Which Teachers Make a Difference?

Implications for Policy Makers in SACMEQ Countries

by

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Abstract

This paper examines the relative contribution of teacher's education, subject matter competency and pedagogical practices to 6th graders mathematics achievement in Namibia at the start of the 21st century. Drawing on the rich dataset collected by the Southern African Consortium for Monitoring Educational Quality (SACMEQ) between 2000 and 2002, which facilitates rich pupil and school-level controls, and using multilevel modelling to take into account for the nested structure of the data, the study finds that teachers matter, but that their competency or effectiveness was defined differently for high and low SES schools in Namibia. In low SES schools, effective teachers had a high level of subject matter competency, worked in schools with a higher average of years of teacher training and set daily homework. In high SES schools, teacher training continued to be associated with effective teaching, but what the teacher did in the classroom in terms of her practices became more relevant. The significance of teacher training and subject matter competence was also replicated in several other SACMEQ countries. These findings support the notion that effective teachers should not only have a sufficient level of subject matter competency but should also receive adequate teacher training in order to develop effective pedagogical practices and contribute to student achievement.

Introduction

The question of which school factors influence student achievement has stimulated lively debate between researchers for many years. Despite initial studies suggesting a limited role for school inputs in determining student outcomes, there is today a growing body of research that suggests that schools make a difference and that teachers play a key role in that process. There is more controversy, however, over which teacher characteristics and practices make the difference. Is it the length of teacher training that matters? Or is it a teacher's experience? Does what teachers *know* about the subject matter or is it more important to understand what a teacher *does* in their classroom? The answers to these questions are critical at a time when the international community has committed to ensuring all children have access to free and quality primary education by 2015 and increasing teacher shortages are already calling attention to the risk of not meeting this goal.

The purpose of this study is to examine these questions in the African context. With a large share of children out of school, a critical shortage of competent teachers and limited school resources, the need for information to guide policy making in this part of the world is essential. Taking advantage of the rich data set collected by the Southern African Consortium for Monitoring Education Quality (SACMEQ), this study investigated the relative role of teacher factors in 6^{th} graders mathematics achievement in Namibia. It focused on Namibia first because, of the fifteen African countries that are now part of SACMEQ, Namibia was one that showed the greatest variability in key teacher characteristics, hence offering a higher chance of disentangling the relative contribution of each one to student achievement. A previous study by Lee at al. (2004) comparing 14 SACMEQ countries had also shown that a single 'teacher quality' variable constructed from several teacher characteristics was a significant contributor to reading achievement in Namibia. Although SACMEQ provides information on student achievement both in literacy and mathematics, it was decided to start the examination of these issues by focusing on maths achievement, since past research has shown that school factors play a larger role in mathematics achievement than in literacy, which tends to be more influenced by home factors (Fuller and Clarke, 1987; 1994).

Theoretical Background

The controversy as to which school factors contributed to school achievement was sparked in the U.S. in the late 1960's with the Coleman report (Coleman et al., 1966) that concluded that family background characteristics and community level variables accounted for more variance in student achievement than school resource variables like pupil-teacher ratios, per pupil expenditures or teacher characteristics. The Coleman study marked a turning point in educational research in the U.S. since the conclusions were based on the richest and most comprehensive dataset ever collected on American schools, surveying over half a million students and collecting information on more than 3,000 schools. The results, which were disappointing for researchers and society at large, have been challenged on methodological and interpretative ground over the years and hundreds of studies have been conducted in the world around these same questions since then.

In the developing world initial results tended to be more optimistic, showing a stronger impact of schools in promoting student achievement in poorer countries (Heyneman and Loxley, 1983), but subsequent studies led to similar conclusions to the developed world and reaffirmed the dominance of home background in determining student achievement. Using multilevel modelling to analyse data from secondary students in Zimbabwe, Riddell (1989) challenged previous studies by showing that most of the variation in achievement in English and mathematics was attributed to home background characteristics. Other authors also argued that home factors had been underestimated in studies conducted in the developing world by using Western indicators of socioeconomic status that did not really capture local class differences (Fuller and Clarke, 1994; Lockheed, Fuller and Nyrongo, 1989). The stronger contribution of home factors to student achievement has also recently been confirmed by Woesmann (2005a, 2005b) in a study of primary students reading achievement in Colombia and Argentina and in East Asia (Hong Kong, Japan, South Korea, Singapore and Thailand) using TIMSS data to analyze achievements in maths and science and by Ammermuller et al. (2004) in Eastern Europe. Another recent examination of this same issue on cross-national data from the 1994-1995 TIMSS in 36 countries, using both ordinary least squares and multilevel models, confirmed that the predominant role of family background on achievement was similar across nations, regardless of national income (Baker et al., 2002).

Methods to examine the determinants of student achievement have varied, but the production function, favoured by many economists, tends to dominate. Under this framework, the attention is placed on the relationship between student or school outcomes and measurable resources or inputs. Hanushek's reviews (1979, 1997) of over 400 studies in this tradition concluded that there was not a consistent relationship between student performance and school resources after variations in family background were taken into account. Of the teacher factors examined in the studies, he found that teacher education had a positive significant effect on only 9% of the studies and teacher pupil-ratios in 15% of the cases, while teacher experience had the highest proportion of positive significant effects at 29%. However, the fact that there were also several studies that found a negative effect of these same inputs and a large number that found no effect at all led Hanushek to conclude that "there is no strong or systematic relationship between school expenditure and student performance".

Somewhat similar findings were obtained from his review of about 100 studies from the developing world (Hanushek, 1995). He found the results inconclusive regarding the impact of class size and teacher experience, but found that teacher education appeared to have a stronger impact in the developing world. He also recognized that there was a larger share of studies in the developing world that reported a significant effect of school resources, suggesting that school resources are likely to play a more significant role in the developing world than in the U.S. Similar conclusions were reached by Velez, Schiefelbein and Valenzuela (1993) in their review of 18 studies and 88 regressions models from Latin America. Teacher education, subject matter knowledge, active methodologies and teacher experience appeared significant in a large share of the studies, but they found no effect for in-service training and class size.

Hanushek's conclusions have been challenged on several grounds: (i) by more refined meta-analysis of the same education production functions he reviewed that show a stronger impact of school resources; by (ii) new research that attempts to address the complexities of the education process using more sophisticated statistical analysis.

The "vote-counting" approach used by Hanushek in his initial review of the production function studies in the U.S. has been questioned by Hedges et al. (1994). Using more sophisticated meta analysis techniques, the authors reanalyzed the studies reviewed by Hanushek and concluded that global resource variables such as per pupil expenditure are important, as are more specific categories of resources such as smaller schools and classes.

They also concluded that variables that describe the quality of teachers, such as teacher ability, teacher education and teacher experience show very strong correlations with achievement. A subsequent study by the same authors including additional production function studies confirmed their initial findings (Greenwald, Hedges and Laine, 1996).

The fact that there are differences among teachers and that those differences have implications for schools and student learning has been recognized by Hanushek and other researchers that have investigated the problem using an approach that allows the estimation of the impact of differential effectiveness of teachers and schools on student outcomes. These results confirm that there are significant differences in teachers' effectiveness. The difficulty has been on consistently identifying what aspects of teacher attributes are important. Part of the limitation with the economic production function tradition is that it has tended to ignore what goes in the classroom or has examined it through measures of teacher characteristics that are easily available such as years of education or experience, but that are removed from the classroom. It is not surprising that results have tended to be inconclusive in that sense.

Some of Hanushek's recent work has attempted to show that teacher quality matters. Using data from the state of Texas, where several cohort of students have been followed over time (Rivkin, Hanushek and Kain, 2004), the authors developed a model that controlled for fixed students characteristics, schools by grade and in some cases school by year effects and then related remaining differences in achievement gains between grades in cohorts to differences in school characteristics, or teacher composition. The within school variance in teacher quality was based on the notion that teacher turnover increased the variance in student outcomes across grades and cohorts in a school. The results show large differences in student achievement associated with differences in teacher quality, even larger than with class size. However, those differences were not associated with any of the typical measurements of teacher characteristics like education and experience, confirming again that the choice of variables used to assess the contribution of teachers to student outcomes is critical.

In the last few years, a series of reviews have summarized the evidence available regarding teacher preparation and effectiveness (Darling Hammond, 1999; Gustaffson, 2003; OECD, 2005; Rice, 2003; Wilson et al., 2001). Based on research conducted mostly in the U.S. and the developed world, the reviews conclude that:

Subject matter knowledge matters, particularly for higher grades. Research suggests that the relationship might be curvilinear, with diminishing returns at higher levels. It is less conclusive on the kinds or amount of subject matter preparation that best equips teachers for practice suggesting that there might be a need to change the way teachers are prepared to be effective.

Pedagogical knowledge also matters, but research tells little about the specific contents that make a difference.

Teacher experience, as measured by the years of practice, also appears to have a curvilinear relationship, with diminishing returns after a few years of practice; some authors suggesting two years to be the cut off time, others five.

In-service training reviews have concluded that intensity and duration make a difference (Shields et al., 1998; Weiss et al., 1998); that courses that focus on mathematics and science content and the way students learn that content are more effective (Cohen and Hill, 2000); that in-service training can be more cost-effective in raising student achievement than reducing school size or providing additional hours of instruction (Angrist and Lavy, 1998); that professional development activities that focused on specific instructional practices increased the use of those practices in classroom and that active learning opportunities increased the effect of professional development on teachers' instruction (Desimone et al., 2000).

In recent years studies have tried to move away from the economic production function tradition and combine the knowledge gained through qualitative research about the impact of specific classroom practices with large scale quantitative studies and sophisticated analytical methods, in an attempt to better link teacher practices and student achievement. In the U.S., four studies relating classroom practices and student achievement have found positive and significant coefficients relating to:

- a focus on higher order thinking skills in maths (National Center for Education Statistics, 1996);
- reform oriented classroom practices in California (Cohen and Hill, 2000);
- the use of higher order skills, lower order skills, hands-on learning, traditional assessment and authentic assessment (Wenglinsky, 2002)[1]; and
- classroom management skills, individualisation and student engagement (Fidler, 2002).

In the developing world several studies have also investigated the relative impact of teachers on student achievement using multilevel modelling. In general, results have shown limited impact of traditional teacher characteristics like teacher education, training and in-service, results consistent with the literature in the developed world and confirming the inadequacy of those indicators to capture the different contribution of teachers to student achievement. The general picture from these studies remains ambiguous: for example, no effect for in-servicing training was found by Raudenbush et al. (1992) in Thailand but an effect was found by Fuller, Hua and Snyder (1994) in Botswana.

Teachers' subject matter knowledge, where tested, has been found to be a better predictor of student achievement with positive effects found by Mullen et al. (1996) in Belize, Harbison and Hanushek (1992) in Brazil and Fuller et al. (1999) in Brazil (for language proficiency). Evidence for the importance of classroom practices on student achievement is emerging from the developing world with Lockheed and Komenan (1989) finding a positive relationship between increased teacher lecture time (Nigeria) and time spent monitoring and evaluating student performance (Swaziland) and student achievement. In Brazil, Fuller et al. (1999) found that student literacy achievement was higher when they were in classes with children more consistently engaged in instructional tasks; when the teacher spent less time disciplining children; when more structured tasks were organized throughout the school day; and when they relied on more student-made materials and products. In the context of the Francophone African countries, some significant and positive effects of teachers' education attainment

[1] This study also found that the total size of the teacher quality effects were potentially larger than the home background effect on achievement

(Michaelowa, 2001) and continuation training (Michaelowa, 2000) have been found using data from the Program on the Analysis of Education systems (PASEC), but they are not consistent effects across countries. Bernard (1999) finds that if a teacher is able to correctly detect mistakes when correcting a fictitious student's dictation, this produces a significant and positive impact on student performance. However, there is no significant correlation between the results of this exercise and the teacher's own educational attainment.

Research Questions

It is clear from the review of existing literature that while teacher quality has proven to be an important factor in determining student achievement both in developed and developing countries, it has proven more difficult to identify what characteristics of a teacher's background, knowledge and practices make the difference. Methodological constraints have certainly contributed to these inconclusive results. More sophisticated statistical analysis and more refined conceptual approaches to the teaching and learning process allowed to re-examine these issues today in the context of Namibia. This article explored the following research questions:

1. After controlling for student home background factor and school resources, what was the relative contribution of teachers' education and training, subject matter knowledge and classroom practices in promoting 6th graders achievement in mathematics?

2. Were the effects of teachers' educational background, competencies and practices similar in schools with pupils of higher socio-economic (SES) and lower socio-economic backgrounds?

3. For which countries might these findings be replicable?

Brief description of Namibia[2]

The Republic of Namibia attained national independence from the former apartheid South African government in 1990, after many years of political, diplomatic and armed, national liberation struggle. The country spreads over an area of 824,269 square kilometres and is one of the driest countries south of the equator, characterised by frequent droughts. The distribution of the population follows the rainfall pattern, with over 60 per cent of the 1.8 million people living in the northern parts of the country and the remaining 40 per cent of the population sparsely distributed across the rest of the country. With a population growth rate of between 2.6 and 3.0 per cent per annum, the demand for school places is ever increasing and exerts further pressure on the available resources.

Namibia *may* be regarded as a middle income country with a per capita income of US$2,000 and endowments of uranium, diamonds and other minerals. However, 65 per cent of the country's income is concentrated in the hands of 10 per cent of society. As a result, the ratio

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[2] The background information about Namibia and its education system presented in this paper comes from the country SACMEQ II Report.

of per capita income between the top 5 per cent and the bottom 50 per cent is about 50:1. This extreme inequality of socio-economic circumstances is important to the understanding of inequalities in the development of the Namibian education system.

A total of 486,252 pupils were enrolled in Grades 1-12 in 1995. By 2000 this number had increased by an average of 1.8 per cent per annum to 530,554 pupils. The number of teachers also increased from 15,531 in 1995 to 17,332 by the year 2000. Gross enrolments rates for primary school in 2001 were 106 per cent and net enrolment rates were 78.2 per cent with about 81,000 children of school age remaining out of school. The average repetition rate for primary school was 13 per cent and the average dropout rate 13.7 per cent, with higher rates of repetition and dropout in first and fifth grade. The survival rate to grade 5 and 6 was 94.2 per cent and 86.3 per cent, respectively (UNESCO, 2005). Grade 5 is the first year of upper primary and the first year that instruction is in English rather than a native language.

The whole country was sub divided into 13 regions at end of 2002. While the Ministry retains overall responsibility for the running of the education system, it is the regional education offices that carry the bulk of the implementation of educational programs on a day-to-day basis by working closely with schools and communities in their respective regions. See Appendix I for additional information on the education system in Namibia and the geographical distribution of schools.

Data

The data used to carry this study came from the 2nd Southern Africa Consortium for Monitoring Education Quality (SACMEQ) survey of data on fifteen African education systems collected between 1998 and 2001. The main focus of SACMEQ II was an assessment of the performance level of 6th grade students and their teachers in the areas of literacy and mathematics. Around 50,000 students, 5,000 teachers, and 2,500 school principals from 2,500 primary schools were involved in the project. The target population was all students at grade 6 level in the year 2000 at the first week of the month of school year who were attending registered mainstream primary schools. Small schools and special education schools were excluded from the target population. See Appendix II for additional information on SACMEQ and the instruments used.

In the case of Namibia, strong clustering required a larger sample than the rest of SACMEQ countries and 270 schools were included from the 13 regions of the country. Students in schools with less than 15 students in grade 6, students in inaccessible schools and in special schools were excluded which represented 882 students, or 1.8 per cent of all students. Within each sampled school, fixed-size clusters of 20 grade 6 students were randomly drawn from across grade 6 classes. In all, a 91.8 per cent of the planned students were included in the final sample and 100 per cent of schools, representing 5,048 students out of 5,500 initially planned. The reason for the shortfall was student absenteeism the day the data was collected.

The instruments developed by SACMEQ II include a student test on basic literacy and mathematics, a student questionnaire, a teacher questionnaire, a school head questionnaire and a subject matter test for teachers.

The mathematics test for teachers and students

Mathematics literacy was defined as “the capacity to understand and apply mathematics procedures and make related judgments as an individual and as a member of the wider society". The focus of the test for both pupils and teachers was on assessing skills related to the curriculum. Three domains were identified as critical: number, measurement and space-data. Most test items were multiple-choice with four options per item. The teacher test was fine-tuned in order to ensure the difficulty range would suit the higher level of competence of teachers but at the same time provide enough overlap with the student test to permit the performance of students and teachers to be measured on the same scale.

The student questionnaire

There were 26 items in the student questionnaire, covering basic information about the student and his home background, parental education, availability of reading materials at home, parental practices regarding homework and reading, and basic information regarding learning resources at school.

The teacher questionnaire

There were 31 items in the teacher questionnaire. They covered information about the teachers' education and home background, learning resources available in class, time allocation, views about teaching, a self-report on their classroom practices and opinions on school head support and inspectors.

The school head questionnaire

The school head questionnaire included 34 items. It assessed basic information about the school heads education, training, and personal background; school and teaching staff characteristics, school operations and school facilities.

Hierarchical data structure

The SACMEQ II data for Namibia follows a hierarchical structure as shown in table 1.

{Insert table 1 here}

Traditional regression approaches assume fixed classroom or school level effects on achievement. But these level 2 (school) factors may also shape the distribution of the student achievement (level 1) inside the classroom. Since, for example, we wanted to explore whether certain teacher characteristics influenced the mean achievement of any given classroom *and* moderated the disparity in achievement that was associated with different socio-economic backgrounds, a multilevel model was fit to the data in order to explicitly recognise the hierarchical structure present. The consequences of failing to do this are as follows:

- aggregation to the school-level discards almost all information about pupils, so causal interpretation is highly unreliable;
- retaining the pupil-level information, ignoring clustering produces standard errors of regression coefficients that are generally underestimated; and
- retaining the pupil-level information and using fixed effect dummies to distinguish between schools is inefficient. We would also be unable to explain the differences in school effects, which is exactly our purpose.

The MLwin software (Rabash et al., 2004) was used to implement the procedures[3]. Further discussions of multilevel modelling can be found in Bryk and Raudenbush (1992), Longford (1993) and Goldstein (1995).

Measuring and Locating Variability in Pupil Maths Achievement

The dependent variable in this study was a continuous and normally distributed measure of maths achievement. This variable, along with all other variables used and constructed for this study, is described in appendix III. Each student was tested in the eighth month of his or her sixth-grade year. Test scores, equated with Item Response Theory (IRT) methods, were standardized across SACMEQ countries to a mean of 500 and standard deviation (s.d.) of 100. In Namibia, the mean maths score was 438 which was 0.62 s.d. below the average for the whole of SACMEQ II. The variance in maths achievement between pupils was lower in Namibia than the average for SACMEQ II: the s.d. was 87 (versus 100 for SACMEQ II). Table 2 partitions the residual variance in the maths test score into components corresponding to each level in the hierarchy.

{Insert table 2 here}

Too small a proportion of the total variability in maths achievement in the data was explained at the teacher level; therefore it was not possible to specify a model with teacher as a level. There were several reasons why this might have been the case. First, only 54 of the 270 schools had more than one teacher. Second, there might have been too few pupils sampled in the multi-teacher school classroom to isolate a significant effect. Finally, it is possible that there was a high degree of homogeneity between teachers within schools. It was therefore necessary to aggregate all teacher variables to the school level.

The lack of teacher as a level in the model slightly altered the research question but was legitimate in the absence of a control for prior achievement since achievement in this case was the result of students' accumulated learning over different grades and teachers in the same school. The study attempted to isolate the totality of the effect of the teachers at a school on maths achievement and relate this to the characteristics of the entire teaching body at a school. Therefore, as far as possible, the teacher variables will reflect the characteristics of all teachers, regardless of whether they had taught the pupil in question.

Only the proportion of variance that lied systematically between schools (the coefficient of intra-class correlation or ICC) as opposed to within schools might be explained by school effects. About 45 per cent of the variance in maths achievement lies within schools, leaving an ICC of 55 per cent. This is very high compared to developed countries where 20-40 per cent would be more common.

[3] IGLS estimation procedure was used, with results replicated using MCMC methods to check robustness of procedure.

Pupil control variables[4]

Pupil maths achievement was defined as being conditional *only* on a measure of the socio-economic status of the child.[5] Ideally we would have preferred to also have a measure of prior achievement but this was not available in the SACMEQ II dataset. It was important that the pupils' family background be accounted for in exploring school effects on educational outcomes since it affects the level of achievement of the pupil, regardless of the school the pupil attends.

It was important, if at all possible, to aggregate a variety of pupil social characteristics into one variable to examine the interaction between pupil SES and teacher characteristics. The pupil SES control selected for the final model, *pupilses*, weighted two key factors equally and captured the within-school variability in SES by standardising each score on the school mean:

1. the quality of the pupil's home environment including the building fabric and the number of possessions at the home, such as radios, telephone, refrigerator, piped water and electricity; and
2. the average education level achieved for the pupil's mother and father. Rather unusually, in Namibia parent's education displayed quite a low correlation ($\rho=0.3$) with pupil maths achievement.

There were other pupil characteristics that were associated with pupil maths achievement, such as meal regularity and the amount of English spoken in the home. However, for the purpose of this study it was just necessary to ensure the pupil-level variables acted as sufficient controls to isolate teacher effects, and not to explain total variability in maths scores. Including a richer set of pupil-level variables did not change the findings.

Since the focus of the study was on the total teacher effect on achievement, there was no need to include an indicator as to whether the pupil had repeated grades or not. This variable could be used as a proxy for differential ability (within school); however, the decision to repeat a grade was entirely endogenous to the schools' policy (with respect to grade repetition) and teaching practices so it was not included.

Variables describing school context

This 'schools effect' study focused specifically on isolating and explaining the teacher effect on pupil outcomes; therefore, all other school-level variables acted as controls on this relationship. It was important to control for those characteristics that might also contribute to educational success because in general teachers are not randomly allocated to schools. The school measures were drawn from aggregates of student variables or reports from school principals:

1. *schresources* is a continuous (mean 0, s.d. 1) variable indicating the resources a school has from a list of 22, including library, hall, electricity, telephone and computer. The square of this variable *schresources^2* was also included to capture non-linearity in the relationship between school resources and mean maths achievement.

[4] Further descriptions of the instruments used to construct all variables can be found in appendix III.

[5] Sex of pupil was used in early models; but only to explore the differential effect of teacher characteristics by gender, since mean math achievement did not differ by gender.

2. *schses* is a continuous (mean 0, s.d. 1) variable which aggregates the pupil-level SES variable. This variable was highly correlated (ρ=0.8) with school resources, therefore the two variables should be interpreted jointly. The square of this variable *schses^2* was also included to capture the very high degree of non-linearity, shown in figure 1. It is possible that this non-linearity could be entirely explained by the nature of existing resource allocation to schools in Namibia; in which case the squared-term would not be necessary.
3. *schsize* is a continuous (mean 0, s.d. 47) variable indicating the size of the school. It was centred on zero, which corresponded to there being 85 pupils in grade 6.
4. *schprincipal* is a continuous (mean 0, s.d. 8.8) variable indicating the school's principal's total years of experience. It was centred on zero, which corresponded to their having 13 years of experience.

{Insert figure 1 about here}

Other school controls were tested but were not found to be significant; notably an indicator for whether the school had shifts or was in an urban area. Mean maths achievement was allowed to vary by region since the variance components model in table 2 indicated that 21% of the total variability was at this level. However, once the school and pupil control variables were added, this variance became insignificant.

Variables describing teachers

Twelve school-level variables describing teachers were selected on the basis that they showed some (unconditional) correlation with pupil achievement. They were intended to characterise the complete teaching body of a school and not those of the grade 6 maths teacher specifically. Therefore, as far a possible, they were constructed using the report from the principal on the teaching body. However, a limited number of variables had been constructed from the teacher questionnaire, and here the opinions of the grade 6 teacher were intended to act as a proxy for the opinions of all teachers in that school[6]: The variables were grouped into three types, in relation to the research questions discussed earlier: education and training; subject matter knowledge; and pedagogical practices. The variables are summarized in table 3.

{Insert table 3 here}

The relationship between the grade 6 maths teacher competency, as measured by their test score, and pupil maths achievement was found to be non-linear (both unconditionally and conditioned on a full set of controls)[7].

[6] Where there is more than one grade 6 teacher the opinions are combined.

[7] The effect of math teacher competency peaked around 1 s.d. above mean teacher competency.

A wide range of other teacher variables (and alternative specifications of these variables) were tested but not found to be significant in early stages of the model. These included:

- an indicator for schools with higher concentrations of teachers with only primary education themselves;
- a principal reported question characterizing the extent of bullying or bad language by teachers and drug/alcohol abuse;
- a general question asking about health problems among the teaching staff;
- maths teacher preferences for setting homework and recitation in class.

Analytic Method

Model Building Strategy: the Baseline Model

The baseline model contained no teacher effects variables: pupil maths achievement ('*pupilmathscore*') (of pupil i in school j in district k) was simply modelled as a function of the pupil background ('*pupilses*') and school-level controls ('*schoolcontrols*'), but achievement was allowed to vary across schools.[8] It was this school-level unexplained variance that according to the hypothesis might be due to between-school differences in teacher quality. The model was defined as follows:

$$pupilmathscore_{ijk} = \beta_{0ijk} + \beta_1 pupilses_{ijk} + \beta_2 schoolcontrols_{jk} + u_{0jk} + e_{0ijk}$$

where: $u_{0jk} \sim N(0, \Omega_u)$

$e_{0ijk} \sim N(0, \Omega_e)$

This model resulted in a very large (over 75 per cent) reduction in between-school unexplained variance in the variance components model[9] (see Tables 4 and 5). However, the high degree of pupil clustering meant that the reduction in within-school variance was modest. The model indicates that the level of school resources had a strong impact on pupil achievement. However, as was pointed out earlier, this variable was collinear with the school mean SES of pupils so it was not possible to disentangle these two effects with any confidence.

{Insert table 4 here}

It did not prove necessary to allow mean achievement to vary by region because the regional differences in pupil achievement could be explained by the differing characteristics of both

[8] Relevant pupil-level sample weights are applied to all analysis (pweight2 in SACMEQ dataset).

[9] A reduction from σ^2_u=4,164.027 to σ^2_u=747.995

pupils and schools by region[10]. However, in subsequent models the effect of teacher variables were allowed to vary by region.

Model Building Strategy: Random Intercept Teacher Effects Model

The first specification of the teacher effects model tested whether the 12 school-level teacher variables (‘*teachervars*’) were able to reduce the unexplained residual for each school. This specification was a random intercept model: the coefficient on the teacher variables was fixed but the overall (unexplained) school effect was allowed to vary according to school:

$$pupilmathscore_{ijk} = \beta_{0ijk} + \beta_1 pupilses_{ijk} + \beta_2 schoolcontrols_{jk} + \beta_3 teachervars_{jk} + u_{0jk} + e_{0ijk}$$

where: $u_{0jk} \sim N(0, \Omega_u)$

$e_{0ijk} \sim N(0, \Omega_e)$

Table 5 provides estimates showing that five of the 12 teacher variables were significant in this particular model.

{Insert table 5 here}

Model Building Strategy: Random Slopes and Interactions

As explained earlier, the development of the Namibian education system by region has been uneven. Therefore, the school-level variables indicating the average years of teacher training in the school (*tchtraining*) and a binary variable indicating if the grade 6 teachers had not attended in-service training in the past three years (*tchnoinservice*) were allowed to vary by district. This reflected between-district differences in past and current policies with respect to training. For example, some districts had fewer fully trained teachers; therefore they were using in-service training to complete their teaching certification.

An interaction was added to identify the differential effect of not having had any in-service training in relation to the proportion of teachers who were not trained in the school. The rationale for this interaction was that a detrimental effect of having had no recent in-service training in schools should be witnessed where the overall years of teacher training were low.

An interaction was also added between the teacher maths competency and the level of teacher training. It was hypothesised that the effectiveness of teacher training might depend on the maths competency of the teacher in question.

Finally, it was tested whether the teacher’s competency in maths might influence the level 1 slopes between children’s family background characteristics and their achievement, that is, moderating or exacerbating SES effects. This was done via an interaction between the pupil SES and the teacher’s maths competency. Ideally, a measure of pupil prior attainment would have been included, but as was mentioned before, this was not available. Therefore, the variable should be interpreted with care. Since *pupilses* indicated within-school variability in

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[10] The possibility that the pupil-level variance was not constant across SES was also tested; but though the resulting model was marginally significant, it appeared to be unduly influenced by very few high SES and high achieving outliers.

SES levels, an interaction between *schses* and *tchmathscore* was also included to identify differential effects of maths competency on between-school effectiveness.

The final model was defined as follows:

$$pupilmathscore_{ijk} = [\beta_{0ijk} + u_{0jk} + e_{0ijk}] + \beta_1 pupilses_{ijk} + \beta_2 schoolcontrols_{jk} + \beta_3 fixedteachervars_{jk} + [\beta_4 tchtraining_{jk} + v_{4k}] + [\beta_5 tchnoinservice_{jk} + v_{5k}] + \beta_6 tchnoinservice.tchnottrained_{jk} + \beta_7 tchmathscore.tchtraining_{jk} + \beta_8 pupilses.tchmathscore_{ijk} + \beta_9 schses.tchmathscore_{ijk}$$

where: $v_{0jk} \sim N(0, \Omega_v) : \Omega_v = \begin{bmatrix} \sigma^2_{4k} & \\ \sigma_{4k}\sigma_{5k} & \sigma^2_{5k} \end{bmatrix}$

$u_{0jk} \sim N(0, \sigma_{0u})$

$e_{0ijk} \sim N(0, \sigma_{0e})$

Isolating Teacher Effects

Often local clustering of a set of teacher characteristics is found due to commonalities in the social background of teachers in a region, common teacher recruitment and training policies in a district, or simply endogeneity in the allocation of teachers to particular school types (i.e. certain types of teachers systematically select certain types of schools). If school fixed characteristics and teacher characteristics were collinear, we would not be able to distinguish the effects of the two on pupil achievement. The implications of this could run in either direction: we might be forced to conclude that a particular teacher characteristic did not result in increased pupil achievement or that the size of the teacher effect was lower than it actually was (i.e. a type II error); alternatively, the findings might suggest that a particular teacher characteristic resulted in greater pupil achievement when in fact the significant coefficient resulted not from causal relationship but from an 'omitted' pupil or school context variable that explained both (i.e. a type I error).

In this case, teacher variables were not *highly* correlated with school contextual effects. However, there was a 'clustering[11]' of particular teacher characteristics in well-resourced and high-SES schools where:

- teachers had a higher mean average years of teacher training;
- teachers were more likely to be tertiary educated;
- the grade 6 maths teacher had higher than average maths competency and prefered 'traditional' teaching methods.

{Insert table 6 here}

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[11] Correlations of between 0.25 and 0.53

Correlations between teacher variables

Where variables explaining teacher characteristics are correlated, it is difficult to separate the effects of the variables on pupil maths achievement. Fortunately, no teacher variables in the data displayed a correlation of more than 40 per cent. However, as above, clustering occurred because schools with high average teacher training years for staff also had a higher than average proportion of teachers with tertiary education, more female teachers, a grade 6 maths teacher with higher than average maths competency and preferences for more 'traditional' teaching methods such as individuals working alone. See full table of correlations between variables in tables 7 and 8.

{Insert table 7 here}

{Insert table 8 here}

Results

Presentation of ML Modelling Results

Three models are presented here. The first was estimated for all 4,990 pupils in the model and is presented in table 9. The model showed a positive pupil SES effect both within-school and between-school; this means that within a classroom, the higher SES pupils had a higher expected maths score and that schools with a higher mean SES of pupils also had a higher expected mean maths score. As explained earlier, it was not possible to interpret the positive coefficient on school resources as indicative of a causal effect due to its correlation with school SES.

In this model a significant (and signed as expected) effect was found for a large set of teacher characteristics, including maths competency and teacher training levels (and interactions between these and SES). However, few of the pedagogical practice variables were significant; only the variable that identified schools that set homework daily had a significant effect on expected mean maths score. The negative association between school achievement and the teacher never meeting parents was only borderline significant.

{Insert table 9 here}

The high level of complexity of this model – with many nonlinear variables, interactions between variables and impact of training levels varying with respect to district – generally resulted from the highly segregated nature of the Namibian education system. A section of the Namibian sample was of substantially higher SES and was educated in schools with far greater resources. As far as possible, the analysis attempted to control for the fixed contexts these schools operate in. However, there was a concern that some of these coefficients were confounded by the high degree of clustering of particular teacher characteristics in the very high SES schools in Namibia. To address this, the model was re-fit excluding all schools where the mean SES of the pupils was one standard deviation above the school mean for Namibia (figure 1 shows the extent to which these schools had much high mean pupil achievement). The result of doing so was that the variance of response in many of the teacher characteristics was substantially reduced (as was the variance in the response variable), thereby increasing the risk of committing a type II error (being forced to accept the null hypothesis of no effect when one does in fact exist). However, this seemed preferable to the possibility of claiming to find teacher characteristics effects that were actually confounded by the fixed characteristics of the school.

Table 10 shows the estimates for this model that excluded the 1,252 pupils (25 per cent of sample) who were educated in the high SES schools. A variance partition model shows that the ICC for this new sub-sample was low at 16.4 per cent, suggesting a high degree of homogeneity between these lower SES schools. The model was successful in explaining 50 per cent of the between-school variability in mean maths achievement.

When these high SES schools were excluded the expected mean maths achievement was no longer dependent on the SES of the school's intake. However, a pupil whose SES score was 1 s.d. above the class average was expected to achieve a marginally higher (3 points) maths score. Once again, the level of school resources had a strong effect on pupil achievement, but it was now linear.

{Insert table 10 here}

A more limited set of the teacher variables remained significant in this model: years of teacher training, teachers subject matter competency and their interaction and the setting of daily homework. It is not possible to know whether this was because there was *actually* no effect or because no effect could be identified given the reduced variance of teacher characteristics in this sub-set of Namibian schools.

For completeness, a model for the 25 per cent of pupils educated in the high SES schools in Namibia was estimated. The ICC between these 65 schools was extremely high at 58 per cent; however, the model explained 92 per cent of this between-school variance. Table 11 sets out the results for the high SES schools. Many teacher variables were significant in this model and particularly those regarding pedagogical practices. A brief interpretation of these is discussed in the next section. However, the teacher maths competency variable and teacher experience were significant but wrongly signed (negative). The negative relationship between *very* high maths competency and pupil achievement had been consistently found in the Namibian schools data. The discussion section examines the characteristics of these high maths competency teachers to try and explain why this relationship persisted in the data.

{Insert table 11 here}

Discussion of Findings

The second model – excluding the high SES schools – forms the basis for most of this discussion since it is the model where with more confidence the teacher effects have been isolated and non-confounded. The teacher variables that were significant in this model are:

Teacher Maths Competency (*tchmathscore*): A teacher with a maths competency score of 1 s.d. above Namibia's average would, all else being equal, produced an 8 point increase in pupil achievement. This effect wass linear in this model. Figure 2 shows that Namibia was characterised by quite low overall teacher maths competency (mean = 735 score), relative to some of the other SACMEQ countries, with higher variability in teacher competency. This high variability made possible to isolate a teacher maths competency effects where others had not. The linearity of the effect of this variable over this sub-set of schools meant that it is not possible to state a minimum level of maths competency that is desirable; there were no diminishing returns to competency levels. This contrasts with the first model for all Namibian school in table 9 where the effect of maths competency was non-linear.

{Insert figure 2 here}

The effect of being taught by a teacher who was competent in maths might by greater for the higher SES pupils in the class, though this was only borderline significant. Because of the absence of a prior achievement control, SES is most likely acting as a proxy for either ability or pupil capacity to learn. The implication is that Namibian schools with higher maths competency teachers may have high mean levels of achievement (the 'intercept') but may also have greater 'slopes' with respect to the SES of the pupil, producing greater within-classroom inequity in educational outcomes by SES. This is illustrated in figure 3.

{Insert figure 3 here}

The effect of being taught by a teacher who was competent in maths was greater where the overall SES of the pupils in the school was higher. This meant that a teacher with high maths competency (of 1 s.d. above Namibian mean) would produce 8 point increase in the mean expected pupil maths score in a typical Namibian school (where the pupil mean SES equals the mean for Namibia). However, if they were placed in a higher SES school, the gains in expected pupil maths score would rise to 18 points. Again, SES is likely to be acting as a proxy for mean ability.

Teacher Training (*tchtraining*): the average years of teacher training at a Namibian school was 2.4 years. A school with highly trained teachers (so for example their mean years of training was 3.4 years) would, all else being equal, produce a higher expected mean pupil achievement (8 points higher). There was also a significant interaction between teacher training and the maths teacher competency. This could be interpreted in one of two ways:

1. The effect of teacher maths competency on pupil achievement was at it's greatest where the teacher had been trained in how to teach maths; or
2. Teacher training produced larger gains if the teacher's themselves were competent in the subject they were trained to teach.

Figure 4 shows that there was little gain to be made from having higher competency teachers if they had received little teacher training. There was also little gain to be made in training teachers who continued to have low maths competency. The substantial gains in expected pupil achievements resulted from the combination of having maths teachers with high competency who had also completed the 3 years teacher training programme. This does need to be interpreted with some care since the teacher training variable related to training levels in the entire school, not just those of the grade 6 teacher.

{Insert figure 4 here}

The Setting of Daily Homework (*tchhwdaily*): The 93 per cent of schools where the pupils reported receiving daily homework had an associated effect of a 10 point increase in pupil achievement. It is impossible to infer that the causation was direct: schools where homework was set daily might have other shared characteristics such strong school policies in areas other than homework, more traditional teaching methods or greater focus on exam achievement.

Discussion of the High SES Model

Table 11 shows the estimates for the model of 65 schools with a mean pupil SES of at least 1 s.d. above the Namibian mean. The results should be interpreted with a great deal of caution since there were only 65 schools, with very high variability of pupil mean achievement, and the school level residuals were not very well-fitted. The effect of teacher training on pupil achievement remained significant and positively signed, but an effect for the teacher's years of experience was found: for these 65 schools, the less experienced teachers appeared to be producing a greater effect on achievement.

Many pedagogical practices were significant in this model. There was a positive effect associated with those schools who set daily homework and those schools where teachers met the parents. Teachers who displayed a self-reported preference for pupils working alone, rather than in pairs, produced a greater effect on achievement; as did teachers who reported that they used everyday and local examples in their teaching of maths. Time spent teaching was positive and significant, possibly because these schools also had longer lesson time for pupils.

The teacher math competency variable was negative and significant in this model. This identified the phenomenon in the Namibian data (see figure 5) where relatively few very high competency teachers were associated with lower pupil achievement. This is counter-intuitive and takes some explaining, though it is worth noting that it is only negative because the interaction between competency and school SES is included in the model. When this is removed, or 3 outlying teachers are removed, competency becomes insignificant.

{Insert figure5 here}

Replication of Teacher Effects Model to other SACMEQ Countries

We replicated a reduced version[12] of the teacher effects model in the other eleven SACMEQ II countries who administered a teacher competency test. These were Botswana, Kenya, Lesotho, Malawi, Mozambique, Seychelles, Swaziland, Tanzania, Uganda, Zambia and Tanzania (Island of Zanzibar). The specification and results of this model are in table 12. We specifically wanted see whether a significant effect of teacher training and teacher maths competency could be isolated in any other countries. However, replicating a model developed for one country is risky because the SES and resource controls appropriate to Namibia may not adequately capture the true fixed circumstances of a school in another country. Therefore, all findings should be interpreted as indicative only, reflecting an increased chance of omitted variable bias.

{Insert table 12 here}

Teacher training. A positive and significant effect of average school level of teacher training on pupil maths achievement was found in five of the eleven additional SACMEQ countries examined. These are Lesotho, Malawi, Seychelles, Swaziland and Zanzibar. Of the remaining six countries:

- the Ugandan model produced a positive and significant teacher training effect when pupil mean achievement was allowed to vary by district[13];
- the Mozambique model produced an effect, but only via the interaction with teacher maths competency;
- Kenya and Zambia had no variability in average teacher training years, therefore finding an effect would be technically impossible (see figure 8);
- Tanzania and Botswana had relatively few schools with an average far below the median of 2 years, so assuming it was lack of teacher training (rather than benefits to more than 2 years) that matters; it was not surprising that there was no effect.

{Insert figure 6 about here}

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[12] Other models with fuller sets of teacher characteristics were also tested.

[13] In general the Ugandan model was not a success, with a large proportion of the unexplained school-level variance attributable to the district-level.

Teacher maths competency. A positive and significant effect of grade 6 teacher maths competency on pupil maths achievement was found in five of the eleven SACMEQ countries studied. These were Lesotho, Mozambique, Seychelles, Swaziland and Zanzibar. In addition, a positive and significant coefficient was found in Botswana, but only under certain specifications of the model that included other teacher characteristics. The data included only a measure of the grade 6 maths teacher competency, yet a pupil achievement is total maths achievement and not progress between grades 5 and 6. Therefore, to claim a causal effect of maths competency on pupil achievement in these countries, at least one of the following statements must be true:

- that a pupil was able to make significant progress in maths in grade 6 (relative to overall achievement in test) if taught by a teacher competent in maths;
- that the grade 6 maths teacher was likely to have taught the pupils maths for more than one grade (more likely to be true in smaller schools); or
- that there was some clustering of maths competency amongst teachers in a school, such that the grade 6 maths teacher competency acted as a proxy for general maths competency at the school.

No effect of teacher maths competency on pupil achievement was found in the remaining six (or seven if Botswana is included in this list) countries. Figure 2 shows that this absence of effect could not be attributed to lower variance in teacher scores in these countries. It must be true that the level of maths competency of teachers matter in some circumstances and the absence of any effect might be for one of the following reasons:

- that teacher competency did not matter above a certain level (for example in Kenya teachers generally have much high competency than in other SACMEQ countries);
- that an effect might be isolated with a better specified model that had, for example, a measure of prior attainment or better school controls; or
- that an effect might be isolated if there was a test score for every teacher who had taught the child maths.

Overall, this study appeared to find more 'teacher quality' effects than the model of reading attainment using the same SACMEQ II data reported by Lee et al. (2004); this may simply be because this study examined maths rather than reading achievement. They found a positive and significant effect for an aggregated teacher quality variable in Botswana, Mozambique, Namibia and Seychelles. However, as with their findings, given the data - with no prior attainment measure and not enough teacher-level variance – it is important to be cautious about these findings. For the most part not enough significant effects on the pedagogical variables were isolated as was expected. However, this is likely to have been due to the nature of the self-report teacher questionnaire, which allowed teachers to claim they were using all methods in their classroom, rather than force them to choose between teaching methods they prefer. As a result these variables had relatively little variability.

Policy Implications

The results of this study confirmed that in Namibia, teachers matter. Over and above the effects of pupil socioeconomic background and school resources, it was possible to isolate the effects of specific teacher characteristics. Specifically, the study found that teacher effectiveness could be attributed to a combination of teacher training, subject matter competency and pedagogical practices. This study goes one step further in showing that teacher effectiveness was expressed differently in high and low SES schools. The separate models developed, which took into account of the nesting of children within schools and regions, were able to explain half of the school-level variation in pupil math achievement in low SES schools and almost all school-level variation in high SES schools.

In schools with a lower mean SES of pupils, mathematics achievement would be higher if, all else equal, the school had most of their teachers trained and the 6^{th} grade math teacher had a higher level of maths competency. The fact that these two factors interacted supports the conclusion that neither subject competency nor classroom competency is sufficient on its own to produce high quality teachers; teachers needed to be both competent in mathematics and trained as a teacher to be effective. As figure 4 showed, all other things being equal, when the level of subject matter competency of a teacher was one standard deviation below average, regardless of the average years of teacher training in the school, pupil expected achievement would be about the same. However, when a teacher maths competency was two standard deviations above the mean, in schools where average years of teacher training were below two, expected pupil achievement would be 402 while in schools with almost four years of average teacher training, pupil achievement would be 448. In these schools, pupil achievement also tended to be higher if daily homework was set, suggesting that teacher practices were important.

In high SES schools, interestingly enough, years of teacher training continued to be a significant predictor but teacher pedagogical practices became more critical. Pupils tended to achieve at higher levels in schools where, again, teachers set daily homework, but also where teachers reported using local problems to teach math, had students working alone rather than in pairs, and met with parents. They were also the sixth grade teachers that reported having more lessons hours per week that tended to have higher achieving pupils. The indication in the high SES model that very high levels of maths competency was associated with lower achievement should almost certainly be ignored: they were unduly influenced by 3 teachers in the sample of 65 high SES schools.

The findings also show that within any one classroom, the higher SES pupil tended to benefit more from more competent teachers. Also, schools with higher pupil mean SES benefited more from the higher competency teachers. While this finding can be an issue of concern from an equity point of view, it is quite likely that SES in this study was acting like a proxy of prior achievement, since there was not such a measure to include in the analysis. Taking this factor into account, the findings could suggest that as pupil overall achievement level improves in Namibia, the competencies and pedagogical practices of the teaching body will become more essential to promote higher achievement.

This study was also able to replicate the teacher effects model in eleven other SACMEQ countries and found evidence that years of teacher training and the level of subject matter competency teachers had were important determinants of pupil mathematics achievement in several of the other SACMEQ countries. While this replication has to be taken with caution since the model tested was specifically developed for the Namibian context, it provides support for the notion that investing in teachers' development is important.

These findings have important implications for policy makers, education official and teacher training institution concerned with teacher development and teacher recruitment policies. However, because this study is cross-sectional and non-experimental, caution must be used when interpreting the results. First, the research examined student achievement, not learning. Achievement refers to the level of mastery that a student has attained, measured at a single point in time. Learning refers to changes in the level of mastery over time. It is critical to recognize this distinction, particularly in relation to the design of policy interventions as well as keeping in mind that the non-experimental nature of the data collection precludes the inferring of causal links between predictors and student achievement. However, to the extent that this study demonstrated an association between selected teachers characteristics, competencies and practices and student achievement, it can support the claim that effective teachers may lead to higher achievement. The representativeness of the dataset used also allows generalizations to the population of six grade students in Namibia and the other SACMEQ countries.

Regarding teacher education and professional development policies, the study confirmed the importance of teacher training, an aspect that previous studies have had difficulty in identifying due in part to numerous methodological and conceptual constraints. But results suggested that it was a certain type of training that makes a difference: just having more years of training was not necessarily sufficient. Training should provide a balance to ensure primary school teachers have sufficient subject matter competency in addition to the pedagogical competencies needed to put in place effective classroom practices. While it was not possible to find a strong effect for in-service teacher training, this is probably more the result of the type of training provided and the current strategy for using in-service training to certificate existing teachers rather than due to the ineffectiveness of in-service training in general. As a more coherent framework for teachers' initial education and professional development is put in place, one that consistently addresses the need to develop the necessary subject matter and pedagogical competency, one could expect that training in general, be it at initial stages or later on in a teachers' career, would be important. The findings also suggest that, as far as possible, only individuals displaying a certain minimum subject matter competency should be admitted to begin training as teachers. If this is not possible, the teacher training programme must provide substantial opportunities for individuals to improve their subject matter knowledge. Because of the way the level of subject matter competency was assessed, it is difficult to say what is the necessary minimum level a teacher should have to be competent in math or what type of competency is needed.

While the study provided evidence that schools with higher average of years of teacher training tended to have better student outcomes in mathematics, it is not possible to conclude that there is a need to increase the length of teacher training programmes. What can be said is that all teachers should have some training, since a low school average in general was the result of some teachers not having any training at all. It is neither possible to conclude how many years of training are necessary, but it is possible to note that Kenya with only 2 years of teacher training manages to have very competent math teachers and one of the highest average mathematics achievements among all SACMEQ countries. So if a teacher candidate is already competent in mathematics, probably two years of teacher training would be enough, assuming the content of that training is oriented towards developing the necessary competencies and practices.

While the results from this study provided support to the notion that it was not only what a teacher knows but what a teachers does that makes a difference, there are several limitations to what we can conclude from them: the range of classroom and pedagogical practices assessed was constrained by those included in the questionnaire, there were limitations in the way the scales where constructed which led in many cases to very little variation reported. In addition, the practices included were based on teachers self-report and were not the result of direct observation. In spite of these limitations, the study found that some practices were associated with higher achievement and even more clearly in high SES schools. The setting of daily homework and the regular meeting with parents appeared to play an important role. These practices provide opportunities for teachers to have a better understanding of the pupil as an individual, to monitor more closely his or her individual progress and to involve the family in the learning process. Making the learning relevant to the local context by using local problems to teach math also appeared to play an important role which suggests that effective teachers help students make the link with the outside world and apply their knowledge and competencies to solve real problems. Having students working alone rather than in pairs may be interpreted as a sign of a more traditional pedagogical practice, but at the same time, with large groups, it may well be that by working alone and having the teacher monitor more closely each students progress, their effectiveness increases. Acknowledging that pedagogical practices are important implies developing teacher training programmes that ensure sufficient time and attention is given for new teachers to develop those practices. Subsequent studies could try to better define which practices are most effective, for whom, under what context, and for what type of learning.

These findings have also implications for recruitment and selection policies. Clearly, for teachers who have already completed a teacher training programme, those who exhibit both a certain level of subject matter competency *and* demonstrate effective classroom practices should be given priority in hiring. It is recommended that selection mechanisms include opportunities for officials and school administrators to check on a teachers' competency level, and not just base a selection decision on credentials.

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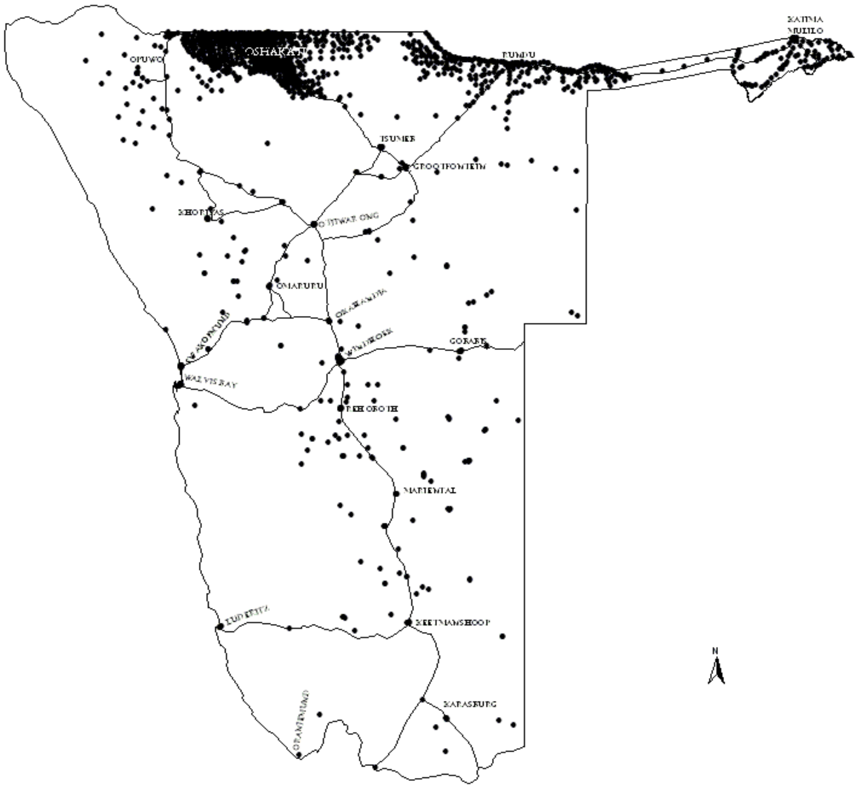
Appendix I: Structure of Namibian School System

The formal school system in Namibian government schools consists of:

- 4 years of lower primary, using mother tongue as medium of instruction;
- 3 years of upper primary, (English as a medium of instruction starts in Grade 5 at upper primary, up to Grade 12, the end of senior secondary school);
- 3 years of junior secondary; and,
- 2 years of senior secondary.

The distribution of all primary schools in Namibia from which the SACMEQ II sample was selected is presented in the following map. It can be seen from the map that nearly two thirds of all the primary schools were located in the 6 northern regions.

The Distribution of Primary Schools in Namibia



Appendix II: Introduction to SACMEQ

What is SACMEQ?

The Southern Africa Consortium for Monitoring Education Quality (SACMEQ) was established in 1995 with the purpose of undertaking integrated research and training (i) to expand opportunities for educational planners to gain the technical skills required to monitor, evaluate and compare the general conditions of schooling and the quality of basic education and (ii) to generate information that can be used by decision-makers to improve the quality of education. Fifteen Ministries of Education are now members of SACMEQ. The first two SACMEQ projects have focused on an assessment of the condition of schooling and the quality of education.

SACMEQ I was the first educational policy research project conducted by the Consortium between 1995 and 1998. Seven Ministries participated and produced their reports. Around 20,000 students, 3,000 teachers and 1,000 school principals from over 1,000 primary schools across the Southern-Africa Sub-region were involved in the data collection process, that assessed the general conditions of schooling and 6^{th} graders literacy achievement.

SACMEQ II expanded the project to fifteen Ministries and was carried between 1998 and 2001. The main focus of SACMEQ II was an assessment of the performance level of 6^{th} grade students and their teachers in the areas of literacy and mathematics. Around 50,000 students, 5,000 teachers, and 2,500 school principals from 2,500 primary schools were involved in the project.

SACMEQ I and II have employed state-of-the art methodologies in data preparation, sample design, test construction and data archiving to overcome some of the problems found in the past in large scale educational survey research studies conducted in developing countries.

Design and Sample

In order to provide useful information for each country at the national level and at the level of administrative regions used by the Ministries of Education, administrative regions were used as a study domain in both projects. Sample designs were adjusted so that stable estimates of the population characteristics could be obtained for each administrative region and the nation.

Sample designs were prepared so as to provide 95 per cent confidence limits of plus or minus 5 per cent for per centage estimates at the national level, and plus or minus 10 per cent of per centage estimates at the regional level.

The target population was all students at grade 6 level in the year 2000 at the first week of the month of school year who were attending registered mainstream primary schools. Small schools and special education schools were excluded from the target population.

The stratification procedures adopted employed an explicit stratification variable “region” and an implicit one “school size”. This allowed for regional analysis of results and increased sampling precision by sorting schools from mostly rural (small schools) to mostly urban (large schools).

It was decided that the smallest number of students per school that would be included in the data collection was 20. The minimum number of schools needed was established at 175 for an interclass correlation estimated at .4. School and student selection were completed by employing probability proportional to size (PPS) sampling within strata followed by selection of a simple random sample of fixed number of students within school. The technical requirements for SACMEQ research program was that all countries should seek to achieve overall response rates of 90per cent for schools and 80 per cent for pupils.

In the case of Namibia, strong clustering required a larger sample than the rest of SACMEQ countries and 270 schools were included from the 13 regions of the country. Students in schools with less than 15 students in grade 6, students in inaccessible schools and in special schools were excluded which represented 882 students, or 1.8% of all students. Within each sampled school, fixed-size clusters of 20 grade 6 students were randomly drawn from across grade 6 classes. In all, a 91.8% of the planned students were included in the final sample and 100% of schools, representing 5048 students out of 5500 initially planned. The reason for the shortfall was student absenteeism the day the data was collected.

Instruments

The instruments developed by SACMEQ I and II include a student test on basic literacy and mathematics, a student questionnaire, a teacher questionnaire and a school head questionnaire and a subject matter test for teachers. Given the focus of our analysis we will concentrate on SACMEQ II instruments for maths achievement.

The Mathematics Test for students

Mathematics literacy was defined as “the capacity to understand and apply mathematics procedures and make related judgments as an individual and as a member of the wider society”. The focus of the test was on assessing skills related to the curriculum. Three domains were identified as critical: number, measurement and space-data. The first one, number, refers to operations and number line, square roots, rounding and place value, significant figures, fractions, percentages and ratios. Measurements related to distance, length, area, capacity, money an time. The third one, refers to geometric shapes, charts, and tables of data. Five levels of skills competence were identified. A test blueprint was constructed combining domains and skill level. A total of 63 test items were included in the final version, with 27, for the first domain and 18 for each one of the other two. The distribution by level of skills resulted respectively in 6, 20, 17, 12, and 8 items per level. Most test items were multiple choice with four options per item. Individual scores have been converted into standardized scores, with mean set at 500 and standard deviations at 100.

The Mathematics test for teachers

The teacher test was fine-tuned in order to ensure the difficulty range would suite the higher level of competence of teachers but at the same time provide enough overlap with the student test to permit the performance of students and teachers to be measured on the same scale. The extended levels of competence mainly focused on problem solving strategies that required the extraction of information from verbal, graphic or tabular presentation. Of the 41 items included in the final version, there were 13 that overlapped with the student test. Teachers’ scores have also been standardized on the same scale as students to be comparable, with mean set at 500 and standard deviation at 100.

The student questionnaire

There were 26 items in the student questionnaire, covering basic information about the student and it home background, parental education, availability of reading materials at home, parental practices regarding homework and reading, and basic information regarding learning resources at school.

The teacher questionnaire

There were 31 items in the teacher questionnaire. They covered information about the teachers' education and home background, learning resources available in class, time allocation, views about teaching, report on their classroom practices and opinion on school head support and inspectors.

The school head questionnaire

The school head questionnaire included 34 items. They assessed basic information about the school heads education, training, and personal background; school and teaching staff characteristics, school operations and school facilities.

Two days of data collection were required for each sample school. On day one, students took the reading test and completed the questionnaire. On day two, they took the mathematics test. Teachers completed their questionnaires and took the corresponding reading and/or mathematics test on the first day and school heads completed the questionnaire also the first day. These allowed data collectors to check all completed questionnaires during the evening and if necessary obtain any missing data the following day.

The Development of the Mathematics Test: Interpretation of Domains and Levels

Table 1: Mathematics Domain in SACMEQ

Skill Level	Mathematics Domain			
	Number	**Measurement**	**Space-Data**	
Level 1	Recognize numbers. Link patterns to numbers.			
Items	6	0	0	6
Level 2	Apply single operations to two digit numbers or simple fractions.	Recognize units of measurement. Apply basic calculations using simple measurement units.	Link patterns and graphs to single digits. Recognize and name basic shapes.	
Items	8	8	4	20
Level 3	Extend and complete number patterns.	Convert measurement units when undertaking one-step operations.	Translate shapes and patterns. Identify data in tabular form.	
Items	6	4	7	17
Level 4	Combine arithmetic operations in order to link information from tables and charts when performing calculations.	Apply two and three-step arithmetic operations to numbers. Use and convert measurement units.	Combine arithmetic operations in order to link information from tables and charts.	
Items	4	4	4	12

Level 5	Combine operations in order to make calculations involving several steps and a mixture of operations using combinations of fractions, decimals, and whole numbers.	Combine operations in order to make calculations involving several steps and a mixture of operations using a translation of units.	Link data from tables and graphs in order to make calculations involving several steps and a mixture of operations.	
Items	3	2	3	8
Total Items	**27**	**18**	**18**	**63**

Level 1: Pre Numeracy (Linked with Level 1 in the Test Blueprint)
(a) Skills: Applies single step addition or subtraction operations. Recognizes simple shapes. Matches numbers and pictures. Counts in whole numbers.
(b) Example Test Items

- count illustrated objects
- recognise basic numbers and shapes
- carry out simple single operations of addition and subtraction

Level 2: Emergent Numeracy (Linked with Level 1 in the Test Blueprint)
(a) Skills: Applies a two-step addition or subtraction operation involving carrying, checking (through very basic estimation), or conversion of pictures to numbers. Estimates the length of familiar objects. Recognizes common two-dimensional shapes.
(b) Example Test Items

- link simple verbal, graphic, and number forms with single arithmetic operations on whole numbers up to four digits
- recognise common shapes or figures in two dimensions
- estimate accurately lengths of simple shapes

Level 3: Basic Numeracy (Linked with Level 2 in the Test Blueprint)
(a) Skills: Translates verbal information presented in a sentence, simple graph or table using one arithmetic operation in several repeated steps. Translates graphical information into fractions. Interprets place value of whole numbers up to thousands. Interprets simple common everyday units of measurement.
(b) Example Test Items

- recognise three-dimensional shapes and number units
- use a single arithmetic operation in two or more steps
- convert in single step units using division

Level 4: Beginning Numeracy (Linked with Level 3 in the Test Blueprint)
(a) Skills: Translates verbal or graphic information into simple arithmetic problems. Uses multiple different arithmetic operations (in the correct order) on whole numbers, fractions, and/or decimals.
(b) Example Test Items

- convert units in two steps and count tabulated data
- analyse a visual prompt and interpret triangular shapes
- translate verbal to arithmetic form using two operations on fractions

Levels of Mathematics Competency Generated from Skills Audit

Level 5: Competent Numeracy (Linked with Level 3 in the Test Blueprint)
(a) Skills: Translates verbal, graphic, or tabular information into an arithmetic form in order to solve a given problem. Solves multiple-operation problems (using the correct order of arithmetic operations) involving everyday units of measurement and/or whole and mixed numbers. Converts basic measurement units from one level of measurement to another (for example, metres to centimetres).
(b) Example Test Items

- convert basic measurement units
- understand the order of magnitude of simple fractions
- conduct multiple steps with a range of basic operations in a strict sequence using an analysis of a short verbal or visual prompt

Level 6: Mathematically Skilled (Linked with Level 4 in the Test Blueprint)
(a) Skills: Solves multiple-operation problems (using the correct order of arithmetic operations) involving fractions, ratios, and decimals. Translates verbal and graphic representation information into symbolic, algebraic, and equation form in order to solve a given mathematical problem. Checks and estimates answers using external knowledge (not provided within the problem).
(b) Example Test Items

- perform complex and detailed mathematical tasks (involving considerable abstraction of verbal, visual, and tabular information into symbolic forms and algebraic solutions) using knowledge not supplied with the task
- use of an extended verbal or graphic prompt (involving an analysis of steps) to identify the correct sequence of calculations
- convert, and operate on, units of measurement (time, distance, and weight)

Level 7: Concrete Problem Solving (Linked with Level 5 in the Test Blueprint)
(a) Skills: Extracts and converts (for example, with respect to measurement units) information from tables, charts, visual and symbolic presentations in order to identify, and then solves multi-step problems.
(b) Example Test Items

- use multiple verbal order of steps with conversion of time units
- translate verbal to arithmetic form, apply units conversion with long division
- convert from mixed number fractions to decimals

Level 8: Abstract Problem Solving (A New Level Generated from the Skills Audit)
(a) Skills: Identifies the nature of an unstated mathematical problem embedded within verbal or graphic information, and then translate this into symbolic, algebraic, or equation form in order to solve the problem.
(b) Example Test Items

- identify the nature of a problem, translate the information given into a mathematical approach, and then identify the correct mathematical strategies to obtain a solution

The NRCs decided to add a name to each of the levels – in order to summarize the competencies associated with each group. The first three competency levels in reading and mathematics employed the same prefixes ("Pre", "Emergent", and "Basic") in order to reflect the mostly mechanical nature of the most elementary competencies. From the fourth level upwards the prefixes of the summary names were different and tended to reflect deeper levels of understanding of subject specific competencies.

The NRCs considered that the use of a skills audit to generate the eight levels presented was important because the competencies provide a more concrete analysis of what pupils and teachers can actually do, and they also suggest instructional strategies relevant to pupils who are learning at each level of competence. Such descriptions are of great assistance for the construction of textbooks, the design of teacher in-service training programmes, and the development of general classroom teaching strategies - because all of these activities require a sound knowledge of the skills already acquired and the higher order skills that should be aimed at in order to transfer to the next stage of learning.

New levels were identified and derived through the skills audit, but the match between the "proposed" and "derived" levels in the dimensions of reading and mathematics competency were strikingly similar. This indicated that the NRCs had been quite successful in designing tests according to specifications as set out in the original test blueprints. It is also provided clear evidence of the content and construct validity of the reading and mathematics tests.

Table 2: Mathematics Competency Levels Cut-off Points and Frequency Distributions

Mathematics Competency	Rasch Score Range	500 Score Range	Per centage at Competency Level (SE)	
			Pupils	Teachers
			SACMEQ II	SACMEQ II
1: Pre Numeracy	Lte –2.199	Lte 364	6.2	0.0
2: Emergent Numeracy	Gt 2.199 -1.325	Gt 364 - 462	34.3	0.0
3: Basic Numeracy	Gt 1.325 - 0.709	Gt 462 - 532	29.8	0.9
4: Beginning Numeracy	Gt 0.709 - 0.213	Gt 532 - 587	14.6	2.0
5: Competent Numeracy	Gt 0.213 - 0.293	Gt 587 - 644	7.5	6.0
6: Mathematically Skilled	Gt 0.293 - 0.962	Gt 644 - 720	4.6	16.7
7: Concrete Problem Solving	Gt 0.962 - 1.728	Gt 720 - 806	2.2	36.0
8: Abstract Problem Solving	Gt 1.728	Gt 806	0.9	38.5

Appendix III: Construction of Variables

This appendix documents the source of data for the construction of the variables used:

(1) tchtraining (Mean years of teacher training for all teachers in school)

Q.17 on principal's questionnaire: How many of the teachers in your school have completed the following teacher training?

Variable = (0.5*stchshor + 1*stch1yr + 2*stch2yr + 3*stch3yr + 4*stchmore)/stchtot3

(2) tchnottrained (Proportion of teachers who are not trained)

Q.17 on principal's questionnaire: How many of the teachers in your school have completed the following teacher training?

Variable = stchnott/stchtot3

(3) tchtertiary (Proportion of teachers with tertiary education)

Q.16 on principal's questionnaire: How many of the teachers in your school have completed the following levels of academic education?

Variable = stchtert/stchtot2

(4) tchexperience (Years of experience of grade 6 teacher)

Q.6 on maths teacher's questionnaire: How many years altogether have you been in teaching?

Variable = yexper

(5) tchnoinservice (No in-service training for teacher in last 3 years)

Q.8 on maths teacher's questionnaire: After having completed your initial teacher training, what is the total number of days altogether that you spent attending these [in-service] courses during the past three years?

Variable = yinservd (if 0 then tchnoinservice=1, 0 otherwise)

(6) tchmathscore (Grade 6 teacher maths competency)

Test score of maths teacher on the all-country scale where 500 is mean pupil score for all pupils in SACMEQ II and 100 is the standard deviation.

Variable = zmaloct

(7) tchdailyhw (Pupils are set daily homework)

Q.36 on pupil questionnaire: How often are you usually given homework in mathematics?

Variable = phmwkm (if 4 then tchdailyhw=1, 0 otherwise)

(8) tchnotmeetparents (Teacher never meets parents of pupils)

Q.17 on maths teacher's questionnaire: How often do you usually meet with parents or guardians of the pupils in your class to discuss pupil performance or related matters?

Variable = ymeetpar (if 1 then tchnotmeetparents=1, 0 otherwise)

(9) tchlessonhours (Teacher reported total weekly teaching hours)

Q.14/5 on maths teacher's questionnaire: How many periods/lessons of actual teaching do you have in a typical school week at this school? How long are the periods?

Variable = yperiods*yminutes/60

(10) tchactivities (Teacher shows preference for 'modern' teaching methods over pupils working alone)

Q.40 on maths teacher's questionnaire: How important do you consider the following pupil activities be in the teaching of mathematics?
40.01 Working in pairs or groups to solve mathematical problems
40.02 Working alone on problems
40.03 Preparing projects of posters to be shown to the class.

Variable = first principal component extracted from tmact01, tmact02, tmact03

(11) tchstyle1 (Teacher uses everyday and local problems to teach maths)

Q.45 on maths teacher's questionnaire: How often do you use the following approaches when teaching mathematics?
45.01 Using everyday problems (verbally, written or worksheets)
45.07 Relating to everyday life situations as much as possible
45.10 Using available local materials

Variable = first principal component extracted from tmappr01, tmappr07, tmappr10

(12) tchstyle2 (Teacher prefers whole class teaching over small group work)

Q.45 on maths teacher's questionnaire: How often do you use the following approaches when teaching mathematics?
45.02 Teaching the whole class as a group
45.03 Teaching in a small group

Variable = first principal component extracted from tmappr02, tmappr03

(13) pupilses (Socio-economic status of pupil)

Q.7 on pupil questionnaire: Which of the following things can be found in the place (home) where you stay during the school week? [Daily newspaper, magazine, radio, TV set, VCR, cassette player, telephone, refrigerator/freezer, car, motorcycle, bicycle, piped water, electricity, table to write on]
Q.8 What is the main source of lighting by which you can reading the place (home) where you stay during the week?

Q.13 What is the surface (covering of the floor of the place (home) where you stay during the school week mostly made from?
Q.14 What are the outside walls of the place (home) where you stay during the school week mostly made of?
Q.15 What is the roof of the place (home) where you stay during the school week mostly made of?
Q.11 What is the highest level of education that your mother (or female guardian) has completed?
Q.12 What is the highest level of education that your father (or male guardian) has completed?

Variable = weights pupil home environment and parent's education equally via the following method:

1. zplight+zpfloor+zpwall+zproof+ppos01 to ppos14 are summed and standardised to (0,1)
2. zpfmedmn is standardised to (0,1)
3. 1. and 2. are added together and standardised on (0,1) *within* each school.

(14) schses (Average SES of pupils in school)

Derived directly from pupilses above. This is the mean of the pupilses (prior to being centred on the school).

(15) schsize (Size of school)

Q.19 on school principal's questionnaire: What is the total enrolment in Primary 6 in your school?

Variable = spupboy6 + spupgir6

(16) schresources (School resources)

Q.38 on school principal's questionnaire: Which of the following does your school have? [library, hall, staffroom, office for head, store room, first aid kit, playground, water, electricity, telephone, fax, garden, typewriter, duplicator, radio, tape recorder, overhead projector, TV, VCR, photocopier, computer, fence]

Variable = zsrtot22 (i.e. a count of the number of items above)

(17) schprincipal (Experience of the school principal)

Q.10 on school principal's questionnaire: How many years altogether have you been a School Head or Acting School Head?

Variable = sexpall

(18) pupilmathscore (Pupil maths competency in Grade 6)

Test score of pupil on the all-country scale where 500 is mean pupil score for all pupils in SACMEQ II and 100 is the standard deviation.

Variable = zmalocp

Tables and Figures

Table 1: Structure of the Namibian SACMEQ Data

Level	N in level	Notes:
4 = district	13	
3 = school	270	216 have one grade 6 maths teacher 52 have two grade 6 maths teachers 2 have three grade 6 maths teachers
2 = maths teacher	326	22 teachers are also English teachers
1 = pupil	5,048	Sample reduced to 4,990 due to missing response variable in 58 pupils

Table 2: Variance Components Model for Namibian Maths Test Score

Level	Variance	% of Total Variance at Level
Total	7570.886	
4 = district	1588.551	21.0%
3 = school	2478.295	32.7%
2 = maths teacher	118.309	1.6%
1 = pupil	3385.731	44.7%

Table 3: Teacher Variables

Variable name	Mean	S.D.	Description	Source
Education and training				
tchtraining	2.36 years*	0.62	Mean years of teacher training for all teachers in school	Principal
tchnottrained	7.7%*	0.25	Proportion of teachers who are not trained	Principal
tchtertiary	26.4%*	0.38	Proportion of teachers with tertiary education	Principal
tchexperience	11.7 years*	8.21	years of experience of grade 6 teacher	Grade 6 teacher
tchnoinservice	binary (1=25%)	-	no in-service training for teacher in last 3 years	Grade 6 teacher
Subject matter knowledge				
tchmathscore (& tchmathscore^2)	0***	1	grade 6 teacher maths competency (test score)	Grade 6 teacher
Pedagogical practices				
tchdailyhw	binary (1=93%)	-	Pupils are set daily homework	Pupils
tchnotmeetparents	binary (1=10%)	-	teacher never meets parents of pupils	Grade 6 teacher
tchlessonhours	21.1 hours/week*	6.63	teacher reported total weekly teaching hours	Grade 6 teacher
tchactivities	0	1	teacher shows preference for 'modern'[14] teaching methods over pupils working alone **	Grade 6 teacher
tchstyle1	0	1	teacher uses everyday and local problems to teach maths**	Grade 6 teacher
tchstyle2	0	1	teacher prefers whole class teaching over small group work**	Grade 6 teacher

Notes: * indicates the variable is centered on zero in estimation.
**indicates factor has been extracted from a set of answers to questions using principal components
*** centred on (0,1). Namibian teacher mean score is 735, where 500 is the mean score for all pupils in SACMEQ.

[14] 'Modern' is used to refer to preference for pupils working in pairs and creating posters.

Table 4: Baseline Model for Namibia

-2*loglikelihood (IGLS Deviance): 55142.680 (4990 cases)			
	Beta	**S.E.**	**Significant at:[15]**
Control variables			
constant	400.030	2.728	1%
pupilses	5.350	0.968	1%
schsize	-0.103	0.040	1%
schses	11.996	2.868	1%
schses^2	19.062	2.332	1%
schresources	13.605	2.507	1%
schresources^2	10.907	2.239	1%
schprincipalyears	-0.103	0.241	n.s.
Variance estimates			
σ2 (constant by school)	747.995	103.785	1%
σ^2 (constant by pupil)	3378.309	122.918	1%

[15] Chi-squared test on the reduction of IGLS deviance

Table 5: Fixed Effect Model for Namibia

-2*loglikelihood (IGLS Deviance): 55098.690 (4990 cases)			
	Beta	**S.E.**	**Significant at:**[16]
Control variables			
constant	388.481	6.479	1%
pupilses	5.351	0.968	1%
schsize	-0.123	0.040	
schses	9.565	2.945	1%
schses^2	16.680	1.963	1%
schresources	10.750	2.469	1%
schresources^2	8.363	2.280	1%
schprincipalyears	-0.029	0.228	n.s.
Teacher education and training			
tchtraining	17.097	3.845	1%
tchnoinservice	10.151	4.497	5%
tchtertiary	-1.696	5.311	n.s.
tchexperience	0.132	0.267	n.s.
Teacher subject matter knowledge			
tchmathscore	1.912	2.500	n.s.
tchmathscore^2	0.137	0.920	n.s.
Teacher pedagogical practices			
tchhwdaily	17.071	6.079	1%
tchnevermeetpar	-11.820	5.181	5%
tchactivities	-4.545	1.938	1%
tchstyle1	-0.460	1.648	n.s.
tchstyle2	2.698	1.762	n.s.
tchlessonhours	0.105	0.272	n.s.
Variance estimates			
σ2 (constant by school)	610.003	84.273	1%
σ^2 (constant by pupil)	3377.729	122.892	1%

[16] Chi-squared test on the reduction of IGLS deviance

Table 6: Descriptive Statistics

	All schools	Low SES schools	High SES schools
Number of pupils	4990	3738	1252
Number of schools	270	205	65
Variable name	**Mean (all schools)**	**Mean (low SES schools)**	**Mean (high SES schools)**
Pupilmathscore	430.86	409.13	523.49
Pupilses	0	-0.30	1.26
Schoolses	0	-0.40	1.69
Schoolresources	0	-0.34	1.44
Tchtraining	2.36 years	2.20 years	3.04 years
Tchtertiary	26.3%	21.4%	47.2%
Tchexperience	11.72 years	10.86 years	15.40 years
Tchmathscore	734.63	712.25	830.04
Tchdailyhw	binary (1=92.7%)	binary (1=92.0%)	binary (1=95.5%)
Tchnotmeetparents	binary (1=10.4%)	binary (1=11.8%)	binary (1=4.4%)

Table 7: Correlations between Teacher Variables in Whole Dataset for Namibia

	tchtraining	tchtertiary	tchdailyhomework	tchnoinservice	tchnevermeetparents	tchlessonhours	tchmathscore	tchactivities	tchstyle1	tchstyle2
tchtertiary	0.28 *0.00*									
tchdailyhomework	0.06 *0.29*	0.03 *0.62*								
tchnoinservice	0.00 *0.96*	0.06 *0.32*	0.00 *0.98*							
tchnevermeetparents	-0.03 *0.63*	-0.01 *0.83*	0.02 *0.73*	0.08 *0.21*						
tchlessonhours	0.00 *1.00*	-0.04 *0.53*	0.07 *0.26*	-0.01 *0.81*	0.03 *0.63*					
tchmathscore	0.28 *0.00*	0.19 *0.00*	0.09 *0.14*	0.00 *0.98*	0.05 *0.37*	0.07 *0.22*				
tchactivities	-0.30 *0.00*	-0.14 *0.02*	-0.03 *0.57*	-0.04 *0.52*	0.04 *0.46*	-0.02 *0.72*	-0.40 *0.00*			
tchstyle1	0.15 *0.02*	0.13 *0.03*	-0.04 *0.52*	-0.01 *0.84*	-0.12 *0.05*	-0.01 *0.85*	0.24 *0.00*	-0.07 *0.23*		
Tchstyle2	-0.20 *0.00*	-0.08 *0.17*	-0.04 *0.52*	-0.14 *0.02*	-0.19 *0.00*	0.06 *0.31*	-0.18 *0.00*	0.20 *0.00*	0.02 *0.68*	
tchexperience	0.17 *0.00*	0.10 *0.12*	0.05 *0.38*	-0.20 *0.00*	-0.25 *0.00*	-0.08 *0.19*	0.07 *0.26*	-0.03 *0.61*	0.09 *0.13*	-0.04 *0.56*

Note: p-values in italics

Table 8: Correlations between Teacher Variables (High SES School Excluded)

	tchtraining	tchtertiary	tchdailyhomework	tchnoinservice	tchnevermeetparents	tchlessonhours	tchmathscore	tchactivities	tchstyle1	tchstyle2
tchtertiary	0.14									
	0.04									
tchdailyhomework	0.05	0.02								
	0.52	*0.75*								
tchnoinservice	-0.09	0.00	0.01							
	0.20	*0.97*	*0.93*							
tchnevermeetparents	0.09	0.01	0.02	0.11						
	0.22	*0.84*	*0.73*	*0.13*						
tchlessonhours	-0.04	-0.07	0.07	-0.02	0.02					
	0.61	*0.35*	*0.33*	*0.79*	*0.79*					
tchmathscore	-0.05	0.07	0.12	-0.06	0.10	0.04				
	0.44	*0.34*	*0.09*	*0.38*	*0.14*	*0.56*				
tchactivities	-0.09	-0.04	-0.03	0.07	0.04	0.00	-0.27			
	0.20	*0.58*	*0.69*	*0.33*	*0.61*	*0.98*	*0.00*			
tchstyle1	0.02	0.12	-0.02	-0.07	-0.11	0.02	0.18	0.02		
	0.79	*0.08*	*0.75*	*0.29*	*0.11*	*0.80*	*0.01*	*0.82*		
tchstyle2	-0.10	-0.05	-0.03	-0.19	-0.23	0.10	-0.10	0.15	0.08	
	0.17	*0.47*	*0.70*	*0.01*	*0.00*	*0.15*	*0.16*	*0.04*	*0.27*	
tchexperience	0.05	0.07	0.00	-0.26	-0.25	-0.06	-0.01	0.05	0.06	0.02
	0.50	*0.33*	*0.98*	*0.00*	*0.00*	*0.38*	*0.94*	*0.45*	*0.40*	*0.81*

Note: p-values in italics

Table 9: Estimates for Full Model

-2*loglikelihood (IGLS Deviance): 55008.950 (4990 cases)			
	Beta	**S.E.**	**Significant at:**[17]
Control variables			
Constant	395.428	5.674	1%
Pupilses	4.882	0.909	1%
Schsize	-0.053	0.030	10%
Schses	11.092	2.309	1%
schses^2	10.848	1.507	1%
schresources	7.512	2.202	1%
schresources^2	5.176	1.716	1%
schprincipalyears	-0.214	0.171	n.s.
Teacher education and training			
tchtraining	12.661	3.714	1%
tchnoinservice	6.220	4.366	n.s.
tchnotraining.tchnoinservice	-38.814	15.747	5%
tchtertiary	1.515	4.610	n.s.
tchexperience	0.164	0.203	n.s.
Teacher subject matter knowledge			
tchmathscore	4.530	2.098	5%
tchmathscore^2	-3.385	0.875	1%
Pupilses.tchmathscore	3.652	1.220	1%
schoolses.tchmathscore	10.104	2.240	1%
tchmathscore.tchtraining	6.462	3.089	5%
Teacher pedagogical practices			
tchhwdaily	14.829	5.281	1%
tchnevermeetpar	-7.581	4.101	10%
tchactivities	-1.046	1.700	n.s.
Tchstyle1	-1.790	1.312	n.s.
Tchstyle2	1.915	1.436	n.s.
tchlessonhours	0.139	0.199	n.s.
Variance estimates			
σ^2 (tchtraining by district)	806.566	237.917	1%
σ^2 (tchnoinservice by district)	629.325	239.079	1%
σ σ (tchnoinservice.tchtraining)	418.896	209.892	5%
σ2 (constant by school)	120.751	45.987	1%
σ^2 (constant by pupil)	3363.071	120.903	1%

[17] Chi-squared test on the reduction of IGLS deviance

Table 10: Estimates for Reduced Model (Excluding High SES Schools)

-2*loglikelihood (IGLS Deviance): 40,578.160 (3,738 cases)			
	Beta	**S.E.**	**Significant at:**[18]
Control variables			
Constant	401.354	5.206	1%
Pupilses	3.026	0.927	1%
Schsize	-0.023	0.029	n.s.
Schses	6.129	4.090	n.s.
schses^2	4.582	3.319	n.s.
schresources	7.724	2.360	1%
schresources^2	4.737	2.154	5%
schprincipalyears	-0.287	0.165	10%
Teacher education and training			
tchtraining	7.707	3.481	5%
tchnoinservice	6.027	4.020	n.s.
tchnotraining.tchnoinservice	-19.552	12.899	n.s.
tchtertiary	-1.455	4.791	n.s.
tchexperience	0.334	0.215	n.s.
Teacher subject matter knowledge			
tchmathscore	7.583	2.473	1%
tchmathscore^2	-2.170	1.597	n.s.
pupilses.tchmathscore	1.988	1.05	10%
Schoolses.tchmathscore	9.857	3.417	1%
tchmathscore.tchtraining	6.617	2.836	5%
Teacher pedagogical practices			
tchhwdaily	10.237	4.642	5%
tchnevermeetpar	-4.865	4.534	n.s.
tchactivities	-1.389	1.850	n.s.
tchstyle1	-0.560	1.454	n.s.
tchstyle2	2.422	1.540	n.s.
tchlessonhours	-0.092	0.193	n.s.
Variance estimates			
σ^2 (constant by school)	284.826*	47.677	1%
σ^2 (constant by pupil)	2867.817	93.092	1%

Note: there is no variation at district level in this model
* compared to VPC of 565.673; so 50% of school level variance remains unexplained.

[18] Chi-squared test on the reduction of IGLS deviance

Table 11: Estimates for High SES Schools Only

-2*loglikelihood (IGLS Deviance): 14,229.270 (1,252 cases)			
	Beta	**S.E.**	**Significant at:[19]**
Control variables			
constant	336.786	46.744	1%
pupilses	10.502	2.892	1%
schsize	-0.433	0.090	1%
schses	41.719	55.398	n.s.
schses^2	-7.565	16.085	n.s.
schresources	64.294	15.685	1%
schresources^2	-15.555	8.189	10%
schprincipalyears	1.766	0.713	1%
Teacher education and training			
tchtraining	43.078	14.663	1%
tchnoinservice	-2.263	8.146	n.s.
tchnotraining.tchnoinservice	-236.834	154.636	n.s.
tchtertiary	2.231	7.231	n.s.
tchexperience	-1.492	0.589	1%
Teacher subject matter knowledge			
tchmathscore	-41.029	12.151	1%
tchmathscore^2	0.477	2.086	n.s.
pupilses.tchmathscore	2.821	2.519	n.s.
schoolses.tchmathscore	21.852	5.671	1%
tchmathscore.tchtraining	-2.823	6.624	n.s.
Teacher pedagogical practices			
tchhwdaily	61.983	17.277	1%
tchnevermeetpar	-50.252	19.144	1%
tchactivities	-10.930	3.508	1%
tchstyle1	8.012	4.014	5%
tchstyle2	7.259	5.538	n.s.
tchlessonhours	1.532	0.615	1%
Variance estimates			
σ^2 (constant by school)	419.031*	129.391	1%
σ^2 (constant by pupil)	4800.254	319.393	1%

Note: there is no variation at district level in this model
* compared to VPC of 6884.445; so 6% of school level variance remains unexplained

[19] Chi-squared test on the reduction of IGLS deviance

	BOT	KEN	LES	MAL	MOZ	SEY	SWA	TAN	UGA	ZAM	ZAN
Intra-class correlation (ICC)	21%	36%	30%	12%	21%	9%	25%	25%	63%	21%	34%
% of school-level variance explained by controls	66%	41%	23%	20%	9%	82%	49%	45%	17%	37%	30%
% of school-level variance explained by teacher vars	3%	0%	8%	7%	11%	7%	10%	3%	3%	2%	14%
Cons	504.847	558.386	444.923	432.216	552.97	557.74	508.507	521.413	502.062	428.421	472.314
	0%	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Pupilses	8.991	9.034	2.09	5.704	-0.149	23.147	2.819	9.583	2.91	8.379	5.041
	0%	*0%*	*2%*	*0%*	*88%*	*0%*	*3%*	*0%*	*5%*	*0%*	*0%*
Schoolses	11.801	24.389	1.42	1.621	5.339	22.767	8.3	33.937	26.798	12.252	-5.588
	0%	*0%*	*63%*	*65%*	*3%*	*0%*	*0%*	*0%*	*2%*	*0%*	*35%*
Schoolsessq	5.931	1.874	2.769	2.628	0.746	2.587	5.338	-2.208	3.044	3.147	5.651
	0%	*46%*	*10%*	*28%*	*72%*	*33%*	*0%*	*39%*	*55%*	*30%*	*9%*
Schsize	-0.078	-0.263	-0.005	0.054	0	-0.004	-0.144	-0.055	-0.775	0.005	0.13
	35%	*1%*	*94%*	*9%*	*100%*	*97%*	*4%*	*19%*	*17%*	*74%*	*2%*
Schresources	6.937	5.666	5.918	3.357	-1.923	-2.981	-1.067	-3.118	4.848	7.143	-6.487
	4%	*26%*	*2%*	*22%*	*52%*	*63%*	*70%*	*34%*	*62%*	*7%*	*5%*
Schresourcessq	2.119	2.197	0.092	-1.099	2.111	-5.049	4.71	4.811	-0.971	1.865	4.326
	23%	*33%*	*92%*	*34%*	*24%*	*9%*	*0%*	*0%*	*79%*	*51%*	*0%*
Tchtraining	1.242	1.75	7.169	9.564	0.352	23.42	8.44	3.743	15.286	4.735	24.82
	87%	*92%*	*1%*	*2%*	*92%*	*7%*	*10%*	*58%*	*12%*	*41%*	*5%*
Tchtertiary	12.454	0.86	-4.992	-24.238	-17.688	-9.029	-4.026	-31.213	-24.629	9.201	-26.663
	34%	*94%*	*37%*	*0%*	*1%*	*59%*	*44%*	*54%*	*17%*	*14%*	*11%*
Tchmathscore	5.568	1.245	6.112	0.555	4.56	8.974	10.539	3.794	-5.719	2.615	6.944
	13%	*73%*	*0%*	*81%*	*3%*	*19%*	*0%*	*28%*	*54%*	*37%*	*3%*
Pupilses.tchmathscore	-1.764	1.486	-0.814	2.23	-1.311	-2.438	-1.35	1.077	0.984	-1.451	0.523
	13%	*33%*	*35%*	*5%*	*19%*	*51%*	*29%*	*54%*	*63%*	*27%*	*55%*
Schses.tchmathscore	5.244	1.733	2.856	2.08	-6.479	0.057	-0.228	-5.653	5.898	1.382	-2.533
	7%	*47%*	*9%*	*40%*	*4%*	*99%*	*92%*	*20%*	*53%*	*69%*	*46%*
Tchtraining.tchmathscore	-7.35	-23.049	-1.578	3.823	10.123	8.038	7.424	9.97	-4.597	-2.032	11.086
	28%	*22%*	*39%*	*34%*	*4%*	*53%*	*9%*	*11%*	*66%*	*76%*	*38%*

Table 12: Results from other SACMEQ countries

Figure 1: School Level Residuals Extracted from 2-Level Variance Components Model

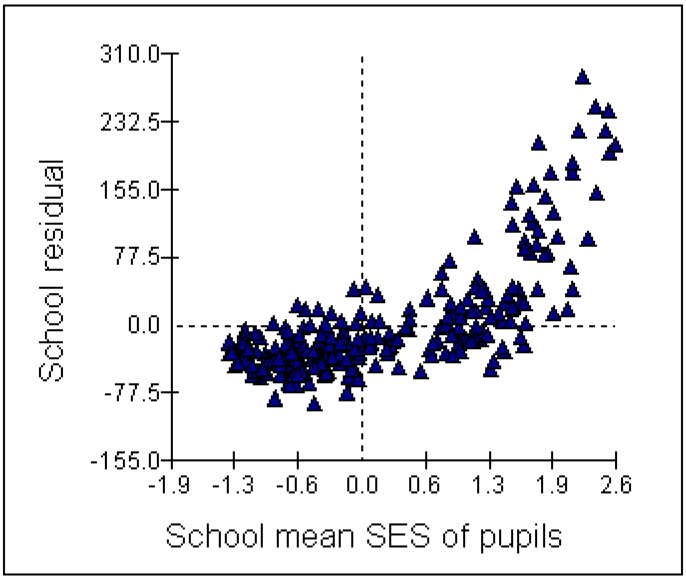


Figure 2: Grade 6 Teacher's Maths Competency Score

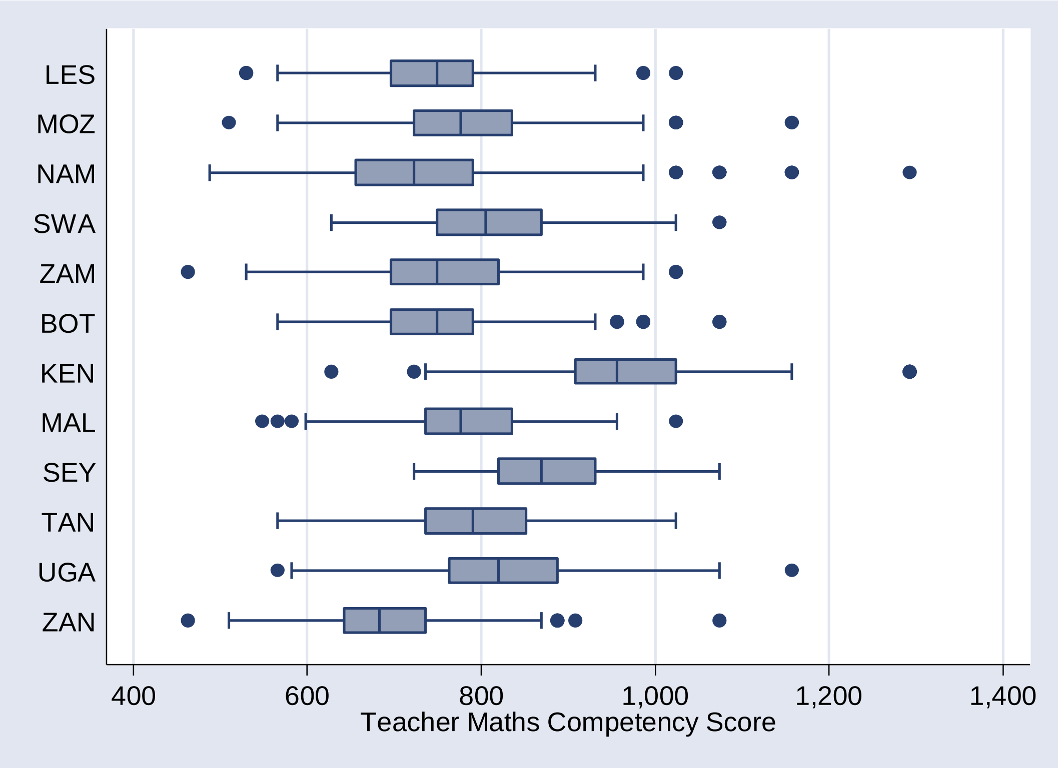


Figure 3: Within School Differences in Expected Pupil Achievement

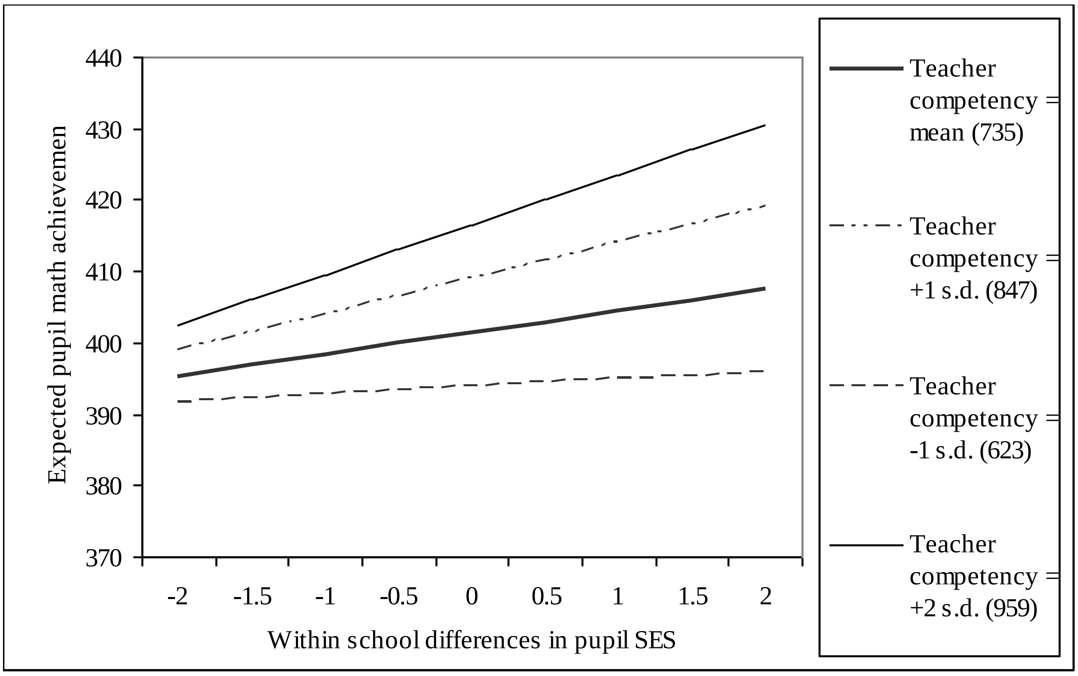


Figure 4: The Interaction between Maths Competency and Teacher Training

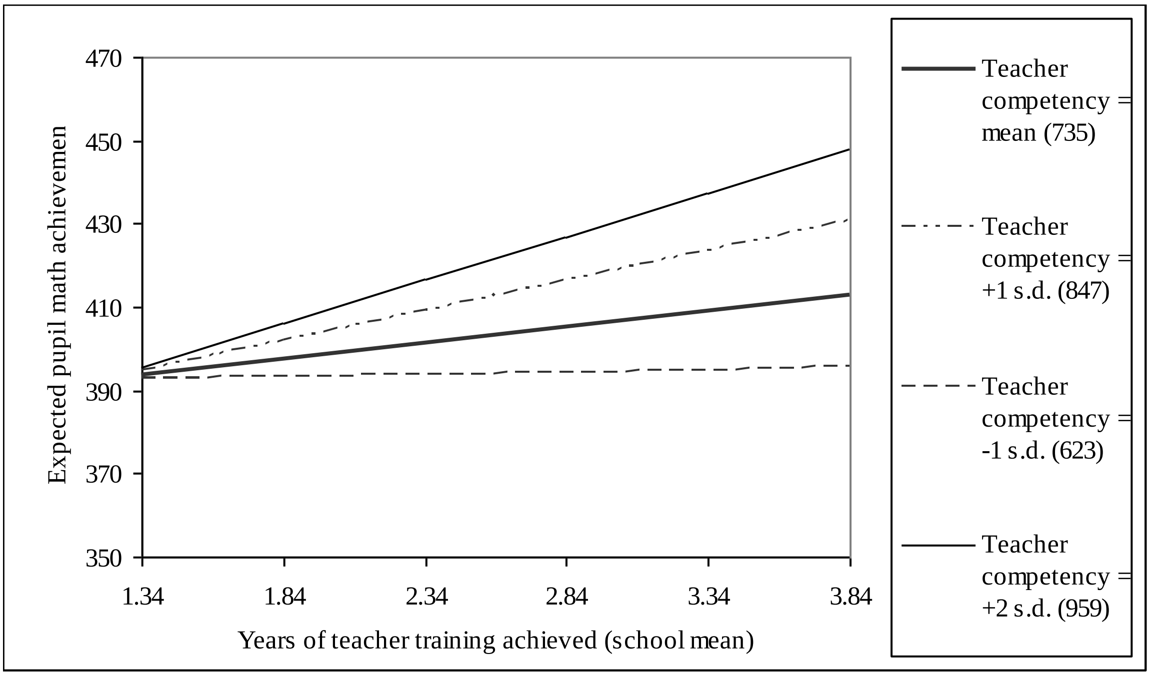


Figure 5: Residuals for Namibia Model (Whole Dataset)

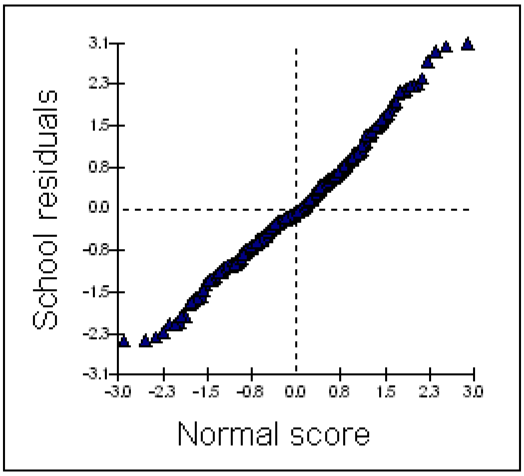


Figure 6: Pupil Mean Achievement versus Teacher Maths Competency

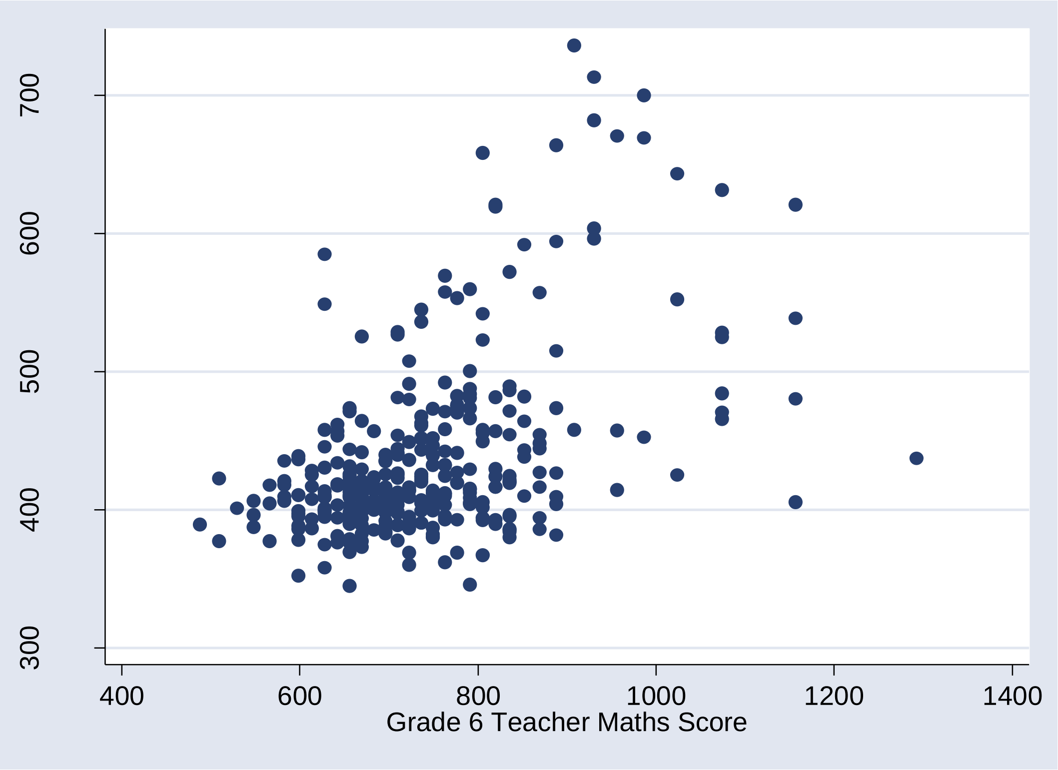


Figure 8: Variation in Average Teacher Training Years by Country