Identifying the attributes of effective rural teachers: Teacher attributes and mathematics achievement among rural primary school students in northwest China[†]

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2012

[†] Acknowledgments: The Gansu Survey of Children and Families is supported by a grant from the United Kingdom Economic and Social Research Council and Department for International Development (ESRC RES-167-25-0250). Earlier support for data collection came from The Spencer Foundation Small and Major Grants Programs, The World Bank, and NIH Grants 1R01TW005930-01 and 5R01TW005930-02. An earlier version of this paper was presented at the Annual Meeting of the Comparative and International Education Society Conference, March 2005, Stanford, CA.

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Abstract

Using matched student-teacher, I investigate what kind of teacher attributes make a difference for student achievement in resource-constrained rural communities in northwest China. Results from a series of random-effects models controlling for student background and community economic and social resources identifies several teacher attributes that are associated with student mathematics achievement in the early years of schooling. Students who are taught by teachers who have official credentials, high levels of motivation to improve practice, commitment to the profession, and strong interpersonal skills have higher math achievement, on average. In addition, students who are taught by teachers with 3-5 years of teaching experience have the highest performance, on average, controlling for other student, family, and community characteristics. Importantly, the analyses indicate that teacher attributes to be a distinct dimension of community inequality in rural Gansu rather than as an immediate link between community resources and student achievement. The findings provide a complex picture of the influence of wide range of teacher characteristics on achievement, and carry important policy implications for teacher recruitment, retention, and professional development in rural disadvantaged communities in China and around the world.

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1. Introduction

Research from around the globe has confirmed that teaching is characterized by great unevenness (Harbinson & Hanushek, 1996; Lockheed & Verspoor, 1991; Paine, 1998). There are dramatic differences in teacher quality within regions, within communities, and even within schools In the U.S., schools serving low income students are often staffed with teachers with less experience and education than schools attended by their middle-class counterparts (Ingersoll, 1996; Lankford, Loeb, & Wycoff, 2002; Jackson, 2009; Hanushek, Kain, & Rivkin, 2004). Similarly, in many developing countries, schools in rural areas employ teachers with less preparation, less experience, and less subject knowledge than schools in urban areas (Lockheed & Verspoor, 1991; Heyneman, 1983) In Honduras, teachers in rural areas scored lower than urban teachers on tests of basic skills (McEwan, 1999). In China, top ranked schools in counties and townships have higher percentages of high-ranking teachers compared with schools in rural villages (Paine, 1998). The uneven distribution of teachers is particularly troubling given the evidence from around the world linking tangible measures of teacher quality to student achievement, and ultimately, may result in an achievement gap between students who live in different communities.

There is little question that teachers are an important influences on what children can achieve in school. Empirical research indicates that student achievement depends on the teachers they have, regardless of child background (Goldhaber, Brewer, & Anderson, 1999; Rivkin, Hanushek, & Kain, 2005; Murnane, 1975; Lloyd, Mensch, & Clark, 2000). In fact, some research suggests that differences in teacher quality account for more variation in student achievement than any other school-related influence (Goldhaber, Brewer, & Anderson, 1999; Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004). Yet, while researchers seem to agree that teachers are important, there

is less agreement about what teacher characteristics matter (Hanushek, 1986). What kinds of teacher attributes make a difference? And what role do differences in teacher attributes play in linking community disadvantage to student achievement?

In China, these questions are increasingly relevant given research indicating that disadvantaged, rural communities lack the resources necessary to recruit and retain good teachers (Li, Park, & Wang, 2007). Evidence has established a connection between local economic indicators, such as village per capital income with the percentage of qualified teachers in a school (Li, Park, & Wang, 2007). Similarly, research points to the unequal distribution of newly qualified teachers. Recent graduates of teacher training institutions are often assigned disproportionately to township central schools (Paine, 1998). As a result, the most disadvantaged children in the poorest villages are often served by the least qualified teachers, further exacerbating the existing disparities between township and village schools.[1]

In this paper, I use rich, matched-student teacher data to investigate the association between specific teacher attributes and student mathematics achievement in one rural interior province in China: Gansu. I address the following questions: First, after controlling for child background and community characteristics, does student mathematics achievement depend on specific attributes of the child's classroom teacher? If so, what attributes matter? Second, do differences in teacher attributes play an intermediate role in linking community resources to student achievement? I begin by providing a synthesis of studies that have linked dimensions of teacher quality with student outcomes. Next, I describe the conditions of teachers and teaching in rural China. In the section immediately following, I specify the dataset I used, identify key variables, and outline my data analyses. Finally, I contend that the results of this study reveal that particular attributes of classroom

[1] In recent years, the State has pursued an aggressive strategy to improve teaching quality in rural schools as a way to reduce rural-urban educational inequality. For example, the State has implemented the New Curriculum to transform teacher-student interactions in the classroom and increase student engagement. In addition, the central government has provided new incentives to urban teachers and graduates from teacher training colleges to teach in rural schools.

teachers matter for student achievement. These findings have significant implications for improving the quality of teaching and learning in poor areas in China, and in other rural, resource-constrained settings.

2. Current State of Knowledge

2.1 Understanding Teacher Attributes and Student Outcomes

Understanding the relationship between teacher characteristics and student achievement presents several challenges. One particular problem is that student achievement results not only from the experience students have with their current teacher, but also from experience with previous teachers. An additional issue is that student achievement is affected not only by school characteristics, but also by factors in the home. In this way, student achievement is a cumulative outcome of several current and past factors. As a result, the most persuasive investigations of teacher quality and student achievement account for prior student achievement as well as other observable characteristics of students. Yet even when data allows researchers to effectively control for these alternative explanations, the results are often puzzling. Some studies using traditional regression models indicate that some teacher characteristics are related to student achievement (Goldhaber & Brewer, 1996; Goldhaber, Brewer, & Anderson, 1999). However, these studies also show that likely teacher characteristics, such as education, credentials, and years of experience do not explain much of the between classroom variation in student achievement.

The difficulty of establishing clear links between teacher qualities and student achievement can also be partially attributed to the measurement and specification of important teacher qualities. For example, many school districts in the U.S. collect data on how many years a teacher has worked in the current district rather than how many years the teacher has taught overall. In addition, many studies use a linear specification of teacher experience that treats all of the years of teaching as the same even though research indicates that there are important differences between early and late

experience (Murnane, 1975; Darling-Hammond, 2000; Murnane & Phillips, 1981). Similarly, particular teacher attributes may only matter in specific contexts. For example, experience may only matter in the first few years of teaching, and teacher degree might only be important for secondary school teachers (Goldhaber & Brewer, 1996). However, even in studies that have addressed the issues raised above, our understanding of teacher effects is limited by potential bias. For example, the strategy of attributing the large achievement differences between classrooms to teachers does not take in to account other unobservable factors in the classroom that may influence achievement. Similarly, value-added studies that investigate variations in student achievement gains from one teacher to another also may be biased by "lagged effects" – the effects of prior teachers may not reveal themselves right away.

Yet despite the challenges in identifying and accurately estimating the effect of teachers, research from around the globe suggests that teachers do matter (Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004; Sanders & Rivers, 1996; Sanders, 1998; Park & Hannum, 2001). More recent work using panel data with multiple observations of student achievement and teachers over time has focused on the differences in achievement gains of the same student with different teachers by examining teacher fixed effects and controlling for time-varying student and school characteristics (Rockoff, 2004). For example, Rockoff's (2004) investigation of teacher's influence on the reading and mathematics achievement of more than 10,000 elementary school students in two New Jersey counties found teacher fixed effects to be a significant predictor of achievement in all subject areas. In rural China, Park and Hannum (2001) discovered that approximately one quarter of the variation in student mathematics achievement was due to overall teacher differences. In the U.S., Goldhaber, Brewer, and Anderson (1999) used NELS data to estimate the effect of particular teacher characteristics, as well as overall teacher effects, on 10th grade mathematics achievement in the U.S. Their results indicate that overall teacher effects explained 8.5 percent of the variation in student

achievement. Similarly, in their study of elementary school students in Texas, Rivkin, Hanushek, and Kain (2005) found that differences in school effects on achievement were largely attributed to differences in teachers across schools. Even more striking, their results indicated that teacher effects explained more than any other measures of school quality. Sanders (1998) work in Tennessee also supports the conclusion that teachers matter more for student achievement than any other school characteristics.

For several decades, researchers investigating teacher effects have established connections between specific teacher attributes, such as teacher experience and certification, and variations in student achievement (Rivkin, Hanushek, & Kain, 2005; Goldhaber, Brewer, & Anderson, 1999; Ferguson, 1991). For example, Murnane's (1975) study of 875 inner city school children was one of the first to establish a relationship between teacher experience and achievement. Importantly, Murnane's early work suggests that there are differences in the effect of teaching experience accrued during the first few years of teaching compared with experience gained later. His work demonstrates that teacher effectiveness considerably increased during the first few years of teaching, rising upward to a peak at approximately the third year of experience before declining lightly or leveling off. These results are supported by research suggesting that the benefits of teacher experience accrue during the first five years of teaching (Darling-Hammond, 2000; Kain, 1995; Murnane & Phillips, 1981). For example, in a study of low-income elementary school students, Murnane and Phillips (1981) found that teacher experience had a positive effect on student achievement among teachers in their first seven years of teaching. In contrast, they found a weak negative relationship between experience and achievement among teachers with 8-14 years of experience. The researchers suggest that the early effect of experience can be explained by "learning by doing" while the late career effect reflects differences in the average abilities of teachers who entered teaching at different points in time. Murnane and Phillips also explain that the apparent

decrease or plateau observed after the early years of teaching can be partially attributed to selection effects. In this way, differences between those who leave the classroom and those who stay are also reflected in experience measures making the relationship between teaching experience and student achievement difficult to interpret.

In recent years, researchers, including those working in international settings, have extended their explorations of teacher attributes to include dimensions of teaching that are more difficult to measure, such as teacher attitudes, autonomy, and interpersonal skills. For example, Vegas' (2002) investigation of teachers in Chile indicates that there is a positive relationship between autonomy that teachers enjoy in planning their lessons and student achievement when decentralized decision-making is present. Researchers in the United States have documented the ways in which teacher interpersonal skills influence the teacher-student relationship, and ultimately, student learning (Frymier & Houser, 2009; Rodriguez, Plax, & Kearney, 1996). This line of research describes teaching as a relational process requiring a positive interpersonal relationship between teacher and student to facilitate learning (Rodriguez, Plax, & Kearney, 1996; Graham, West, & Schaller, 1992; Frymier, 1994; Plax & Kearney, 1992). In Kenya, researchers discovered that positive teacher attitudes about math was associated with better educational outcomes for girls (Lloyd, Mensch, & Clark, 2000). In China, Park and Hannum's (2001) work suggests that children who are more connected to the local community have higher mathematics scores, on average. Taken together, these results highlight the complexity of the relationship between teachers and student achievement as well as the wide range of teacher attributes that can affect what students learn in classrooms

2.2 Teachers in Rural China

China has more than 10 million teachers. In poor, rural China, most teachers are government employees known as *gongban* (managed by the public) teachers. Gongban teachers are credentialed teachers, meeting China's teacher qualification standards (Wang, 2002). For example,

primary school teachers are required to graduate from a secondary school level teacher training institution. Gongban teacher salaries are provided by the county education department rather than the local community. However, for decades rural schools have hired unofficial or temporary teachers, known as *daike*, at lower salary levels using locally raised funds. The service of these "temporary" teachers sometimes lasts for several years even though most *daike* teachers have low qualifications (Bray, Ding, & Huang, 2004). Similarly, for many years rural schools continued to employ *minban* (managed by the local community) teachers, who are regarded as low quality due to their lack of academic preparation and little formal teacher training[2]. Although most *daike* and *minban* teachers did not have the required level of schooling or pedagogical training needed for teaching primary school, they were hired by schools in poor, remote areas because of the shortage of qualified teachers. For example, my research in Gansu Province reveals that 33 percent of primary schools in the sample employed *minban* teachers and 56 percent of primary schools had *daike* teachers on their staff in the year 2000. As a result, approximately 17 percent of the primary school teachers in the sample did not have the required teaching credentials.

China's rural teachers also struggle financially because salaries are low and often late. In 2000, the average salary for a credentialed primary school teacher in Gansu Province was 568 yuan per month, approximately 70 U.S. dollars. Average salaries for teachers without the required credentials were much lower, roughly 148 yuan, or 18 U.S. dollars, per month in the same year. In many areas, lack of government funds delayed teacher salaries for long periods of time. For example, eighty-five percent of the primary school teachers in the sample were owed wages, typically three months worth. In addition, fieldwork suggests that schools sometimes take funds out of teacher

[2] The Ministry of Education estimated that 13.8% of primary school teachers were *minban* teachers in 1998. As China has refocused educational reform efforts to focus on improving school quality, the government has adopted various methods to improve *minban t*eachers qualifications, such as providing training. In addition, *minban* teachers have been dismissed or transferred out of the profession. See Wang (2002).

salaries to meet other financial obligations (Xiao, 2001). As a result of low and late wages, many rural teachers find it necessary to engage in other work, usually farming, for a second source of income. Nearly half of the primary school teachers surveyed in the GSCF worked as farmers, and approximately 21 percent had another kind of part-time job to supplement their teaching wages.

The efforts of many rural teachers are challenged not only by their own lack of qualifications, but by the shortage of instructional materials and the poor conditions of school facilities (World Bank, 1999; Tsang, 1994). In Gansu, teachers sometimes work in unheated classrooms with poor lighting. Primary school classrooms often did not meet safety standards. Several classrooms could not be used in bad weather. Classrooms did not have enough desks and chairs for all students. Teachers strictly ration chalk, pencils, and paper to make the very limited supplies last until the end of the school year. Even so, 31 percent of teachers surveyed in the GSCF reported using their own money to purchase chalk, paper, and pencils for their students.

As a result of the poor conditions and low salaries, some rural teachers do not enter the profession because they want to. The opening of the labor market in the late 1990s created alternative career paths for potential teacher candidates, and in turn, some graduates seek employment in more lucrative or fashionable professions. Consequently, some of those who enter teaching do so not because they want to be teachers, but because they perceive few other employment opportunities. Many of these teachers do not like the profession, and do not want to remain a teacher for very long (Su, Hawkins, Zhao, & Huang, 2002; Sargent & Hannum, 2005).

Because conditions are particularly difficult and salaries are often late in rural areas, these communities encounter even more problems recruiting and retaining good teachers. As a result, the schools often hire teachers who do not have the required teaching credentials. In this way, the neediest children may be paired with least qualified teachers. This theory is substantiated in part by recent research in rural China indicating that the percentage of qualified teachers in a school is

associated with differences in village per capital income (Li, Park & Wang, 2007). Furthermore, research indicates that top ranked schools in the county and townships have higher percentages of highly qualified, or high-ranking, teachers (Paine, 1998). In recent years, these disparities in teacher quality have captured attention in China as educators and policymakers refocus their efforts on improving school quality in rural areas.[3]

2.3 Addressing the Limitations of Previous Research

In this paper, I address some of the limitations of previous research to advance our understanding of the influence of teacher attributes on student achievement in rural China. First, most research on teacher effects both in the U.S. and abroad has been hampered by data limitations and measurement issues. As a result, these studies have generally focused on a narrow set of teacher characteristics, such as teacher education, years of experience, and, types of teacher certification (Goldhaber & Brewer, 1996; Murnane, 1975). Strikingly, an investigation using NELS data revealed that many of the commonly measured teacher characteristics explain only a very small percentage of the overall effect of teachers on student achievement (Goldhaber, Brewer, & Anderson, 1999). In addition, studies of teacher effects often use aggregate teacher data collected at the school or district level (Card & Krueger, 1992). Because there is variation in teacher attributes within schools and districts, these studies cannot account for the true teacher effects on particular students. In my work, I utilize a rich set of matched student-teacher data, which includes measures of several teacher characteristics. In doing so, I can link students to the individual level attributes of their classroom teachers, and I can examine a wider range of attributes, such as time spent collaborating with other teachers, teacher motivation, and teacher interpersonal skills.

An additional issue that arises when examining the influence of teachers on student achievement is how to account for alternative explanations for differences in achievement. For

[3] For a description of recent initiatives aimed at improving rural teaching, see Yiu & Adams (2012).

example, student economic background or community characteristics may be correlated with teacher characteristics at a particular school. When analyses fail to account for these alternative explanations, the results tend to overestimate teacher effects. Here, I take advantage of a detailed data set which links students to information gathered about their families, communities, and teachers. As such, I am able to account for student family background, absence from school, and financial and social resources in the community. This approach allows me to better isolate the effect of teacher attributes.

Unique conditions in rural China resolve a second problem in studies of teacher effects: selection bias within the community due to mobility or choice and within the school as a result of non-random student assignment. In the United States, many parents relocate based on perceptions of school and teacher quality. In this way, people tend to self-select into the same school communities. Similarly, in many developing countries, parents who are most interested in their child's schooling seek out better schools (Glewwe & Jacoby, 1994). In rural China, the issue of school choice at the primary school level is not relevant because geographic mobility is extremely restricted. Further, there is system of residency laws that require most children to attend the village primary school, which is usually the only primary school in the village.[4] In this way, selection bias due to parental choice or mobility is not an issue. In addition, non-random student assignment within the school is not a problem because most rural primary schools in rural China, and all of the village schools in the sample, have only one class per grade.

As described earlier, some recent studies of teacher quality have used value-added model to focus on gains in student achievement during a specific period of time (Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004) These models are generally more accurate way to isolate the effect of specific

[4] In the early 2000s, school consolidation programs aggressively worked to merge smaller rural schools into larger central schools. Nationwide, the number of primary schools in rural China has fallen dramatically since 2002, from 384,000 to approximately 258,000 in 2010 (Ministry of Education, 2011). As a result, many villages in China's northwestern region no longer have primary school. For further information on the effects of school consolidation, see Liu et al (2008).

teachers on student achievement. These models take into account that student achievement results not only from the experience that the student has with their current teachers, but also from experience with previous teachers. Unfortunately, due to data limitations, I cannot account for prior student achievement, nor do I have information about the students' previous teachers. In this paper, I cannot completely resolve this potential source of bias, however, unique schooling conditions in rural China help to reduce the problem. Many of the students have only been taught by their current teacher because teachers in China generally move along with their class from grade to grade. In these analyses, which examine the achievement of first, second, and third graders, more than half of the students have only been taught by their current teacher. Not surprisingly, all first-graders had only been taught by their current teacher, but notably, 54% of second-graders had been with their current teacher for two years. Among third graders, 32% had been with their current teacher for three years, and 21% had been with their teacher for two years. Although this distinct characteristic of Chinese schools helps to reduce the potential of bias, it doesn't eliminate the issue. Therefore, in this paper, I include dummy variables in the analyses to identify the children who have only had one teacher. In addition, I re-fit the models on a subset of children who have only had one teacher.

3. Data and Methodological Approach

3.1 Data: Gansu Survey of Children and Families

In my analyses, I use data from the first wave of the Gansu Survey of Children and Families (GSCF-1), a multi-level survey of children aged 9-12, which was conducted during the summer of 2000 in 100 villages in Gansu province. Gansu exemplifies the poor economic conditions and geographic diversity that characterize many of China's interior provinces. The survey collected detailed information regarding children's schooling, achievement, and welfare in the context of rural poverty by matching a primary sample of 2000 children with secondary samples of children's

mothers, teachers, school principals, and village leaders. Additionally, a teacher questionnaire was administered to all teachers in schools attended by sample children; providing a census of nearly 1000 primary school teachers. The random multi-stage, cluster design employed at each stage was residency based, drawing children from village lists of school-aged children. In addition, achievement tests in mathematics or Chinese language, designed by specialists at the Educational Commission were administered to all children in the sample[5].

3.2 Analytic Sample

To examine the effect of teacher attributes on student mathematics achievement, I use an analytic sample of 433 students who live in 84 of the sampled villages in Gansu. The children in the analytic sample were in primary grades 1-3 during the 1999-2000 school year, and took the mathematics exam. I restricted the sample due to methodological and substantive issues. First, I limit the study to the 970 children who were administered the mathematics exam, rather than those who took the Chinese examination. Previous research in the United States indicates that mathematics achievement is more sensitive to differences in teacher and school characteristics than language achievement (Murnane, 1975). Within this group of children, some of the students were administered the exam for children in grades 1-3, and some were given the exam for grades 4 and above. In these analyses, I focus on the children in grades 3 and below because a majority of these children have only had one teacher, or at most two teachers while in primary school, and in turn, the linkages between student achievement and the attributes of their current teacher are more accurate. Next, because my own research in Gansu indicates that community resources influence student achievement (Adams, 2006), I limited the sample to children who attended school in their own

[5] One half of the students were randomly selected to take the mathematics exam; the remaining half took the Chinese exam.

village.[6] Ultimately, I investigate a sample of 431 students in grades 1-3 who were given the mathematics exam and enrolled in school in their own village. Next, I linked each individual student's data with the data collected from the student's teacher, mother, village leader, and school.

3.3 Measurement

In this paper, I examine a subset of questionnaire items that measure specific teacher attributes. In addition, I include variables to control for individual and community characteristics. In Table 1, I display descriptive statistics for all variables included in the analyses.

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The student-level data consist of controls for the children's socioeconomic status and other factors that are hypothesized to influence student learning. The village level data include variables to control for village economic and social resources as well as village population and topography. The teacher data consists of matched student-teacher data, which reflect teacher experience, education, credentials, motivation, and other attributes. In addition, Table 1 describes the educational outcome explored in my analyses: student mathematics achievement.

Children's mathematics achievement is measured by a test developed by the Provincial Educational Commission in Gansu. The exam, which was scored on a scale of 0-100 points, measures the appropriate range of the primary school mathematics curriculum for students in grades one through three. The average exam score in the analytic sample is 43.04, with scores ranging from 0 to 99.

In the analyses, I include the following child background measures. First, I incorporate a categorical indicator of the student's *grade* in school and the child's *age*, which ranges from 7 years to 13 years. I also include student *gender* (coded 0 if 'female' and 1 if 'male) as a control predictor

[6] In addition, children who were enrolled in school at boarding schools or attended school in another village were not included in the sample. China has a system of residency laws that require most children to attend schools in their official residences. However, most children walk to the school, and in turn, may attend school in a neighboring village if it is closer to their home. Similarly, some children attend boarding schools if their homes are so remote that they are unable to commute to school daily. Due to these circumstances, I excluded 16 children from the analysis.

because previous research findings from rural China suggest that girls may experience more barriers to schooling (Hannum, 1998). As indicated in Table 1, 49 percent of the analytic sample is female. *Family wealth* is also included as a control because researchers have linked financial resources in the home and schooling outcomes in rural China (Brown & Park, 2002; Adams, 2001). *Mother's education* is included as an additional measure of socioeconomic background. The sample average value for the log of family wealth is 8.95 with a standard deviation of 0.94. I also include two control predictors which represent children's opportunity to learn. The first is the variable, *absent*, which captures the number of days a child has missed school during the previous semester. The average number of days absent in the sample is less than one, suggesting that most students do not miss school very often. However, as illustrated by the standard deviation that is more than three times as large as the mean, there is large variation in days absent across children. The number of days absent during the semester ranges from 1 to 8 for the students who have missed school. These absences may limit children's opportunity to learn, and in turn, influence their achievement. In addition, I control for the *number of books* that the family purchased that semester as an indicator of the family's interest in reading materials. I also control for whether the child attended *preschool* prior to entering primary school; approximately 61 percent of the children attended preschool for at least one year.

Table 1 also presents descriptive statistics on the village-level variables selected to control for the effect of community characteristics. I include these controls because my own research in Gansu indicates that resources in a community influence student achievement (Adams, 2006). In these analyses, I control for *village population* and *topography*. I include topography, which indicates whether a village is located in a hilly area compared with a plain or mountainous area, to represent remoteness and development. Because research in China suggests that community financial resources were important for local schools during this period (Adams, 2001; Adams & Hannum, 2005; Li, Park, & Wang, 2007; Adams, 2006), I also control for economic resources devoted to

education in the village. I include both the *log of per pupil expenditure from government funds*[7] and the *log of per pupil expenditure from non-government*, or extrabudgetary, resources.[8] Finally, I control for the effect of social resources in the village by including a variable to represent *village social capital*.[9]

Most importantly, Table 1 describes the particular teacher attributes investigated in these analyses. I draw on previous research by including *teacher experience* as a categorical variable rather than modeling in linearly.[10] I include three categories in the models: 1 to 2 years of experience, 3 to 5 years of experience, and 6 to 10 years of experience. The comparison group is teachers with more than 10 years of experience. As indicated in Table 1, the majority of teachers in the sample have been teaching for more than 10 years. I also include the *teachers' highest level of education*, which reflects the completion of middle school, senior high school, or university. In addition, I investigate whether the teacher has official *credentials* or not. This variable indicates whether the teacher has the required level of academic qualifications and pre-service training for the level of school they are teaching. Seventy one percent of teachers in the analytic sample have their teaching credentials, and seventy two of teachers have completely either senior high school or university. In addition, I investigate the effects of several teacher demographics: *age, gender*, and whether the teacher is *native* to

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[7] In the year 2000, most village primary schools did not receive funding from the government, but instead relied completely on financial resources collected at the village level. In my analytic sample, 32 schools, less than half received some funds from the government. The value of funds from the government was imputed in 31 percent of villages. Using the imputed values results in estimates that are less biased than either excluding the cases with missing data or using the mean value of GOV to replace the missing values. See Winship (2000).

[8] This variable represents the funds received by village schools from the villages, social organization, school's own revenue, and donations from students, teachers, and officials.

[9] I drew on the work of James Coleman in creating a value to represent village social capital. Coleman identified the concept of "intergeneration closure" which can be defined as an individual student's parents' relationship with their children's friends' parents. He hypothesized that when relationships in a community are strong that communities can establish norms to guide behavior and values of children. For an in-depth discussion, see James Coleman (1988). In the GSCF, mothers were asked if they knew the parents of their child's friends. I use the average response of mothers in the village to this question to capture village "closure", or social capital. The variable ranges from 0 to 1, with villages that score closer to 0 having less social capital and villages with scores closer to 1 having more social capital.

[10] Murnane's (1975) early work demonstrates that teacher effectiveness noticeably increases over the first three years of teaching, peaks between three to five years of teaching, and then either decreases slightly or plateaus. In more recent work, Murnane & Phillips (1981) explain that the apparent decrease or plateau observed after the early years of teaching can be partially attributed to selection effects – the best experienced teacher may leave the classroom to become administrators or to take positions in other professions. In this way, the teachers who remain in the classroom may not be the best teachers.

the village. Park and Hannum's (2001) research in rural China suggests that math test scores are higher when the gender of the teacher and the student are the same. In addition, their work indicates that being taught by a teacher who is from the local village is associated with higher math achievement.

Table 1 also displays important, but often difficult to measure, teacher attributes. One of these variables is *teacher motivation to improve practice*. I operationalize the concept of teaching motivation by investigating the number of hours each week that a teacher spends collaborating with other teachers in their teaching-research group. The teaching-research group is an organizational group that Chinese teachers are required to participate in each week. This group plays an important role in a teacher's professional life (Paine & Ma, 1993; Ma, 1999). A teacher is not only responsible for her students, but also for working with other teachers to improve their own teaching as well as educational practice throughout the school. Together the teachers engage in lesson planning and discussions about how to deal with particular topics, classroom practices, what homework to assign, and why. In this group, teachers receive appraisal and feedback on their own teaching. They analyze exams together to identify weaknesses of past teaching. I include this variable in my analyses because it may influence student achievement in two important ways. First, the actual time spent examining one's teaching plans and reviewing student homework with colleagues may improve teaching practice. In this way, teachers who spend more time in the teaching-research group may have a better understanding of their subject matter, national teaching objectives, and how to teach these. Most importantly, time spent in the teaching-research group is an indicator of the teacher's motivation to improve practice. The sample average value for number of hours per week spent in the activities of the teaching-research group is 4.5, roughly one hour each day, but notably, there is substantial variation with some teachers spending three times as much time in these activities. Next, I investigate *teacher commitment to the profession*. Research in China suggests that for many teachers in

China that teaching is not their first choice of career (Sargent & Hannum, 2005). Many teachers do not come into teaching because they want to, but instead because they have no other employment opportunities at the time; these teachers generally hope to leave the profession quickly (Su, Hawkins, Zhao, & Huang, 2002). I measure teacher commitment to the profession by examining whether the teacher actively pursued teaching as a career or not. Ninety four percent of teachers in the sample actively pursued teaching as a career. Finally, I investigate teacher interpersonal relationships with students. Previous research indicates that teacher interpersonal skills are a significant predictor of learning outcomes for students (Frymier & Houser, 2009; Rodriguez, Plax, & Kearney, 1996). Teachers with stronger interpersonal skills can facilitate the learning process by helping students believe in themselves, fostering regulative behavior, and encouraging students to be their best (Frymier & Houser, 2009). In the analyses, I use students' perception of how encouraging their teacher is as a measure of teacher interpersonal skill. Teachers were identified as not encouraging, encouraging, and highly encouraging according to student responses.

3.4 Analytic Strategy

In the set of fitted regression models explored in this paper, I use random effects analysis to explore the effect of teacher characteristics on student mathematics achievement. In these analyses, I ask, on average, do children whose teachers have particular teacher attributes have higher mathematics achievement, controlling for child and family background, resources in the community, and other teacher characteristics? I fit these models using GLS regression analysis in order to account for the random effects of village. An examination of the estimated coefficients associated with each of the teacher main effects indicates whether the selected teacher attributes influence student mathematics achievement in Gansu, net of child background, resources in the community, and other teacher characteristics. An example of a typical random effects model is:

$$MATH_{ij} = \gamma_{00} + \gamma_{01}VILPOP_j + \gamma_{02}VILTOP_j + \gamma_{03}LGOVPPE_j + \gamma_{04}LNGOVPPE_j + \gamma_{05}CLOSURE_j$$
$$+ \gamma_{10}TEXP1_{ij} + \gamma_{20}TEXP2_{ij} + \gamma_{30}TEXP3_{ij} + \gamma_{40}TCRED_{ij} + \gamma_{50}TEDUC1_{ij} + \gamma_{60}TEDUC2_{ij} + \gamma_{70}TJYZ_{ij} +$$
$$\gamma_{80}TACTIVE_{ij} + \gamma_{90}TENC1_{ij} + \gamma_{100}TENC2_{ij} + \gamma_{110}LWEALTH_{ij} + \gamma_{120}AGE_{ij}$$
$$+ \gamma_{130}AGESQ_{ij} + \gamma_{140}GENDER_{ij} + \gamma_{150}GRADE2_{ij} + \gamma_{160}GRADE3_{ij} + \gamma_{170}ABSENT_{ij} + \gamma_{180}BOOKS_{ij} + u_j + \varepsilon_{ij}$$

where MATH is the mathematics achievement score for the i^{th} child in the j^{th} village. γ_{00} represents the estimated average math score in the population providing all variables are centered on their grand mean, γ_{01}, γ_{02}, γ_{03}….are regression parameters associated with the community level control variables, γ_{10}, γ_{20}, γ_{30},….γ_{110} are the regression parameters representing the main effects of teacher attributes on student achievement, and γ_{120}, γ_{130}, γ_{140} …are the regression parameters associated with the student level control variables. Residual ε is the unique error term associated with student *i* in village *j* and u is a random effect, representing the common unobserved characteristics that distinguish village *j*. I begin by fitting the model containing the student and village level controls. Then, I fit several models that include predictor variables representing teacher characteristics. Models are compared on overall goodness of fit, using the R-squared statistic. A statistically significant and positive coefficient associated with any of the teacher specific variables (γ_{10}, γ_{20}, γ_{30}….γ_{110}) demonstrates that children who have teachers specific levels of that attribute have higher mathematics scores, on average, taking into account the other community, individual, and teacher characteristics in the model.

In addition, because I cannot account for prior student achievement, I include a dummy variable in the model to indicate whether the child has only been taught by the current teacher or whether the child has had previous teachers. I use this strategy to address potential bias that may result from the effect of previous teachers. In addition, I re-fit the models on subset of kids who have only had one teacher to examine the interactions between particular teacher attributes and grade.

To address my second research question, do teacher attributes play an intermediate role in linking community resources to student achievement, I examine the above set of models to see whether the associated impact of community resources remains positive, but becomes diminished, when I account for teacher attributes in the relationship between community resources and student achievement. If teacher attributes play a mediating role in linking community resources to student mathematics achievement, then I would expect the coefficients on the teacher attributes predictors to statistically significant and positive and for the coefficients on the community-level predictors to decline from the values they exhibit before teacher attributes are accounted for in the models. Alternatively, if the teacher quality predictor is statistically significant and positive and the coefficients on the community-level predictors do not decline, then I will know that teacher quality is an independent determinant of student achievement, but is not an intermediate link between community resources and achievement.

4. Results

In Table 2, I display the parameter estimates for a selection of fitted models predicting the influence of particular teacher attributes on student mathematics achievement, controlling for student, village, and other teacher characteristics.

<< INSERT TABLE 2 HERE >>

In Model 1, I estimate a baseline model controlling for the characteristics of the student and the village. This fitted model indicates that the only statistically significant student level predictor of math achievement included in the fitted model is the student's grade in school. The model, which explains 54.1 percent of the within community variation in mathematics achievement, also indicates that village population, topography, the log of per pupil expenditure from non-governmental resources, and village social capital are all positively associated with achievement, controlling for all other variables in the model. In addition, the model controls for whether the child has only been

taught by the current teacher. Taken together, the individual and community characteristics explain 42.2% of the variation between communities in student mathematics achievement.

In the remaining models in Table 2, I display the results of random effects regression analyses in which I control for individual and village characteristics and also take into account several teacher characteristics: teacher experience, whether the teacher has official credentials, teacher education, teacher motivation to improve practice, teacher commitment to the profession, and teacher interpersonal skills. Model 2, in which I present the effect of teacher experience and teacher credentials, yields three notable findings. First, when included in the same model as teacher experience and teacher credentials, the magnitude of effect of the village-level control variables remains relatively consistent, suggesting these teacher attributes may not be an intermediate link between community resources and student mathematics achievement. Second, the coefficients on the teacher experience variables indicate having a teacher with 0-2 years experience is not significantly different for mathematics achievement than having a teacher with more than 10 years of experience. However, more strikingly, these coefficients also indicate that students who have teachers with 6-10 years of experience have higher math scores on average, and students who have teachers with 3-5 years experience have still higher math scores on average, controlling for individual and village characteristics and teacher credentials. Third, all else being equal, students who have teachers with teaching credentials have mathematics scores that are approximately six points higher, on average.

In the remaining models, I examine the relationship between the additional teacher attributes and student mathematics achievement. Surprisingly, the results in Model 3 do not reveal a significant effect of teacher education on student mathematics achievement. Because teacher credentials and teacher education are moderately correlated, I also tested the effect of teacher education while excluding teacher credentials from the model. The results of this model are

consistent with the estimates displayed in Model 3, and suggest that teacher's highest level of education is not a predictor of student mathematics achievement.[11] One explanation for this finding is that teacher education is not an important factor in explaining mathematics achievement in the early grades where mathematical concepts are not particularly challenging. Teacher education may matter in later grades.

The results in Models 4, 5 and 6 indicate those students who have higher motivation to improve practice, commitment to the profession, and stronger interpersonal skills with students have higher math achievement net of controls. These models in reveal several important findings concerning the specific teacher attributes that matter for mathematics achievement among rural first, second, and third graders in Gansu Province. Interestingly, having a teacher who is motivated to improve practice as demonstrated by the time spent each week in the activities of teaching research group, is positively associated with student mathematics achievement. I believe that the effect of this variable reflects two important dimensions of teacher effectiveness. First, to the degree that time spent in these activities is determined by the individual teacher, this variable also captures teacher motivation to improving teaching quality and raising student achievement. Second, from what we know about the nature of the activities of the teaching research group, it seems likely that these time spent collectively engaged in these activities could actually improve teaching practice. These teachers may have developed a better grasp of mathematics and how to teach particular concept more effectively, which ultimately results in higher student mathematics scores. The final model in Table 6 indicates that students who are taught by teachers who spend 5 hours each week in teaching research groups activities have mathematics scores that are 4 points higher, on average, compared with students who are taught by teachers who do not participate in these activities. Similarly, students who are taught by teachers who are committed to the profession, who actively pursued

[11] Teacher education is not included in the remaining models in Table 2. I did test teacher education in a model including all of the variables in Model 6; it was not significant.

teaching as a career, have higher math scores – 7 points higher, on average, when compared with those students who are taught by teachers who did not want to be teachers. Finally, teachers' interpersonal skills with students, as measured by the level of encouragement perceived by students, are associated with higher mathematics scores. Taken together, the results in Table 2 suggest that understudied teacher personal attributes, such as motivation to improve practice, commitment to the profession, and interpersonal skills with students matter for student achievement.

Of course, the results also indicate that traditional measures of teacher quality, teacher experience and credentials, also matter for student mathematics achievement. Students who are taught by teachers with credentials have math scores than are six points higher on average than students taught by teachers without credentials, controlling for all individual, community, and teacher characteristics in the model. When compared with the students of teachers who have more than 10 years of teaching experience, the results indicate that the math scores for those students with teachers with 0-2 years of teaching experience are not significantly different. However, students with teachers with 6-10 years of experience have higher mathematics scores, on average and net of controls, when compared to students of teachers who have been teaching for more than 10 years, while students taught by teachers with 3-5 years of experience have still higher mathematics scores. Notably, rather than being linear, the effect of teacher experience positively influences student mathematics achievement after the second year of experience, and then peaks at approximately year five, after which the effect of teacher experience declines slightly until year 10. However, one possible explanation for the complexity of the results is that the best experienced teachers may leave the poor, rural schools and be assigned to township and county schools. In this way, the more experienced teachers working at the most disadvantaged schools may not be the best teachers.

Finally, a comparison of Model 1 and 6 indicate that including the teacher attributes in the model explains slightly more of the both the within and between village variation in student

mathematics achievement. More specifically, the specific teacher attributes included in these analyses explain 3.9 percent of the variation in mathematics achievement within each village, on average. Interestingly enough, these same attributes explain 2.2 percent of the between village variation in mathematics achievement, suggesting that teachers with desirable qualities may be clustered to some degree in particular villages.

The effect of teacher attributes can be better appreciated if we consider the differences in estimated mathematics achievement in Table 3 for a prototypical child who is taught by a teacher with different sets of credentials. Here, I hold child background and community characteristics constant. In this way, Table 3 displays the estimated math score for a female student, age 9, in grade 2, who attended preschool, has not been absent from school in the last semester and purchased a mean number of books during this period. Her mother has approximately four years of schooling.She lives in an average size village in the hills with an average amount of social capital in the community. Her school does not receive funding from the state, and receives an average amount of funding from community resources. If the prototypical child's teacher has the set of attributes in column 1, a teacher with credentials who is committed to the profession, who is highly motivated to improve practice, with 3-5 years of teaching experience and highly rated interpersonal skills with students, the estimated math score is 66 points. However, the estimated mathematics achievement for the same child who is taught by a the teacher with the set of attributes in column 7, no credentials, who did not want to become a teacher with low levels of motivation to improve practice and low ratings for interpersonal skills, and who has been teaching for more than 10 years, is only 23 points. The gap in estimated mathematics achievement between the two sets of teacher attributes displayed in columns 1 and 7 is dramatic -- 34 points.

<< INSERT TABLE 3 HERE >>

We now return to the results in Table 2 to consider whether teacher attributes play an intermediate role in linking community resources to student achievement? Here, I compare Model 1 and Model 6 to investigate whether teacher attributes connect community resources to student achievement. As discussed previously, Model 1 indicates that village population, village topography, the log of per pupil expenditure from non-governmental resources, and village social capital are all positively associated with mathematics achievement, controlling for all other variables in the model. If teacher attributes play a mediating role in linking community these resources to student mathematics achievement, then I would expect the coefficients on these predictors to remain significant, but decline when I take into account teacher in Model 6. An examination of these coefficients in each of the models presented in Table 2, but particularly in Model 6 indicates that each of the coefficients associated with village-level variables with the exception of village population remains significant. Additionally, the only coefficient that declines ever so slightly (0.4) is the coefficient associated with village social capital. Surprisingly, these results suggest that while teacher attributes are unquestionably associated with student achievement, they are not an intermediate link between community resources and achievement. Instead, differences in teacher attributes represent a distinct dimension of community inequality.

4.1 Sensitivity Analyses

Because due to data limitations I cannot control for prior student achievement, I employed two strategies to reduce potential bias. First, I included a dummy variable in the models to indicate whether a student was taught only by their current teacher or whether the student had been taught by other teachers in earlier grades. The models displayed in Table 2 demonstrate that there is no significant achievement difference between students who have only experienced one classroom teacher and their counterparts who have been taught by more than one teacher. In addition, I re-fit the final model on a subsample of 216 children who had only been taught by one teacher. The

results of the sensitivity analyses indicates positive effects of teacher credentials, motivation to improve practice, commitment to the teaching profession, and interpersonal skills with students. The findings also show a positive effect of teacher experience. However, these analyses indicate that students who are taught by beginning teachers (0-2 years experience) also have higher mathematics scores compared with students who are taught by the most experienced teachers (more than 10 years). Overall, the sensitivity analysis do not reveal any striking differences in the effect of teacher attributes between the analytic sample of children used in Model 6 and the subsample of children who have only had one teacher.

5. Discussion and Conclusion

Considerable evidence from around the world shows that good teachers make a difference for student achievement. In fact, research suggests that difference in teachers explain more of the variation in student achievement than any other measure of school quality. Yet, to date, we know very little about what makes a good teacher. What kind of teacher attributes matter? Do students taught by teachers with particular attributes learn more? In this paper, I used rich, matched student-teacher data to advance our understanding by investigating the links between specific teacher characteristics and student math achievement in rural, northwest China.

This paper makes several contributions in identifying teacher effects. First, by using a rich, student-teacher matched data gathered in rural, Gansu province, I employ carefully measured student and community background characteristics, including but not limited to, days absent from school and local financial resources contributed to schooling to take into account alternative explanations for differences in student achievement, and in turn, better isolate the effect of classroom teachers. In addition, unique conditions in rural China allow these analyses to avoid the common problem of selection bias with the school and community. And perhaps, most importantly, I utilize detailed, individual level information about teachers in my analyses. This

approach allows me to both link individual students to the attributes of their particular teacher and to broaden the common measures of teacher characteristics.

Not unexpectedly, the results underscore that teachers matter. More importantly, the analyses presented in this paper uncover what kind of teacher attributes make a difference for student achievement in disadvantaged, rural schools. Notably, the results provide a complex picture of the influence of teacher experience on achievement by showing that years of experience early in a teacher's career have a different effect than later experience. Surprisingly, the results reveal no significant difference between those students who have a new teacher with 0-2 years of experience and those whose teacher has been teaching for more than 10 years. Instead, the analyses of teacher experience indicates that students taught by teachers with 6-10 years of experience perform have higher math scores, and students taught by teachers with 3-5 years of experience have even higher scores. As noted earlier, the complex effect of teacher experience is difficult to interpret because differences between those who leave the classroom and those who stay are also reflected in experience measures. In the case of rural China where labor market opportunities are limited, the most effective and experienced teachers may leave poor, rural schools to teach in the better conditions of township and county schools. In this way, the achievement differences between students taught by teachers with 3 to 5 years of experience compared with those taught by teachers with 6 to 10 years of experience may reflect the exodus of the most qualified teachers from the school after five years. As a result, the more experienced teachers may not be the most effective teachers.

In addition, the evidence indicates that whether a teacher is credentialed, teacher motivation to improve practice, teacher commitment to the profession, and teacher interpersonal skills all influence student mathematics achievement, net of individual and community characteristics. Notably, teacher education does not significantly influence student mathematics achievement for

children in grades one through three. And although the evidence does not support the hypothesis that teacher attributes serve an intermediate role in linking community disadvantage to student achievement, the result indicate that teacher attributes represent an independent determinant of achievement and one dimension of community inequality.

These results carry important policy implications for teacher recruitment, retention, and professional development in rural China. One of the most dramatic findings is that all else being equal, students who have teachers who are committed to the profession, as measured by whether they actively pursued teaching or not, have mathematics scores that are more than seven points higher, on average. This result raises important questions about how to make teaching a desirable profession, particularly considering that 6 percent of teachers in the analytic sample did not go into teaching actively, and the 18.3 percent would like to change leave teaching. Similarly, the association between the most experienced teachers and lower mathematics scores identifies the important issue of how rural schools can retain their best teachers. Descriptive data reveals the difficult conditions faced by China's rural teachers: low and late salaries, lack of resources, difficult living conditions, and few opportunities for continuing education. As general labor markets, and more specifically teacher labor markets, continue to open in the context of market transition, poor and remote communities will be further challenged in finding and keeping teachers for their classrooms.

The results highlighting the significance of the attributes, teacher motivation to improve practice and teacher interpersonal skills also present an opportunity for Chinese policymakers. Evidence indicates that teachers motivated to improve educational practice, who spend more time each week collaborating with other teachers have students who achieve higher math scores, on average. But, why? What explains these differences? What is happening in the teaching-research groups? Liping Ma suggests that Chinese teachers' understanding of mathematics may develop <u>after</u> they start teaching, and this understanding is advanced by the activities of the teaching-research

group. One explanation is that teachers learn specific mathematical concepts from his or her colleagues. Additionally, the discussion of how to teach the concept to students might actually deepen the teacher's knowledge of the concept, and ultimately improve student achievement. In this way, spending time in the teaching-research group may be especially important in areas where teachers report little access to continuing education or profession development. The apparent success of the teaching-research activities in supporting teacher and improving student learning suggests that policymakers and researchers should further consider not only the time spent by teachers in these activities, but also what activities they are most engaged in. Just as striking, my research demonstrates the importance of teacher-student interpersonal relationships in promoting student achievement. Students who perceived their teachers to be moderately encouraging compared with not encouraging had math scores that were nine points higher, on average and accounting for other individual, community, and teacher characteristics; students who perceived their teachers to be highly encouraging had even higher scores. Certainly, understanding teaching pedagogy and subject knowledge are important contributors to student learning, but these results suggest that pedagogy and knowledge alone may not be enough in rural, disadvantaged schools. Instead, teachers who are committed to the profession, who are motivated to improve practice, and who encourage students to believe in themselves may be just as important to improving the educational experiences of rural students.

In the end, this paper captures the great differences in teacher qualities experienced by Chinese students. It reflects foremost that these differences matter. Particular attributes, such as motivation and commitment, and as well as establishing conditions at rural schools to retain the best experienced and credentialed teachers with strong interpersonal skills can positively influence student performance. Importantly, the findings presented here also indicate that differences in teacher attributes represent a distinct dimension of community inequality. While educational

inequality has been a longstanding problem in rural areas, differences in teacher attributes that pair the most disadvantaged students with the least qualified teachers serves to intensify existing patterns of stratification.

Acknowledgments

The Gansu Survey of Children and Families is supported by a grant from the United Kingdom Economic and Social Research Council and Department for International Development (ESRC RES-167-25-0250). Earlier support for data collection came from The Spencer Foundation Small and Major Grants Programs, The World Bank, and NIH Grants 1R01TW005930-01 and 5R01TW005930-02

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Table 1. Descriptive Statistics for 433 1st, 2nd, and 3rd Grade Students and 203 teachers in 84 villages in Gansu Province,China

Data Source: GSCF-1, 2000

Variable	Mean	Standard Deviation	n
Outcome Variable			
MATH (Grades 1-3)	42.99	(27.92)	433
Student-level Control Variables			
GRADE 1	0.14	(0.34)	433
GRADE 2	0.38	(0.49)	433
GRADE 3	0.48	(0.50)	433
AGE	10.04	(0.95)	433
AGE-SQUARED	101.77	(19.48)	433
GENDER (FEMALE=0, MALE=1)	0.51	(0.50)	433
LOG FAMILY WEALTH	8.95	(0.90)	433
DAYS ABSENT	0.32	(1.04)	433
BOOKS	17.82	(14.95)	433
ONLY TAUGHT BY CURRENT TEACHER	0.50	0.50	433
Village-level Control Variables			
VILLAGE POPULATION	1574.62	(796.13)	84
TOPOGRAPHY (HILLY=1)	0.20	(0.40)	84
LOG GOVT PER PUPIL EXP.	1.08	(1.50)	84
LOG NON-GOVT PER PUPIL EXP	1.52	(1.52)	84
VILLAGE SOCIAL CAPITAL (0-1)	0.73	(0.20)	84
Teacher Attributes			
TEACHER EXPERIENCE			
1-2 YEARS	0.14	(0.35)	203
3-5 YEARS	0.11	(0.32)	203
6-10 YEARS	0.15	(0.36)	203
> 10 YEARS	0.59	(0.49)	203
TEACHER HAS CREDENTIALS	0.71	(0.45)	203
TEACHER EDUCATION			
MIDDLE SCHOOL GRAD	0.28	(0.45)	203
SENIOR HIGH GRAD	0.58	(0.48)	203
UNIVERSITY GRAD	0.14	(0.14)	203
MOTIVATION TO IMPROVE PRACTICE	4.52	(2.97)	203
COMMITMENT TO PROFESSION	0.94	(0.24)	203
INTERPERSONAL SKILLS			203
LOW	0.10	(0.31)	203
MEDIUM	0.44	(0.50)	203
HIGH	0.46	(0.50)	203
GENDER (female=1)	0.70	(0.46)	203
AGE	36	(12.14)	203
NATIVE TO VILLAGE	0.47	(0.50)	203

Table 2. Regression of Student Mathematics Achievement on Student Controls, Village Controls, and Selected Teacher Attributes (n students=431)

Data Source: GSCF-1, 2000

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	-34.285	-56.313	-54.477	-53.150	-62.443	-64.845
Student-Level Control Variables						
GRADE 2	15.636***	13.021***	12.310***	12.465***	12.684***	12.818*
GRADE 3	46.581***	44.496***	43.701***	43.711***	44.493***	43.828**
AGE	-5.385	-8.386	-1.103	-1.166	-1.613	-2.173
AGE-SQUARED	0.245	0.028	-0.040	0.040	0.006	0.089
GENDER	0.127	0.340	0.463	0.044	0.525	0.357
LOG FAMILY WEALTH	1.212	1.045	1.182	1.238	1.206	1.161
MOTHER'S EDUCATION	0.306	0.309	0.297	0.299	0.348	0.435
PRESCHOOL	-1.505	-2.417	-2.564	-1.934	-2.151	-2.034
DAYS ABSENT	-1.592~	-1.414~	-1.569~	-1.470~	-1.385	-1.287
BOOKS	0.110	0.109	0.108	0.121~	0.118~	0.114~
ONLY TAUGHT BY CURRENT TEACHER	1.146	1.134	0.667	0.625	0.247	0.270
Village-Level Control Variables						
VILLAGE POPULATION	6.117*	5.288~	4.832	4.809	4.398	3.181
VILLAGE TOPOGRAPHY	15.366***	16.946***	17.012***	16.311***	16.505***	16.517***
LOG GOVT PPE	1.257	1.105	0.982	0.779	0.773	0.611
LOG NON-GOVT PPE	2.922**	3.120**	3.101**	3.205**	3.197**	3.181**
SOCIAL CAPITAL	15.249*	16.946*	16.206*	13.938*	14.138*	14.847*
Teacher Attributes Variables						
TEACHER EXPERIENCE (comparison group >10 years)						
0-2 years		1.862	2.612	1.440	2.166	0.925
3-5 years		9.260**	10.367**	9.528**	10.912**	10.729**
6-10 years		6.886*	7.668*	6.501*	7.828*	6.527*
TEACHER CREDENTIALS		6.364*	6.646*	6.103*	6.633*	6.309*
TEACHER EDUCATION (comparison group middle school graduate)						
Senior high graduate			3.825			
University graduate			-0.079			
TEACHER MOTIVATION				0.719~	0.748~	0.803*
TEACHER COMMITMENT					9.336*	7.653*
INTERPERSONAL SKILLS (comparison group low)						
Medium						9.300**
High						11.098***
Goodness of Fit						
R^2 within	0.541	0.553	0.551	0.557	0.564	0.580
R^2 between	0.422	0.442	0.466	0.444	0.440	0.444
R^2 overall	0.484	0.492	0.502	0.494	0.497	0.505
Intraclass Correlation	0.248	0.257	0.244	0.264	0.273	0.292

~p<.10, *p<.05, **p<.01, ***p<.001

+I tested the effect of teacher age, teacher gender, and whether the teacher was a native to the village in several of the models. I have not included the variables in this table because I did not find significant effects. I also tested the interactions between each of the teacher attributes and the dummy variable indicating whether the student has only been taught by one teacher. None of the interaction terms were significant.

Table 3. Estimated Mathematics Achievement as a function of Different Sets of Teacher Attributes for a Prototypical Female Student, age 9, and in Grade 2.
(n students=431)
Data Source: GSCF-1, 2000

	1	*2*	*3*	*4*	*5*	*6*	**7**
Teacher commitment	yes	no	no	no	no	no	no
Teacher motivation	high	high	high	medium	low	low	low
Teacher credentials	yes	yes	no	no	no	no	no
Teacher experience	3-5	3-5	3-5	3-5	3-5	>10	>10
Teacher Interpersonal Skills	high	high	high	high	high	high	low
Estimated Mathematics Score	66.2	58.5	52.2	47.0	45.0	34.2	23.1

[+]Unless otherwise indicated, student background variables and community characteristics are set to the mean.