originally theorised to be a unidimensional construct (Rosenberg, 1965), an extensive number of empirical evaluations during the 1980s identified clear, a priori facets of self-concept (for example, Dusek & Flaherty, 1981; Harter, 1982; Marsh, 1987; Marsh, 1984; Marsh, Barnes & Hocevar, 1985). Subsequently, self-concept has been recognised as a multi-dimensional knowledge structure of the self that reflects an individual's multiple roles and experiences (Marsh, 1990). One such dimension is academic self-concept (ASC).

Academic self-concept (ASC) inherently involves a process of social comparison; it is associated with the social context and social cues embedded in schools and classrooms. As argued by Marsh (1986), "[G]roup membership influences the values and standards of performance used by individuals in their self-evaluations" (p.8). It is for this reason that ASC is often used to explain the *big-fish-little-pond* effect (BFLPE). Specifically, BFLPE denotes that higher-achieving students' self-concept can be negatively influenced when surrounded by similarly high-achieving peers. Much of the research that has focused on ASC and the BFLPE has been carried out in Western and OECD countries, with very little attention paid to low- and middle-income countries (LMICs). In fact, to the author's knowledge, no research on the BLFPE has been conducted in the sub-Saharan African context.

This paper aims to add to the literature on the BLFPE through empirically assessing the relationship between academic self-concept and Grade 9 test performance in mathematics and science in South Africa using the 2015 wave of the Trends in International Mathematics and Sciences Study (TIMSS). This dataset was specifically chosen as in addition to standardized assessment data in mathematics and science, Likert-scaled responses to items related to student perceptions of relative and absolute performance, as well as subject enjoyment and motivation are captured in the student contextual questionnaire. Polychoric principal component analysis (PCA) of these items allowed for three separate constructs of subject self-concept, extrinsic motivation and enjoyment to be created. A mixed (multilevel) modelling approach is adopted that allows for the relationship between self-concept and performance to be compared within and across classrooms. In addition to estimating random intercept and random slope models, a cross-level interaction model is estimated that allows for the within-group relationship between self-concept and performance to differ by school wealth (socio-economic status).

The results of the estimated models indicate moderate-to-strong positive correlations between the three constructs, confirming their inter-related and reinforcing nature. As excepted, all three constructs are significantly and positively related to achievement, with mathematics self-concept seemingly more strongly related to achievement than science self-concept. In line with existing evidence of a bimodal distribution of schooling outcomes in South Africa (Van der Berg, 2008; Fleisch, 2008; Spaull, 2013), this paper finds that each of the three constructs present varying degrees of relation to academic performance—within and across classrooms—in the wealthier and poorer subsets of schools. For example, extrinsic motivation presents little to no returns to mathematics achievement in wealthier and above-average performing classrooms and schools, but high returns to achievement in poorer performing schools.

The remainder of this paper is structured as follows. First, a conceptualisation and review of the existing literature on self-concept and the Big-Fish-Little-Pond effect is presented in section 2. This is followed by a description of the data and measures used in section 3. Section 4 and section 5 present the methodological approach followed and empirical results, respectively. Finally, a discussion of the main findings and concluding remarks are provided in section 6.

2. Literature Review

2.1 Self-Concept in the Academic Domain

Perceptions regarding one's own ability, or self-concept, in certain domains is becoming an increasingly important topic when addressing individual performance (Marsh & Hau, 2003). This paper specifically focuses on academic self-concept (ASC), which is a category of self-concept that relates to academic performance and the perception of one's own academic ability

(Dicke et al., 2018). Academic self-concept has been identified as critical for educational success (Marsh & Hau, 2003; Marsh & Craven, 2006; Dicke et al., 2018). Much of the earlier research (see Caslyn & Kenny, 1977; Brooker & Lawrence, 2007) originally hypothesised the relationship between the two as unidirectional; that is, ASC determines future academic achievement (self-enhancement model) or academic achievement determines future ASC (skills development model). However, a Reciprocal Effects Model (REM) (Marsh, 1990; Marsh & Craven, 2006) is now favoured that allows for prior academic achievement to predict future ASC in addition to prior achievement predicting subsequent ASC. The importance of self-concept in educational settings and the positive and reciprocal relationship between academic achievement and ASC has since been confirmed through the research of Valentine et al. (2004), Seaton et al. (2015), Pinxten et al. (2010) and Chen et al. (2013). This is further compounded by the generalizability of this model cross-culturally (Marsh et al., 2002; Guay & Marsh, 2003).

Just as self-concept is multidimensional, so too is ASC (Marsh and Hau, 2003). This is because it links not only to academic achievement, but also long-term aspirations such as career choice (see Judge & Bono, 2011), job satisfaction and motivation, and other important attributes that enhance achievement. In an evaluation of the predictive power of ASC on subsequent study choices, Marsh and Yeung (1997) found that ASC was a more significant determinant than both students' grades and peer choices at predicting future course selection. The importance of ASC's multidimensionality is best highlighted in its frame of reference (FoR) effects (Marsh, 1986): A social comparison is made between a student's performance in a particular subject and the performances of other students in that subject (external FoR), whilst a dimensional comparison is made between own performance in a particular subject with own performances in other subjects (internal FoR). As a result, domain-specific ASCs tend to be more differentiated than subject-specific academic achievement; that is, the correlation between self-concept in math and reading is much weaker than the correlation between academic performance in math and reading. As highlighted by Marsh and Hau (2003), individuals can possess a positive self-concept in one domain, but possess a negative self-concept in another. This is an important finding as it shows that ASC can vary in different contextual domains of education. This is arguably most prevalent in the Big-Fish-Little-Pond-Effect, discussed further below.

2.2 Big-Fish-Little-Pond Effect

The Big-Fish-Little-Pond-Effect (BFLPE) was identified by Marsh (1984) and Marsh and Parker (1984) for studying frame of reference effects within self-concept, specifically academic self-concept. Specifically, it hypothesizes that an individual's ASC is determined not only by their own ability level, but also the ability or achievement levels of peers within the immediate context, such as the classroom (Marsh & Hau, 2003; Wang, 2015; Dicke et al., 2018). BFLPE is rooted in social comparison theory, indicating that the bulk of knowledge regarding ASC is acquired through methods of comparison (Festinger, 1954). The basis for the BFLPE is, by definition, that there will exist students that achieve average or below-average marks in higher-achieving schools. These high-achieving schools are catering to high-achieving students, and it is assumed that the grades they achieve are important to them. Marsh and Hau (2003) explain that in these contexts, students that achieve lower grades would perform processes of social comparison that would lower their ASC, compared to a situation in which the same students are in a lower-performing class.

Two methods of comparison are hypothesised to have opposing effects on ASC: A student's own ability is positively correlated with ASC (*the better I do the smarter I am*), whereas peer achievement levels are negatively correlated with ASC (*the better my peers do the smarter they are compared to me*) (Dicke et al., 2018, Marsh, 1984, Marsh & Hau, 2003). The term Big-Fish-Little-Pond-Effect refers directly to these two methods of comparison: the student (Fish); and the classroom/surrounding peers (Pond). Marsh and Hau (2003) and Marsh and Parker (1984) illustrate that a well-performing student (Big Fish) will identify their own ability level and form their ASC around the performance level of the classroom (Pond) they are placed in; if this well-performing student were placed in a similarly high-performing schooling system or classroom (Large Pond), they may recognize their own ability level to be average or below-average compared to the surrounding, high-achieving peers. According to the BFLPE, this would have detrimental effects on the student's ASC. Similarly, if the same student were placed in a lower-achieving school than the school previously mentioned (Little Pond), they would identify their own ability level as above-average, thus bolstering their ASC (Marsh & Hau, 2003). There is now considerable cross-cultural support for the negative effects of school- or class-avrage achievement on individual ASC (Marsh & Hau, 2003; Seaton et al., 2010; Nagengast & Marsh, 2012).

It is important to note that the BFLPE is highly specific to ASC. Evidence from Marsh & Parker (1984), Marsh (1987), Marsh et al. (1995) and Marsh and Hau (2003) shows that concepts such as self-esteem and general self-concept have little to no effect on the magnitude or direction of BFLPE. Marsh and O'Mara (2008) have furthermore shown that using self-esteem as a proxy for self-concept was weak at best when compared in a multidimensional perspective of self-esteem versus self-concept on student achievement. Additionally, it is difficult for students to avoid making comparisons as achievement levels and social standing is difficult to ignore. Therefore, ASC can be defined as one's own academic accomplishments and ability level in addition to perceived and actual achievement levels of surrounding peers (Marsh & Hau, 2003).

Given that comparison is based on ability, it becomes important to identify the method by which a student measures their ability level, and how this links to ASC. Suls et al. (2002) describe the use of immediate proxy variables when evaluating one's ability levels, such as a student's own grades. If information on the proxy variable is not available, the most immediate peer group's information is used, such as class grade average. The combination of these two sets of information form the basis of ASC and the BFLPE, and further reveals how students with similar grade levels could have very different ASC across classrooms (Wang, 2015).

2.3 Existing Evidence of the Big-Fish-Little-Pond Effect

As mentioned in the introduction of this paper, much of the existing evidence of BFLPE exists in Western and OECD countries, with very little research conducted in low- and middle-income countries (LMICs). The discussion contained in this section therefore focuses predominantly on the most recent evidence that makes use of large-scale, cross-national data to find supporting evidence of the BFLPE, as well as the Reciprocal Effects Model (REM).

A well-documented case study by Marsh (1991) aptly illustrates the BFLPE. This case study involved a high performing student, Jane, who was attending an academically selective school whose aim it was to provide intellectual stimulation through grouping high-performing students together. Jane is, according to the BFLPE, a Big Fish in a Large Pond. However, even though Jane was a high-performing student, her attendance and performance were poor; according to Jane, the work required to simply maintain average performance was not worth the effort. Due to employment reasons, Jane's parents were forced to move and Jane was placed in a non-selective school. Because of her previous academic performance, the new school placed Jane in a lower-performing class. She was now a Big Fish in a Little Pond. The effort now required of Jane to not only achieve average grades, but excel in the new class, was minimal compared to her previous academic environment. The new school noticed Jane increased in the ranks of the school, and her parents noted the new-found attitude Jane had towards her schooling and homework.

The message of this case study by Marsh (1991) was to highlight the importance of ASC through the lens of the BFLPE: Jane found that the effort she required to maintain average performance in her old school was too costly, highlighting the level of self-confidence she had in her own ability relative to that of her classmates. This realisation was detrimental to her ASC, and her academic achievement consequently suffered. Importantly, however, her ability level had not changed. Once Jane was placed in a lower-achieving school, she found the effort required for higher grades was far less costly, and her ASC was strengthened.

In one of the largest cross-cultural tests for BLFPE ever undertaken, Marsh and Hau (2003) assessed 103 558 15-year-olds and 3 851 schools across 26 countries. Nine standardized achievement tests and the Self-description Questionnaire II (SDQII) was used to measure mathematics, science and verbal abilities, whilst simultaneously measuring ASC. A multilevel modelling approach was used in order to assess the relationship between ASC and achievement at differing levels. Consistent with the findings of prior studies (Marsh, 1991; Jerusalem, 1984; Marsh et al., 2000), Marsh and Hau (2003) found significant positive effects on ASC at the individual student level, whilst negative (albeit less substantial) effects were evidenced at the level of school-average achievement. The magnitude of the BFLPE showed consistency across countries at both the individual and school levels, indicating significant support for the BFLPE cross-culturally.

Wang (2015) similarly performed a novel, cross-cultural study using TIMSS 2007 data from 49 countries to test the BFLPE with regards to mathematic self-concept. Test scores on a standardised mathematics assessment and mathematics ASC (constructed by means of self-reported questionnaires) were used alongside within-level (students) and between-level (classes) math ability[3] to determine a student's ASC relative to their classmates. A further addition to the model was the inclusion of an indicator of 'perceived relative standing' at the student level, hypothesized to be a positive predictor of ASC, and therefore likely to reduce or nullify the BFLPE (see Huguet et al., 2009). Wang (2015) found that the within-level effect was present (and positive) in all 49 countries, whereas the between-level effect was only present in 37 countries. In two countries, the between-level effect was negative, suggesting that students within high-achieving classes had lower ASC on average[4]. Once perceived relative standing at the within-level (students) was accounted for, the math ability of students relative to ASC decreased. This indicates that one's perception of own-ability levels and that of classmates plays

[3] The within-level, between-level math ability and ICC were calculated by the author.

[4] It is important to distinguish this from the BLFPE, which states that students of similar ability within a high-achieving class have lower ASC than that of a lower-achieving class.

a more important role in determining ASC than that of true ability levels. However, as hypothesised, the BFLPE remained similar in magnitude, or only slightly decreased.

The validity of both the BFLPE and REM was recently assessed by Seaton et al. (2015) using a sample of 2 786 students between the ages of 7 and 11 attending eight schools in New South Wales, two of which were selective schools catering to academically gifted students. Comparisons of performance on the same standardized mathematics test were made between students attending the selective schools and the mainstream, mixed-ability schools[5]. The study found that REM was similar in both magnitude and direction for both selective and mixed-ability schools, validating the REM across both schooling systems.

The validity of the REM and BFLPE, as well as the school compositional effect of peer spill-over, was recently tested by Dicke et al. (2018). As explained by Dicke et al. (2018) and Stabler et al. (2016), the peer spill-over effect hypothesizes that a student in a high-performing class would be more motivated to achieve higher grades than a student in a lower-achieving class. The study therefore aimed at resolving the seeming paradox between the BFLPE and peer spill-over effects using a multi-level REM that accounts for prior achievement levels to correct for sampling and measurement errors, thereby reducing the bias between the two compositional effects. A sample of 14 985 US primary school students and their mathematical achievement were tracked over a five-year period (from kindergarten to fifth grade). The results of the study identified phantom effects[6] to be the cause of the paradox; specifically, the positive effect of high-achieving classmates on test scores was overstated, whilst the negative effects of the BFLPE were understated[7]. Once prior achievement and other controls (e.g. gender and ethnicity) were added to the model, the positive effect of the spill-over effect fell to near zero, strengthening evidence in favour of the BFLPE. These findings are consistent with literature on the invalidity of the peer spill-over effect (see for example Nash, 2003; Marks, 2015).

3. Data Description and Constructs

In order to gauge the relationship between the academic performance and self-concept of Grade 9 learners in South Africa this study makes use of the Trends in International Mathematics and

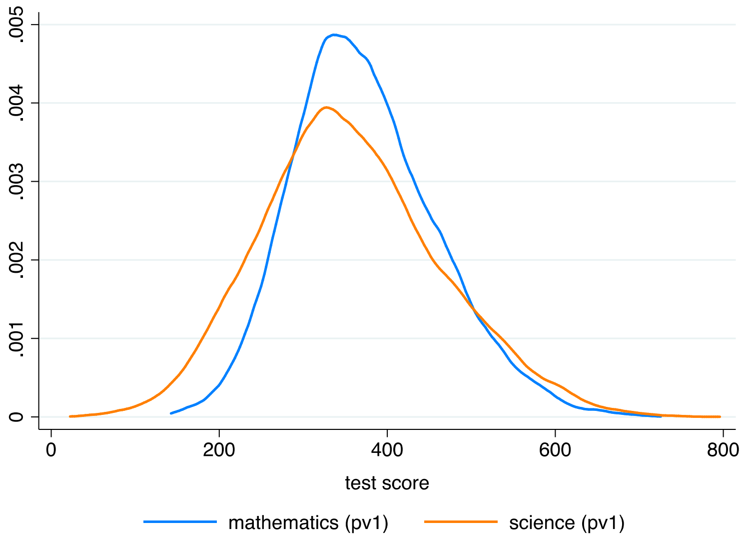
[5] Standardized tests allow for comparability across schools that vary in achievement levels. If grades were used, there is a risk of the normalization factor that occurs within a schooling system
[6] Effects that occur due to modelling misspecification and/or inaccurate analysis, which would disappear once the appropriate statistical model is used (Harket & Tymms, 2004)
[7] There were inconsistencies in the findings when phantom effects were not controlled for, including a positive relationship between average achievement and individual achievement, and a negative relationship between average achievement and ASC

Science Study (TIMSS) of 2015[8]. TIMSS is one of the most comprehensive international schooling surveys conducted in South Africa that aims at collecting information on mathematics and science performance. TIMSS was first administered in South Africa in 1995, and has continued to be administered in four further cycles in 1999, 2003, 2011 and, most recently, 2015. In the 2015 wave of TIMSS, 12 514 Grade 9 learners, as well as 331 and 334 sciences and mathematic teachers, respectively, were interviewed across 292 schools (including both public and private schools) (Reddy et al., 2016).

The TIMSS assessment questions are presented as multiple-choice and constructed response, and increment in difficulty throughout the paper. Students are not required to answer the entire battery of questions, of which there are close to 900; rather, 28 blocks of items—approximately 12 to 18 questions per block—are combined to produce 14 different assessment booklets per subject. Item Response Theory (IRT) scaling methods are then employed to generate five plausible values for both the mathematics and science results. This allows for more reliable estimated proficiency scores, as opposed to a singular test score for each student. For purposes of this study, however, only the first plausible value is adopted. In 2015, South African Grade 9 students were observed to score an average of 371 and 356 on the TIMSS mathematics and science assessment, respectively (see figure 1 below). This is 129 and 144 points below the international average of 500. The mathematics test scores are noticeably less dispersed, with a standard deviation of 81.7, compared to a standard deviation of 101.7 for science test scores.

[8] South Africa being one of the only of 39 countries to participate at the Grade 9 level

Figure 1: Distribution of Grade 9 mathematics and science test scores (first plausible value)



Notes: own calculations using South Africa TIMSS 2015.

In addition to standardised assessment scores, TIMSS conducts contextual surveys given to students, teachers and school principals. The student questionnaire pertains to aspects of students' lives at school, such as self-perception of ability within a certain academic domain, motivation and confidence, as well as aspects outside of school, such as household environment and demographic information[9]. Responses to Likert-scaled questions for mathematics and science contained in the student contextual surveys[10] were used to create several constructs of academic self-concept and motivation for both subjects; these were informed by the work of Marsh et al. (2014) and Ryan & Deci (2000). First, *subject-specific self-concept* (SSC) was constructed from eight questions related to the student's perceived ability in the subject, as filtered through their own achievements and external information (for example, comments made by the teacher). Secondly, *extrinsic motivation* (MOT) was constructed using a combination of nine questions aimed at capturing student motivation[11]. Specifically, the construct MOT captures motivation that has become 'internal' to the student, which Ryan and Deci (2000:71-72) refer to as autonomous and controlled motivation in Self-Determination Theory (SDT). Finally, *subject*

[9] TIMSS 2015 Assessment Frameworks. Copyright © 2013 International Association for the Evaluation of Educational Achievement (IEA). Publisher: TIMSS & PIRLS International Study Centre, Lynch School of Education, Boston College

[10] Specifically, questions 17, 19 and 20 for mathematics, and 21, 23 and 24 for science

[11] Ryan & Deci (2000:71-73) illustrate extrinsic motivation to be a combination of four regulations: external, introjected, identified and integrated. These motivations are internalised within the individual over time, allowing them to experience greater levels of autonomy in their actions. However, these regulations are not finite goals, and instead adapt over time to changing circumstances. The nine questions included in this construct aim to capture at least one of the four regulation elements.

enjoyment (ENJOY) was constructed from six questions pertaining to the intrinsic enjoyment and satisfaction derived from the subject.

Given the ordinal nature of the Likert-type responses—scaled from 1 = 'Agree a lot' to 4 = 'Disagree a lot'—on the questionnaire items, Polychoric Principal Component Analysis (PCA) was employed to generate the construct measures SSC, MOT and ENJOY for both subjects. A list of the questions used for each construct and the factor loadings are provided in Table A.1 of the Appendix. The internal consistency of each construct, measured by Cronbach's alpha, reveals high levels of internal validity for all six constructs (α values range from 0.76 to 0.96). Each of the constructs presented low-to-moderate positive correlations with each other (see Table 1 below), with SSC and MOT for mathematics yielding the lowest correlation (ρ = 0.29), and SSC and ENJOY for science yielding the highest (ρ = 0.68). Such results suggest that there is a moderate positive relationship between the three constructs. Summary statistics (means and standard deviations) of the three constructs are indicated in Table 2.

Table 1: Pairwise correlations of SSC, MOT and ENJOY constructs

Mathematics			
	SSC	*MOT*	*ENJOY*
SSC	1.000		
MOT	0.297	1.000	
ENJOY	0.648	0.444	1.000
Science			
	SSC	*MOT*	*ENJOY*
SSC	1.000		
MOT	0.460	1.000	
ENJOY	0.681	0.609	1.000

Note: own calculations using TIMSS 2015

Table 2: Mean and standard deviation of SSC, MOT and ENJOY constructs

Mathematics			
	SSC	*MOT*	*ENJOY*
Mean	0.59	0.36	0.22
S.D.	1.58	1.24	1.51
Science			
	SSC	*MOT*	*ENJOY*
Mean	0.10	0.41	0.22
S.D.	1.53	1.71	1.40

Note: own calculations using TIMSS 2015

Measures of student and school socio-economic status, as well as students' sense of safety and belonging in their school were also derived using responses to items included in the contextual questionnaires. Socio-economic status was measured at the student level using a proxy of household wealth based on first PCA of eleven questions related to home-based assets (including learning resources)[12]. School level SES was generated using the average SES of the students in each school, following which schools were ranked by average SES and sorted into five quintiles of school SES[13]. A safety index was constructed using Polychoric PCA on nine questions relating to student bullying and safety in school. Both the SES and safety measures showed suitable levels of internal validity (α_{SES} = 0.71, α_{SAFETY} = 0.78).

4. Methodological Approach

As discussed earlier in this paper, BFLPE is a contextual effect; that is, it is influenced by factors at both the student and classroom/school levels. Therefore, analysis at the individual level needs to be accompanied by estimation at these higher levels. This paper adopts a multilevel (mixed) modelling approach to identify the within and across classroom effects of self-concept, student motivation and satisfaction on academic performance in mathematics and science.

The model is built in three stages. First, a baseline model is estimated that allows for random intercepts (class differences in average test scores), as well as controls for a set of explanatory variables (the fixed parameters), including the three constructs SSC, MOT and ENJOY. Variation in the intercept allows for the assumption that the effect of explanatory variables lead to (random) variation between classrooms, depending on particular circumstances; for example, because students learn in classes, and features of their classrooms (such as the ability of other students) are likely to influence a student's educational attainment, we would expect test scores for students in the same class to be more alike than scores for students from different classes. This model can be represented by:

$$y_{ij} = \beta_{0j} + \beta_1 SSC_{ij} + \beta_2 MOT_{ij} + \beta_3 ENJOY_{ij} + \propto \boldsymbol{X}_{ij} + \mu_{ij} \quad [1]$$

$$\beta_{0j} = \beta_0 + \varepsilon_{0j} \quad [2]$$

$$\mu_{ij} \sim N(0, \sigma^2); \quad \varepsilon_{0j} \sim N(0, \tau_{00}); \quad cov(\mu_{ij}, \varepsilon_{0j}) = 0 \quad [3]$$

[12] These included: A computer / tablet owned individually or shared, study desk / table, own room, internet connection, mobile phone and/or a gaming system

[13] The five school SES (wealth) quintiles used are not the same as those used by the Department of Education, and are instead only based on the created SES index

where y_{ij} is the mathematics (science) test score of student i in classroom j, β_0 is the intercept that varies by classroom (equation [2]), $SSC, MOT, ENJOY$ are the subject-specific self-concept, extrinsic motivation and subject enjoyment, respectively, ε_{0j} and μ_{ij} are classroom- and student-level idiosyncratic error terms, and $\boldsymbol{X}$ is a vector of level-one (student and home) explanatory variables, including: student sex; how often the student speaks the test language at home; home socioeconomic status (SES); the highest level of education attainment of the parent/s; and the student's sense of safety and belonging at school. A full description of the explanatory variables can be found in Table A.2 of the Appendix.

Following estimation of equations [1] and [2], the assumption of fixed regression slopes is relaxed; specifically, the 'effect' (slopes) of SSC, MOT and ENJOY are allowed to vary between classrooms. This random intercept and random slope model can be represented as:

$$y_{ij} = \beta_{0j} + \beta_{1j}SSC_{ij} + \beta_{2j}MOT_{ij} + \beta_{3j}ENJOY_{ij} + \propto \boldsymbol{X}_{ij} + \mu_{ij} \quad [4]$$

$$\beta_{1j} = \beta_1 + \varepsilon_{1j} \quad [5]$$

$$\beta_{2j} = \beta_2 + \varepsilon_{2j} \quad [6]$$

$$\beta_{3j} = \beta_3 + \varepsilon_{3j} \quad [7]$$

$$\mu_{ij} \sim N(0, \sigma^2); \quad \begin{bmatrix} \varepsilon_{1j} \\ \varepsilon_{2j} \\ \varepsilon_{3j} \end{bmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \tau_{00} & \tau_{01} \\ \tau_{10} & \tau_{11} \end{pmatrix}\right] \quad [8]$$

where equations [2] and [3] still apply, with the inclusion of random slope parameters β_1, β_2 and β_3 (equations [5], [6] and [7]), and the additional classroom-level error terms ε_{1j}, ε_{2j}, ε_{3j}.

Finally, the model is extended to include cross-level interactions between the three constructs and a higher level (classroom or school) variable. This provides the model:

$$y_{ij} = \beta_{0j} + \beta_{1j}SSC_{ij} + \beta_{2j}MOT_{ij} + \beta_{3j}ENJOY_{ij} + \sum_{k=2}^{5} \gamma_{k-1}\, SSC_{ij} * SSES_k$$
$$+ \sum_{k=2}^{5} \delta_{k-1}\, MOT_{ij} * SSES_k + \sum_{k=2}^{5} \theta_{k-1}\, ENJOY_{ij} * SSES_k + \propto \boldsymbol{X}_{ij} + \mu_{ij} \quad [9]$$

where equations [2], [3], [5], [6], [7] apply, and the variance-covariance structure is represented as in equations [4] and [8]. This model is identical in parameters to equation [4], with the addition of interaction effects of school socioeconomic status by quintile, represented by $SSES_k$**,** where k = 1, 2, …, 5[14]. This model allows performance differences to be explained not only by the constructs SSC, MOT and ENJOY, but also the quintile (wealth) of the school.

[14] Quintile 1 is the base category.

It is important to mention the limitations of the chosen model before proceeding. First, although the sample is drawn to be as nationally representative as possible, the sample is drawn at the school level and not the classroom level; this may impact the generalizability of the findings in terms of student-level ASC. Secondly, one cannot necessarily infer a causal interpretation to the random construct slopes across classrooms; instead they hint at the possible systematic variation in the effect of SSC, MOT and ENJOY. Therefore, using the findings of this paper as externally valid would imply that we judge the sample of classrooms to be similar to those that might be studied in future samples (Bingenheimer & Raudenbush, 2004). This would only be possible if we were to repeat the analysis with another sample of suitably comparable classrooms, and compare the findings. Therefore, although the empirical results refer to 'effect', this does not assume a causal interpretation of the findings.

All models adopt maximum likelihood estimation using the *mixed* command in STATA. The residuals μ_{ij}, ε_{1j}, ε_{2j} and ε_{3j} are allowed to covary. As already mentioned, the first plausible value of the mathematics and science assessment is used as the dependent variable.

5. Empirical Results

5.1 Random intercepts model

Results of the random intercepts model for mathematics and science performance are shown in columns (1) to (6) of Table 3 and Table 4. Whilst column (1) does not include explanatory variables, the models shown in columns (2) through (6) allow for a stepwise inclusion of the model controls, including the constructs *SSC*, *MOT* and *ENJOY*.

As expected, the association between the three constructs *SSC*, *MOT* and *ENJOY* and test performance are all observed to be individually positive and statistically significant (1% level). When controlling for all three constructs simultaneously, the coefficients remain positive and significant, aside from *MOT* for science which is now negative. It is important to note, however, that the relative sizes of the coefficients have decreased substantially; this is to be expected given the positive correlations between all three constructs. Although all constructs are positively related to mathematical performance, SSC is distinctly the most important determinant of achievement amongst the three[15].

Although they do not form part of the primary interest of this paper, the coefficients on male and the safety index are nevertheless worth discussing briefly. The consistent positive and

[15] For the purposes of this study, the two concepts achievement and test scores will be used interchangeably

statistically significant coefficient on male suggests that boys outperform girls, even after controlling for *SSC*, *MOT* and *ENJOY*. This indicates that self-concept does little to explain the difference in between-gender performance. The coefficient on sense of safety and belonging for mathematics and science are equally positive and significant across both subjects. This indicates that a sense of safety and personal belonging in an educational environment is important in contributing towards higher achievement levels. Such a result is to be expected in a country such as South Africa, with high levels of crime and poverty. At a grade 8 level, students are reaching a formative social age in which social status and self-concept matter. Safety and a sense of belonging can be seen as synonymous with these ideals, particularly when it links to social interactions.

5.2 Random slopes model

The estimation results indicated in columns (7) to (10) of Table 3 and Table 4 relax the assumption of fixed regression slopes, and allow for the slopes on *SSC*, *MOT* and *ENJOY* to differ among classrooms. The chi-squared statistics from a log likelihood ratio test of random slopes indicate that, apart from the slope on *MOT* for mathematics, the construct slopes vary significantly across classrooms. Assuming a normal distribution, the middle 95 percent of classrooms are estimated to have an *SSC* slope for mathematics (science) that is between -0.73 (1.55) and 19.21 (15.55) points. Similarly, the middle 95 percent of classrooms are estimated to have a slope on *MOT* and *ENJOY* for mathematics (science) that is between -2.15 (-5.99) and 9.53 (1.77) points, and -4.96 (-0.28) and 8.76 (15.34) points, respectively.

The negative, statistically significant coefficient on science *MOT* suggests that, when controlling for self-concept and subject enjoyment, extrinsic motivation is negatively related to science achievement. Although self-concept and motivation are highly interrelated and reciprocal in their influence, even low *SSC* students can express a high extrinsic motivation to perform in mathematics, especially if motivation is driven by parental expectations and a desire to avoid negative affect or ‘punishment’ (for example, love withdrawal). Therefore, the negative coefficient on *MOT* is likely related to this relationship between low performance, low *SSC*, low *ENJOY*, and high *MOT*.

Column 10 highlights the covariances between all four random parameters. A positive covariance between the random slope and intercept parameters implies that better (on average) performing classrooms will have a larger estimated slope on the respective construct, and vice versa for a negative covariance. The positive covariance between the *SSC* slopes and the intercepts for mathematics and (to a lesser extent) science scores suggests that the effect of subject-specific self-concept on achievement is larger in better performing classrooms. Conversely, the negative covariances between the *MOT* and *ENJOY* slopes and the intercepts indicate that the effect of these constructs on test scores is larger in poorer performing classrooms. These relationships are illustrated graphically in Figures 2 and 3: Whilst the slope on *SSC* and *MOT* varies significantly with average classroom mathematics performance, the same does not appear to be true of science performance ($\rho_{CONSTANT,SSC}$ = 0.09 and $\rho_{CONSTANT,MOT}$ = -0.34)[16]. In the case of *ENJOY*, the negative association with average classroom performance in both subjects is clear; poorer performing schools are more likely to have a higher slope on *ENJOY*.

The random *SSC* slopes from the model on mathematics performance are negatively correlated with the slopes on *MOT* and *ENJOY* ($\rho_{SSC,MOT}$ = -0.44 and $\rho_{SSC,ENJOY}$ = -0.97), indicating that classrooms with large (positive) returns to *SSC* on achievement typically have lower returns to *MOT* and *ENJOY*, respectively. One can see this quite clearly from Figure 2: The classrooms with the highest predicted average mathematics performance (largest intercepts) are estimated to have the largest slopes on *SSC* and the smallest slopes on *MOT* and *ENJOY*. With regards to the random slopes from the model for science performance, the negative correlations between the random slopes are substantially smaller ($\rho_{SSC,MOT}$ = 0.09 and $\rho_{SSC,ENJOY}$ = -0.34).

The construct-intercept covariances are observed to increase in size when all three constructs are added as controls in the mathematics model; that is, the relationships between average school performance and the random slopes become more pronounced. In the case of science, whilst the covariance of the slope residuals is individually negative—suggesting that the effects of *SSC*, *MOT* and *ENJOY* on test scores are larger in poorer performing classrooms—the inclusion of all constructs in the model leads to a positive covariance between the *SSC* slopes and the intercepts, whilst the covariance between the *MOT* slopes and the intercepts tend towards

[16] See table A.2 in the appendix for a complete summary of all random parameters' correlations.

Table 3: Random intercept and random slope models for mathematics test scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Random intercepts						Random intercepts and random slopes			
Fixed effects:										
Subject-specific self-concept (*SSC*)			11.10***			9.02***	11.00***			9.24***
			(0.33)			(0.44)	(0.37)			(0.53)
Extrinsic motivation (*MOT*)				8.50***		4.06***		8.34***		3.69***
				(0.42)		(0.48)		(0.44)		(0.51)
Enjoyment of subject (*ENJOY*)					9.75***	2.25***			9.76***	1.90***
					(0.36)	(0.50)			(0.37)	(0.54)
Male student		6.00***	4.74***	8.53***	5.59***	5.15***	4.73***	8.67***	5.60***	5.40***
		(1.33)	(1.03)	(1.04)	(1.04)	(1.07)	(1.03)	(1.04)	(1.04)	(1.06)
Sense of safety & belonging at school		8.81***	7.55***	7.47***	7.30***	7.13***	7.61***	7.42***	7.28***	6.93***
		(0.70)	(0.99)	(0.94)	(0.98)	(1.12)	(0.99)	(0.94)	(0.98)	(1.12)
Constant	379.2***	375.7***	378.01***	375.3***	378.1***	376.73***	377.9***	375.2***	378.06***	375.91***
	(3.55)	(4.16)	(3.76)	(3.78)	(3.89)	(3.84)	(3.75)	(3.79)	(3.89)	(3.81)
Random effects:										
$\sigma^2_{constant}$	4045.78	3645.26	3506.64	3512.08	3777.53	3618.55	3476.09	3551.13	3775.12	3552.72
$\sigma^2_{residual}$	3198.89	2840.64	2714.06	2872.07	2780.15	2644.07	2695.76	2867.25	2777.67	2600.04
σ^2_{SSC}							8.83			25.88
σ^2_{MOT}								3.78		8.88
σ^2_{ENJOY}									1.34	12.24
$\sigma_{SSC,constant}$							98.59			244.17
$\sigma_{MOT,constant}$								-87.58		-160.59
$\sigma_{ENJOY,constant}$									-17.64	-162.72
$\sigma_{SSC,MOT}$										6.62
$\sigma_{SSC,ENJOY}$										17.32
$\sigma_{MOT,ENJOY}$										-5.79
Test for random slopes χ^2							30.16***	11.62***	0.52	111.68***
Log-likelihood	-68882.4	-68814.1	-61599.8	-63693.7	-61458.0	-56027.6	-61584.7	-63887.9	-61457.8	-55971.8
Observations	12 514	12 507	11 352	11 718	11 299	10 341	11 352	11 718	11 299	10 341
Number of classes	328	328	328	328	328	328	328	328	328	328

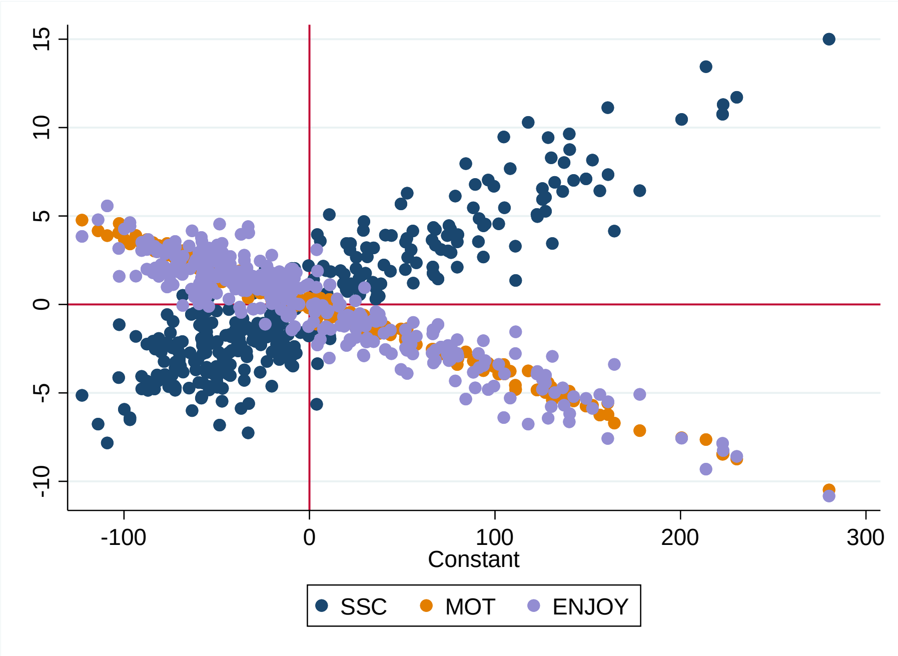
Notes: Models in columns (2) to (10) also control for household socioeconomic status, highest level of parental education, and frequency of speaking the test language at home. *SSC* = academic self-concept, *MOT* = motivation, *ENJOY* = enjoyment of subject. Test for random slopes is based on a likelihood ratio test. Standard errors shown in parentheses. *** p < .01, ** p < .05, * p < .10

Table 4: Random intercept and random slope models for science test scores

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
			Random intercepts				Random intercepts and random slopes			
Fixed effects:										
Subject-specific self-concept (*SSC*)			12.24***			8.33***	12.30***			8.55***
			(0.43)			(0.59)	(0.49)			(0.63)
Extrinsic motivation (*MOT*)				4.88***		-2.16***		4.90***		-2.11***
				(0.39)		(0.49)		(0.45)		(0.51)
Enjoyment of subject (*ENJOY*)					12.51***	7.67***			12.60***	7.53***
					(0.47)	(0.72)			(0.56)	(0.75)
Male student		8.57***	7.96***	9.58***	9.49***	9.49***	8.06***	9.67***	9.55***	9.33***
		(1.27)	(1.28)	(1.31)	(1.29)	(1.29)	(1.28)	(1.31)	(1.29)	(1.33)
Sense of safety & belonging at school		9.46***	10.76***	12.04***	10.53***	10.53***	10.68***	11.99***	10.34***	9.25***
		(0.67)	(1.16)	(1.20)	(1.19)	(1.19)	(1.16)	(1.20)	(1.19)	(1.34)
Constant	366.3***	377.5***	373.1***	376.4***	373.1***	374.5***	372.9***	376.2***	372.9***	374.2***
	(4.36)	(4.37)	(4.51)	(4.45)	(4.51)	(4.56)	(4.51)	(4.47)	(4.52)	(4.58)
Random effects:										
$\sigma^2_{constant}$	6068.46	4537.98	4866.18	4619.18	4862.81	4889.83	4876.94	4679.03	4907.86	4947.71
$\sigma^2_{residual}$	5022.87	4653.28	4275.05	4542.08	4320.08	4171.74	4242.21	4509.44	4272.42	4105.99
σ^2_{SSC}							15.67			12.76
σ^2_{MOT}								12.7		3.92
σ^2_{ENJOY}									27.66	15.89
$\sigma_{SSC,constant}$							-81.24			31.93
$\sigma_{MOT,constant}$								-84.07		-1.61
$\sigma_{ENJOY,constant}$									-175.67	-198.59
$\sigma_{SSC,MOT}$										-0.63
$\sigma_{SSC,ENJOY}$										4.89
$\sigma_{MOT,ENJOY}$										-5.05
Test for random slopes χ^2							15.5***	15.38***	38.92***	41.04***
Log-likelihood	-71698.17	-71146.2	-64371.4	-65584.68	-64508.7	-58842.7	-64363.7	-65576.9	-64489.3	-58822.2
Observations	12 514	12 507	11 390	11 547	11 404	10 427	11 390	11 547	11 404	10 427
Number of classes	328	328	328	328	328	328	328	328	328	328

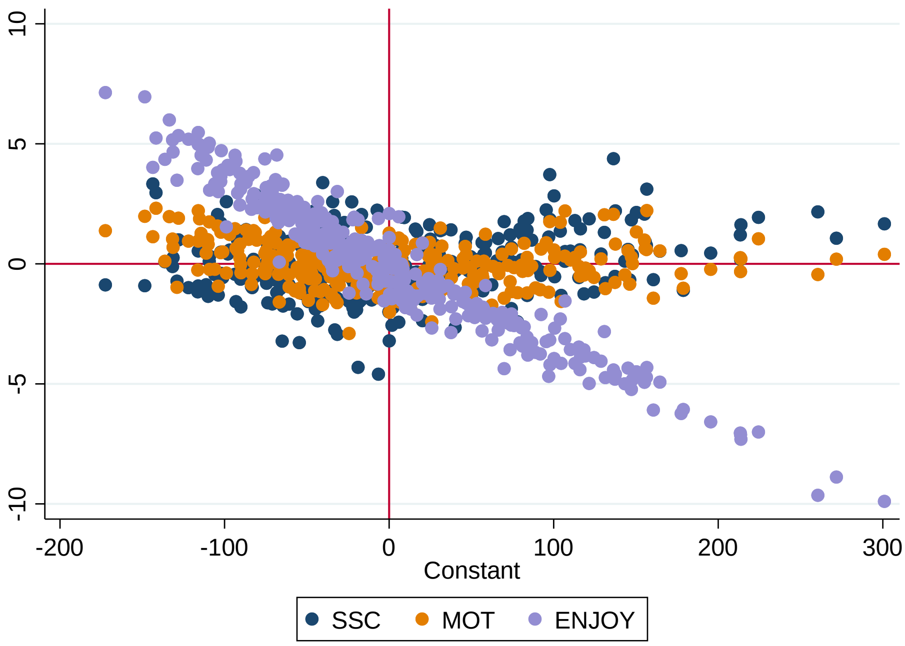
Notes: Models in columns (2) to (10) also control for household socioeconomic status, highest level of parental education, and frequency of speaking the test language at home. *SSC* = academic self-concept, *MOT* = motivation, *ENJOY* = enjoyment of subject. Test for random slopes is based on a likelihood ratio test. Standard errors shown in parentheses. *** $p < .01$, ** $p < .05$, * $p < .10$

Figure 2: Scatter plot of mathematic construct correlations



Notes: own calculations using results from Table 3. Values are normalised around a zero mean.

Figure 3: Scatter plot of science construct correlations



Notes: own calculations using results from Table 4. Values are normalised around a zero mean.

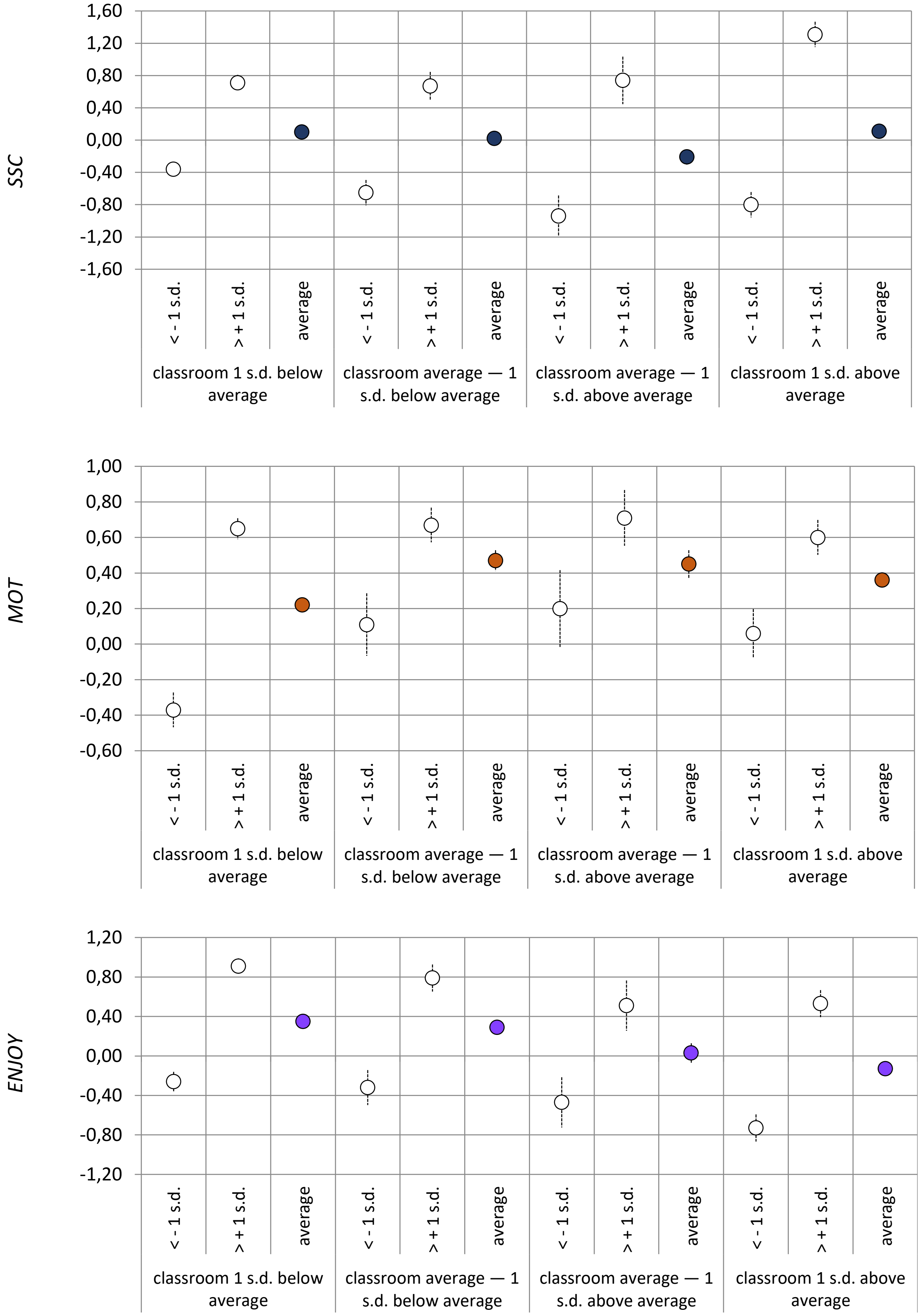
zero. These changes suggest that the mechanisms by which *SSC*, *MOT* and *ENJOY* are related to performance are (i) interrelated and (ii) different across the two subjects and classrooms of differing average performance. This is mostly likely related to differences in the relative distributions of *SSC*, *MOT* and *ENJOY* across better and poorer (on average) performing classrooms.

Figure 4 and Figure 5 below highlight the distribution of *SSC*, *MOT* and *ENJOY* by level of mathematics and science performance, respectively. The purpose of these figures is to illustrate how *SSC*, *MOT* and *ENJOY* are distributed, first, across classrooms and, secondly, across students within those classrooms. A comparison of merely average *SSC* by level of classroom performance would not be revealing of the contextual mechanisms. As can be seen from the first panel of Figure 4, average *SSC* is not significantly different across classroom performance, except in the case of classrooms that perform within one standard deviation above the average. Average *MOT* in mathematics is the lowest amongst students from low-performing classrooms (defined here as a classroom that scores on average lower than one standard deviation below the average of all classrooms), followed by students from high-performing classrooms (defined here as a classroom that scores on average more than one standard deviation above the average of all classrooms). Most notable is the consistent decline in the average value of *ENJOY* from low-performing to high-performing classrooms. These trends are best explained by the relative distribution of these constructs within each classroom type.

The distribution of *SSC* is more narrowly dispersed in low-performing classrooms and more widely dispersed in high-performing classrooms; this is more pronounced for mathematics. In other words, *SSC* is stronger in students surrounded by lower-achieving peers, and lower in students surrounded by higher-achieving peers. Indeed, the weakest performing 16 percent of students in above average performing classrooms have significantly lower *SSC* than their similarly ranked peers in low-performing classrooms. Such a result would be in line with the BFLPE hypothesis that students in high performing classrooms feel demotivated by their high-achieving peers, resulting in lower academic self-concepts. If we relate this to student performance, students scoring 240 points in mathematics (the average score of the bottom 16 percent of performers in low-performing classrooms) are reported to have a self-concept that is significantly higher than students scoring 386 points in mathematics (the average score of the bottom 16 percent of performers in high-performing classrooms). Clearly, context and social comparison matters.

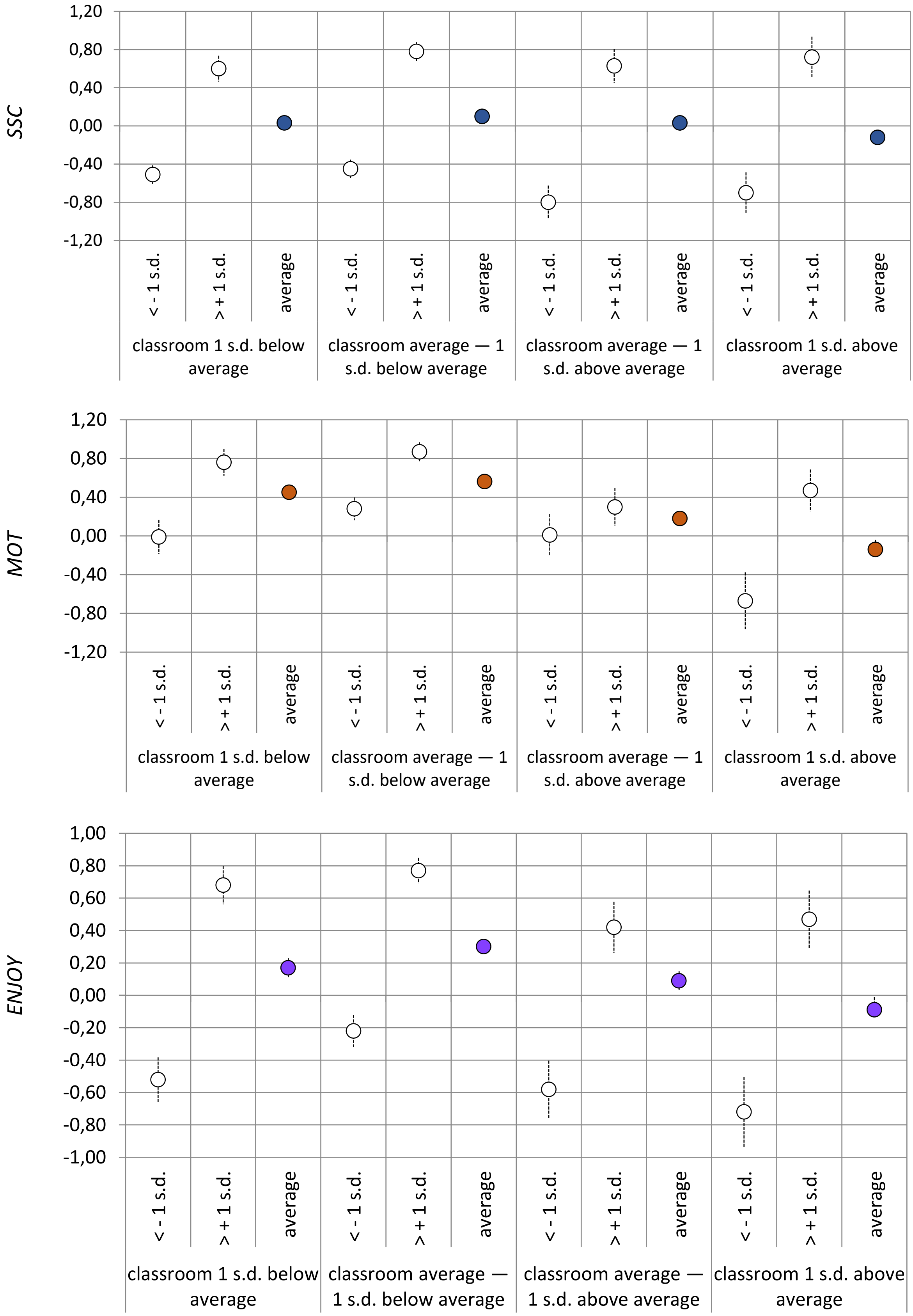
Quite conversely, the dispersion of *MOT* narrows as the average mathematics performance of the classroom increases, with the weakest students in low-performing classrooms substantially less extrinsically motivated than any other group of students. For all other levels of classroom performance, there does not appear to be a statistically significant difference in the

Figure 4: *SSC*, *MOT* and *ENJOY* in mathematics by student and average classroom performance



Note: s.d = standard deviation. 95% confidence intervals are plotted as dashed lines. Solid filled dots represent the average values.

Figure 5: *SSC*, *MOT* and *ENJOY* in science by student and average classroom performance



Note: s.d = standard deviation. 95% confidence intervals are plotted as dashed lines. Solid filled dots represent the average values.

MOT of students of the same relative performance. Conversely, the weakest performing students in high-performing classrooms are the least extrinsically motivated in science, and the top performing students in lower than average performing classrooms are the most extrinsically motivated. The pattern of *ENJOY* is furthermore dissimilar to that of *SSC*: A steady decline in average *ENJOY* emerges as class performance increases. At all levels of relative student performance, students in above average performing classrooms have significantly lower values on *ENJOY* than students in below average performing classrooms.

5.3 Cross-level interaction model

The schooling system is South Africa is highly bimodal: Wealthier (quintile 5) schools significantly outperform poorer (quintile 1-4) schools. This bimodality is important to mention as the results that follow highlight the degree to which ASC functions across school (wealth) quintiles. The results from a model that includes interactions between *SSC*, *MOT* and *ENJOY* and school quintile are shown in columns (6) and (10) of Table 5. For reference, columns (1) and (2) repeat the results from column (10) of Table 3 and Table 4, whilst columns (3) to (5) and (7) to (9) represent cross-level interaction results controlling for only one of the three constructs.

It is immediately noticeable that the average performance of classrooms is related to school SES, and accounts for a large part of dispersion of classroom (average) performance. This is indicated by a substantial decrease in the standard deviation of the random intercepts for mathematics scores from 59.6 to 34.8 points, and from 70.3 to 41.6 points in the case of science scores. This is to be expected, as the intraclass coefficient for Q1 to Q4 schools is approximately 0.3, whilst for the full sample of schools and Q5 schools it is 0.5. Furthermore, the coefficients on the school SES quintile controls indicate that expected performance increases exponentially when moving up school wealth quintiles.

Given that average classroom performance is strongly correlated to school SES, and average performance is related to the magnitude of the *SSC*, *MOT* and *ENJOY* slopes, it is expected that the dispersion of these slopes will change after allowing for interactions with school SES. Scatter plots for mathematics and science performance of the slopes on *SSC*, *MOT* and *ENJOY* against average classroom performance by school SES quintile are presented in Figure 6 and Figure 7. The purpose of these figures is to illustrate the different performance 'effect' of *SSC*, *MOT* and *ENJOY* across school wealth.

As indicated by both figures, the slopes on all three constructs are more widely dispersed amongst classrooms with higher school wealth. Figure 6 shows that quintile 5 classrooms have larger positive slopes on *SSC*, and negative slopes on *MOT* and *ENJOY*. There are a small number of classrooms in lower quintile schools with higher than average performance that similarly share higher than average slopes on SSC. It is also apparent that *MOT* and *ENJOY* only have positive relationships with mathematics performance in the lowest (on average) performing classrooms in low SES schools. With regards to science performance (Figure 7), the positive relationship between average performance and the slopes on *SSC* and *MOT* is weaker than was observed for mathematics. In fact, there appears to be little evidence of higher returns to *SSC* by either average classroom performance or school wealth. Conversely, *ENJOY* is more likely to have an important positive relationship with science performance in poorer performing schools, irrespective of school wealth.

6. Discussion and Concluding Remarks

The aim of this study was to identify whether the big-fish-little-pond effect (BFLPE) is present amongst Grade 9 learners in South Africa. This was assessed empirically using mathematics and science achievement scores and self-reported academic self-concept from TIMSS 2015. Academic self-concept (ASC) was created using three constructs: subject-specific self-concept (*SSC*), extrinsic motivation (*MOT*) and subject enjoyment (*ENJOY*). The correlations between *SSC*, *MOT* and *ENJOY* were all shown, as expected, to be moderately to strongly positive, reiterating the inter-related and reinforcing association between academic self-concept and motivation.

The relationship between ASC and performance and the BFLPE was analysed by means of a mixed (multilevel) model that allowed for the relationship between the three constructs and achievement to differ at the individual and classroom level. Model results indicated that all three constructs are individually significantly and positively related with mathematics and science achievement. Following the inclusion of all constructs simultaneously, *SSC* shows the strongest relationship with test performance in both mathematics and science. For all models, boys were predicted to outperform girls at all levels of *SSC*, *MOT* and *ENJOY*, and a student's sense of safety and belonging proved to be an important determinant of achievement.

Although ASC is most explicitly linked to academic achievement, there are still important relationships between performance and the other constructs, as well as between the three constructs themselves. For example, an average *SSC* and high *MOT* in one context (classroom) may present similar returns to student achievement as a low *MOT* and high *ENJOY* in another; these represent two situations of different self-concept. This can be similarly extend-

Table 5: Random intercept and random slope models for mathematics and science test scores, with random slopes interacted with school SES quintile

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	No interactions		Cross-level interactions with school SES quintile							
	Math	Science	Math				Science			
Fixed effects:										
SSC	9.24***	8.55***	10.41***			5.63***	13.6***			7.89***
	(0.53)	(0.63)	(0.89)			(1.14)	(1.15)			(1.43)
MOT	3.69***	-2.11***		10.41***		5.60***		6.72***		-1.87
	(0.51)	(0.51)		(0.88)		(1.06)		(1.05)		(1.25)
ENJOY	1.90***	7.53***			12.18***	7.08***			16.42***	11.83***
	(0.54)	(0.75)			(0.87)	(1.18)			(1.31)	(1.76)
Male	5.40***	9.33***	4.73***	8.67***	5.60***	5.40***	7.99***	9.63***	9.52***	9.27***
	(1.06)	(1.33)	(1.03)	(1.04)	(4.04)	(1.06)	(1.28)	(1.31)	(1.28)	(1.32)
Safety index	6.93***	9.25***	7.61***	7.44***	7.27***	6.88***	10.6***	11.94***	10.32***	9.11***
	(1.12)	(1.34)	(0.99)	(0.94)	(0.98)	(1.12)	(1.16)	(1.20)	(1.18)	(1.34)
SSES Q2			9.90	8.76	11.31*	11.61*	17.28**	14.60*	16.04**	17.66**
			(6.54)	(6.78)	(6.84)	(6.59)	(7.81)	(7.80)	(7.81)	(7.87)
SSES Q3			23.17***	19.07***	24.32***	24.96***	31.5***	30.06***	32.61***	34.41***
			(6.45)	(6.69)	(6.73)	(6.49)	(7.70)	(7.68)	(7.70)	(7.76)
SSES Q4			45.48***	41.46***	47.12***	48.54***	61.8***	58.90***	61.64***	64.58***
			(6.43)	(6.68)	(6.71)	(6.48)	(7.68)	(7.67)	(7.68)	(7.74)
SSES Q5			130.60***	128.60***	136.65***	134.23***	157***	152.9***	158.4***	160.4***
			(6.44)	(6.66)	(6.72)	(6.49)	(7.70)	(7.68)	(7.70)	(7.75)
SSC * SSES Q2			-1.31			0.80	-1.09			-0.45
			(1.23)			(1.61)	(1.61)			(2.00)
SSC * SSES Q3			-0.02			2.04	-1.09			1.65
			(1.18)			(1.55)	(1.55)			(1.97)
SSC * SSES Q4			1.05			4.86***	-1.99			0.65
			(1.17)			(1.54)	(1.54)			(1.94)
SSC * SSES Q5			3.36***			9.46***	-1.39			1.48
			(1.17)			(1.57)	(1.56)			(2.03)
MOT * SSES Q2				-1.57		-0.45		0.13		1.05
				(1.27)		(1.53)		(1.46)		(1.73)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	No interactions		Cross-level interactions with school SES quintile							
	Math	Science	Math				Science			
MOT * SSES Q3				-0.56		-0.09		-2.39*		0.22
				(1.30)		(1.54)		(1.42)		(1.67)
MOT * SSES Q4				-3.31**		-2.08		-3.79***		-2.56
				(1.33)		(1.54)		(1.41)		(1.63)
MOT * SSES Q5				-4.17***		-6.25***		-1.82		0.69
				(1.30)		(1.54)		(1.38)		(1.62)
ENJOY * SSES Q2					-2.98**	-4.29**			-2.28	-2.83
					(1.21)	(1.68)			(1.82)	(2.43)
ENJOY * SSES Q3					-2.07*	-4.01**			-4.65***	-6.44***
					(1.16)	(1.61)			(1.77)	(2.40)
ENJOY * SSES Q4					-3.55***	-6.81***			-5.38***	-4.13*
					(1.15)	(1.59)			(1.76)	(2.36)
ENJOY * SSES Q5					-2.34**	-9.03***			-5.15***	-7.02***
					(1.17)	(1.69)			(1.75)	(2.43)
Constant	375.9***	374.2***	332.9***	332.5***	330.9***	328.7***	315.8***	321.4***	315.7***	315.2***
	(3.81)	(4.58)	(5.06)	(5.22)	(5.27)	(5.11)	(6.1)	(6.11)	(6.1)	(6.17)
Random effects										
$\sigma^2_{constant}$	3552.72	4947.71	1223.36	1316.35	1333.42	1211.92	1728.46	1701.45	1721.63	1727.21
$\sigma^2_{residual}$	2600.04	4105.99	2695.33	2867.88	2775.68	2897.49	4240.34	4509.46	4270.58	4101.96
σ^2_{SSC}	25.88	12.76	6.09			15.51	15.1			12.21
σ^2_{MOT}	8.88	3.92		0.18		2.93		9.5		2.68
σ^2_{ENJOY}	12.24	15.89			0.62	3.39			23.32	11.78
$\sigma_{SSC,constant}$	244.17	31.93	34.95			60.93	-54.94			3.15
$\sigma_{MOT,constant}$	-160.59	-1.61		-15.43		-44.3		-42.87		5.87
$\sigma_{ENJOY,constant}$	-162.72	-198.59			8.61	-28.75			-91.81	-96.02
Log likelihood	-55971.8	-58822.2	-61418.8	-63730.1	-61288.2	-55796.1	-64197.3	-65412.0	-64317.9	-58647.1
Observations	10 341	10 427	11 299	11 299	11 299	10 341	11.299	11 299	11 299	10 341
Number of groups	328	328	328	328	328	328	328	328	328	328

Note: SSES = school socioeconomic status by quintile. Standard errors shown in parentheses. *** $p < .01$, ** $p < .05$, * $p < .10$

Figure 6: Relationship between average classroom performance and *SSC*, *MOT* and *ENJOY* slopes on mathematics, by school socioeconomic (SES) quintile

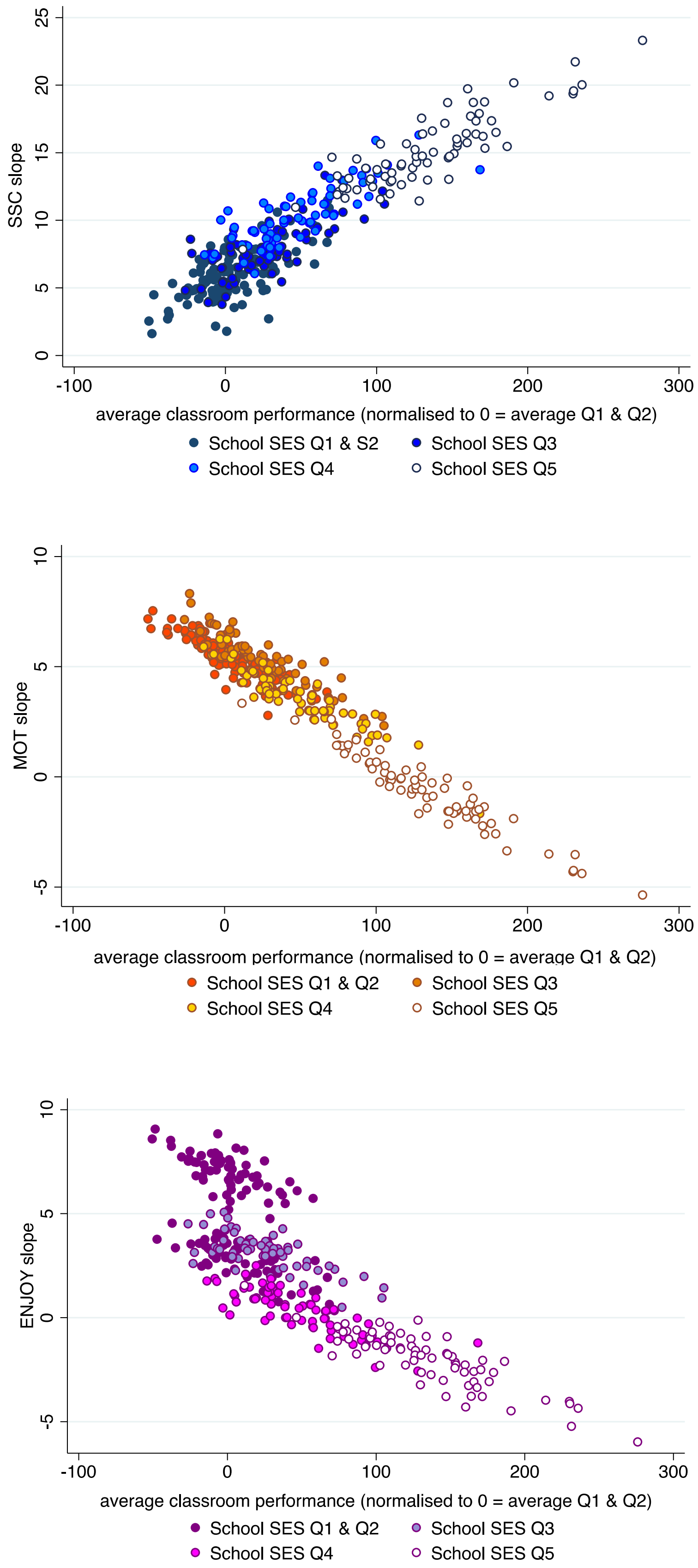
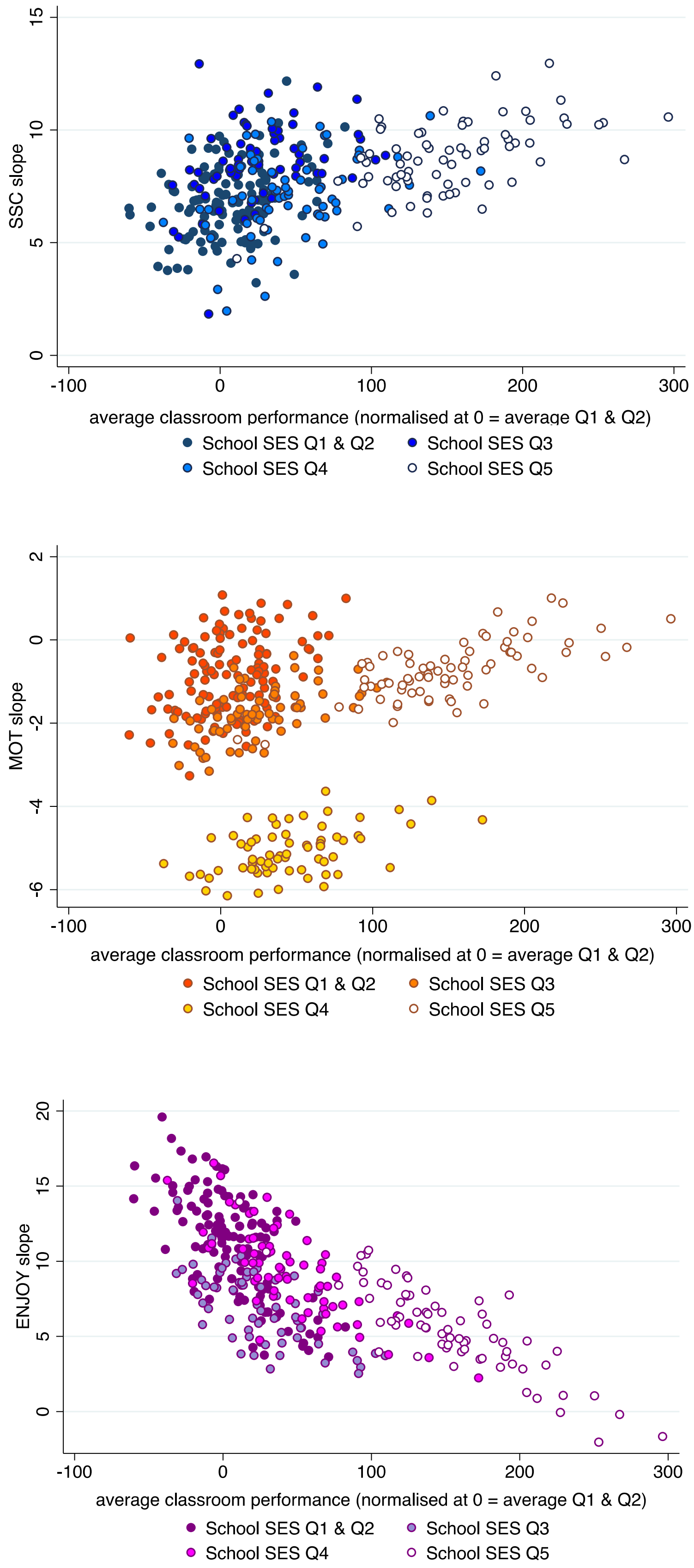


Figure 7: Relationship between average classroom performance and *SSC*, *MOT* and *ENJOY* slopes on science, by school socioeconomic (SES) quintile



ed to a comparison of two students in the same classroom or school with similar achievement, but with very different values on *SSC*, *MOT* and *ENJOY*. Marsh (1986) alluded to this when he argued that being an average ability student in a high-ability classroom may affect self-concept in three ways: First, *SSC* can be below average because comparison is being made to the performances of above-average students; secondly, *SSC* could be above average as a result of group identification/assimilation effect; and finally, *SSC* could be average because the first two occur simultaneously, or the student is unaffected by the immediate context.

It is clear that there is a significant reationship between the three constructs and achievement, yet they manifest varying effects depending on the nature of the context. Comparing the distribution of *SSC* by levels of between- and within-classroom mathematics and science performance, the dispersion of *SSC* was observed to increase as the average ability of the classroom increases. This is in line with BFLPE: The lowest performing students in lower-average ability classrooms have significantly higher *SSC* than the lowest performing students in higher-average ability classrooms. *ENJOY*, on the other hand, was found to be negatively related to average classroom ability, particularly in mathematics. *MOT* showed wider dispersion in lower-average mathematics ability classrooms, whilst lower dispersion in lower-average science ability classrooms. These findings could be related to differences in values and standards of performance across the two subjects under examination, and warrants further investigation in future research.

The classroom-level relationship between the constructs and test performance alters significantly once allowing for cross-level interactions with school (average) wealth. *SSC* is suggested to be more important in mathematics and science for higher performing schools (and high SES schools in the case of mathematics), whereas this return is small if not existent for poorer SES schools. The opposite is true for *MOT* and *ENJOY*, which indicate no real return to mathematic achievement in higher SES schools, yet students with high *ENJOY* see higher returns to performance in poorer and low-ability classrooms.

From the above discussion, it is clear that self-concept is an important construct in determining the academic achievement of South African Grade 9 students. Subject-specific self-concept, extrinsic motivation and subject enjoyment are all revealed to play a unique role in determining performance both within- and between-classrooms, particularly when allowed to vary by school socio-economic status. However, the equivocal nature of academic self-concept renders its achievement more elusive than the provision of additional school resources or teacher training. Further understanding of its nature and measurement in the current educational climate is needed so that it might be managed successfully. This is particularly important in a country such as South Africa, where continued inequality and segregation within the school system can contribute to a sense of hopelessness and lack of motivation. Active steps should be taken to investigate and delineate the barriers that limit student self-belief and motivation, as well as the conditions under which self-knowledge, at a limited cost to performance and motivation, is cultivated.

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Appendix

Table A.1: Description of the self-concept construct questions and TIMSS variables

Math (Science) Questions	Variable name	
	Maths	Science
Subject Self-concept (SSC)	**0.79***	**0.77**
I usually do well in mathematics (science)	BSBM19A	BSBS19A
Mathematics (Science) is more difficult for me than for many of my classmates	BSBM19B	BSBS19B
Mathematics (Science) is not one of my strengths	BSBM19C	BSBS19C
I learn things quickly in mathematics (science)	BSBM19D	BSBS19D
I am good at working out difficult mathematics (science) problems	BSBM19F	BSBS19F
My teacher tells me I am good at mathematics (science)	BSBM19G	BSBS19G
Mathematics (Science) is harder for me than any other subject	BSBM19H	BSBS19H
Mathematics (Science) makes me confused	BSBM19I	BSBS19I
(Likert-scale: 1 = Agree a lot, 2 = Agree, 3 = Disagree, 4 = Disagree a lot)		
Extrinsic Motivation (MOT)	**0.82**	**0.91**
I think learning mathematics (science) will help me in my daily life	BSBM20A	BSBS20A
I need mathematics (science) to learn other school subjects	BSBM20B	BSBS20B
I need to do well in mathematics (science) to get into the university of my choice	BSBM20C	BSBS20C
I need to do well in mathematics (science) to get the job I want	BSBM20D	BSBS20D
I would like a job that involves using mathematics (science)	BSBM20E	BSBS20E
It is important to learn about mathematics (science) to get ahead in the world	BSBM20F	BSBS20F
Learning mathematics (science) will give me more job opportunities when I am an adult	BSBM20G	BSBS20G
My parents think that it is important that I do well in mathematics (science)	BSBM20H	BSBS20H
It is important to do well in mathematics (science)	BSBM20I	BSBS20I
(Likert-scale: 1 = Agree a lot, 2 = Agree, 3 = Disagree, 4 = Disagree a lot)		
Subject Enjoyment (ENJOY)	**0.84**	**0.80**
I enjoy learning mathematics (science)	BSBM17A	BSBS17A
I wish I did not have to study mathematics (science)	BSBM17B	BSBS17B
Mathematics (Science) is boring	BSBM17C	BSBS17C
I like mathematics (science)	BSBM17E	BSBS17E
I like to solve mathematics (science) problems	BSBM17G	BSBS17G
I look forward to mathematics (science) class	BSBM17H	BSBS17H
(Likert-scale: 1 = Agree a lot, 2 = Agree, 3 = Disagree, 4 = Disagree a lot)		
School safety index	**0.78**	
During this school year, how often have other students from your school done any of the following things to you?		
-Made fun of me or called me names	BSBG16A	
-Left me out of their games or activities	BSBG16B	
-Spread lies about me	BSBG16C	
-Stole something from me	BSBG16D	
-Hit or hurt me	BSBG16E	
-Made me do things I didn't want to do	BSBG16F	
-Shared embarrassing information about me	BSBG16G	
-Posted embarrassing things about me online	BSBG16H	
-Threatened me	BSBG16I	
(Likert scale: 1 = weekly, 2 = once/twice a month, 3 = few times a year, 4 = never		

Table A.2: Description of the explanatory variables

Explanatory variable	Description	mean	s.d.	min	max
Male	Gender of the student	0.49	0.50	0	1
Safety index	Index reflecting student's experience of victimisation and bullying at school	-0.18	1.51	-5.04	1.75
SES	Index reflecting level of household possessions, including learning resources	0.00	1.73	-5.55	2.53
SSC math	Subject-self-concept in mathematics	-0.06	1.58	-3.48	3.82
SSC science	Subject-self-concept in science	-0.10	1.53	-2.93	4.39
MOT math	Extrinsic motivation in mathematics	-0.36	1.24	-1.45	5.35
MOT science	Extrinsic motivation in science	-0.41	1.71	-2.04	4.87
ENJOY math	Enjoyment of mathematics	-0.22	1.51	-2.02	3.78
ENJOY science	Enjoyment of science	-0.22	1.40	1.82	4.00
SES Q1	0-20th percentile of school SES	0.22	0.42	0	1
SES Q2	20-40th percentile of school SES	0.19	0.40	0	1
SES Q3	40-60th percentile of school SES	0.19	0.39	0	1
SES Q4	60-80th percentile of school SES	0.19	0.40	0	1
SES Q5	80-100th percentile of school SES	0.20	0.40	0	1
Speak1	Speak test language at home always	0.16	0.37	0	1
Speak2	Speak test language at home almost always	0.14	0.35	0	1
Speak3	Speak test language at home sometimes	0.63	0.48	0	1
Speak4	Never speaks test language at home	0.06	0.23	0	1
Degree	Either parent has at least a degree	0.21	0.41	0	1
Post-secondary	Either parent has at least post-secondary education	0.18	0.38	0	1
Matric	Either parent has at least complete secondary education	0.24	0.43	0	1
Incomplete secondary	Either parent has at least some secondary education	0.08	0.27	0	1
Less than secondary	Either parent has less than secondary education	0.08	0.28	0	1
Don't know	Don't know either of parent's education	0.16	0.37	0	1

Notes: own calculations using TIMSS 2015.