IMPROVING EDUCATION QUALITY IN EGYPT:  
AN ANALYSIS OF TEACHER EFFECTS ON STUDENT OUTCOMES  

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IMPROVING EDUCATION QUALITY IN EGYPT:
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ABSTRACT

Improving education quality in the Middle East and North Africa (MENA) is a topic of prime importance for promoting regional economic development and curbing the rising tide of extremism. While regional governments currently engage in education reform, little quantitative knowledge on factors affecting education quality in the MENA exists. To help fill this knowledge gap, this study examines teacher pedagogical effects on student mathematical achievement in Egypt. Information on teacher effects on student learning will provide insight into how Egypt can engage in meaningful education reforms and will provide guidance to other MENA governments on reform initiatives.

Using pooled data from the 2003 Trends in International Mathematics and Science Study (TIMSS) eighth grade mathematics test in Egypt, this study uses weighted least squares regression analysis to answer the following questions: (1) What pedagogical methods significantly affect 8th grade students’ overall academic achievement in mathematics in Egypt? and; (2) What pedagogical methods affect 8th grade students’ analytical and problem solving skills?

This study finds that one pedagogical method significantly matters in explaining student outcomes: students of teachers who regularly encourage independent problem-solving are associated with higher test scores. The effects of other pedagogical methods,
however, could not be determined with the available data. In light of analysis results, this study concludes with policy guidelines for Egypt and other MENA governments. Policy recommendations include emphasizing pedagogical methods that encourage independent thought in the classroom, increasing the number of hours devoted to mathematics study, and encouraging participation in university-level education among all citizens.
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INTRODUCTION

The Need for Education Reform in the Middle East and North Africa

Education reform in the Middle East and North Africa (MENA) is a topic of prime importance for promoting regional economic development and curbing the rising tide of extremism.\(^1\) Quality failures plague MENA education systems. Teachers emphasize rote memorization so students do not acquire the critical thinking skills needed both to attract private investment and to critically judge important political developments and evaluate extremist ideologies. Additionally, out-of-date curricula predominantly prepare students for public sector work, yet most MENA governments are working to retrench the public sector, leaving many graduates unemployed but unqualified for private sector work. While private investment is needed to spur the currently slow economic growth rates in the region, local entrepreneurs and international companies alike hesitate to invest in MENA countries partially due to unqualified workforces (Iqbal, 2006). The lack of private investment reduces the prospects for economic growth. Combined with a burgeoning youth population and high unemployment rates (World Bank, 2004), the education failures in the region both inhibit economic development and contribute to the spread of radical ideologies that threaten the world order.

Therefore, policies aimed at enhancing education quality in the region, especially in regards to improving the critical thinking skills of the populations, are of the utmost importance (Human Development Network, 1998). While several MENA countries currently engage in educational reform efforts, little analytical information exists on methods to improve the quality of the systems (Berryman, 1997). This dearth of information leaves MENA governments unable to implement the most effective and efficient reforms possible. Through analysis of teacher effects on eighth-grade students’ mathematical achievement (a proxy for education quality), this paper intends to help fill this knowledge gap on factors related to education quality in the Middle East and North Africa. The results of this study will then facilitate the implementation of effective and efficient reforms in the region to improve the quality of the education systems and the systems’ outputs.

**Egypt**

This paper analyzes policy-relevant variables to improve education quality in Egypt. Egypt has implemented numerous educational reforms in recent years and continues work in this arena. Egypt’s engagement in economic development and current attempts to integrate into the global market make human capital formation, of which education is a vital component, a topic of prime concern.

Egypt is an economic and political leader in the MENA region, and leads in education reform. Therefore, study of education policy-relevant variables, particularly teacher variables as they affect student achievement, will be instructive for both Egypt
and for other countries of the region that are economically, politically, and/or socially comparable to Egypt, or for countries that look towards Egypt for policy guidance. For instance, the findings in this study may be relevant for Morocco, which is economically comparable to Egypt. Both countries have similar GDP/capita (with Egypt at $3,900 and Morocco at $4,100), both have similar rankings in Human Development Indicators (Egypt ranks 111\textsuperscript{th} and Morocco ranks 123\textsuperscript{rd} in the world)(UNDP, 2006), and both countries actively engage in economic development and are integrating into the world trade market. Egypt’s economic starting point and educational reform goals are similar to that of many other MENA countries, like Morocco, and therefore policy lessons from Egypt may be applicable to much of the MENA region.

The Egyptian Secondary Education System

Egypt’s secondary\textsuperscript{2} education system is one of the largest in the MENA region. Egypt’s large population size partially accounts for the large education system (U.S. Census Bureau, 2006), but the system’s enormity is also due to the Egyptian government’s recent efforts to ensure access to education throughout the country: Egypt’s lower secondary (grades seven through nine) gross enrollment rate (the number of students actually enrolled as a percent of the total population of that age group) was 97.92\% in 2004 (EdStats, 2006). Egypt also has high gender equality in education, which naturally increases enrollment rates: the gender parity index (the gross enrollment ratio

\textsuperscript{2}In this paper, secondary education refers to grades seven through twelve, which is the typical usage of the term “secondary education” in most literature. However, it should be noted that in Egypt grade 8 (the grade analyzed in this paper) is technically within the “upper primary” stage of education. Since most data on Egypt and education literature place grade 8 within the confines of secondary education, I have chosen to use this delimitation.
between boys and girls) in secondary education is consistently in the low .90’s (0.92 in 2000, slowly rising to 0.94 in 2004) (EdStats, 2006). Egypt’s secondary repetition rate, at 7.3% in 2004, is the lowest among the Arab North African countries (Tunisia’s rate was 14.6% and Morocco’s was 17.6%) and is among the lowest in the entire MENA region (EdStats, 2006). However, outcomes in this country were much lower only a few years ago as Egypt struggled to achieve Universal Primary Education due to high demographic growth rates and large rural populations that place intense pressures on the education systems (Akkari, 2004). Egypt’s successes in education improvements make it a regional leader in regards to education reform.

A combination of the United Kingdom’s education system (which emerged in Egypt during colonial times) and the traditional Koranic model is the basis for the modern-day Egyptian education system (Akkari, 2004; UNESCO, 2004). The Ministry of Education (MOE) exerts direct and far-reaching control over all schools in this highly centralized system. The MOE is responsible for policy, planning, and budgeting (except in higher education), identifies the required qualifications for all teachers, and determines the textbooks and educational aids that teachers may use (UNESCO, 2004). The Center for Developing Curricula and Educational Materials under the MOE standardizes subject and grade level curricula throughout the entire country, revising and modifying curricula in consultation with teachers, supervisors, and university professors with specialized knowledge in each content area (UNESCO, 2004). Importantly for this study, the national curriculum dictates that eighth grade students study mathematics for only 2.25 hours per week out of a total 29.25 hours (UNESCO, 2004) (see table 2 in appendix 1).
The Egyptian education system operates in a very similar fashion to other MENA countries, such as Morocco. Therefore, it is possible to apply insight on teacher effects in Egypt to other MENA countries and inherent education system differences should not skew such comparisons, thus providing a rich source of policy-applicable information. For instance, like Egypt, Morocco based its education system upon a Western model (French) that authorities merged with the Koranic model to create the modern system. Also similar to Egypt, curricula and instruction methods are standardized for each subject and grade level in Morocco’s highly centralized system (UNESCO, 2004). Both countries also require students to pass national exams to progress to the next education level. The fact that the Egyptian and Moroccan education systems operate in very similar fashions means that lessons learned in Egypt can be applied to Morocco, and possibly to other MENA countries.

*Education Outcomes in Egypt*

Egypt made strong quantitative gains in education in the past decade, achieving improvements in equality in access, enrollment rates, and attainment rates (although large disparities between boys’ and girls’, and urban and rural students’, attainment rates still exist) (Educational Attainment Database, 2006). These quantitative gains, however, are not matched with qualitative improvements: education quality has either stagnated or declined as a result of increasing access without increasing teachers and school facilities (Human Development Network, 1998). For instance, while female rates of return to education slightly increased in recent years, male rates of return decreased (i.e. from 1988
to 1998, male rates of return to lower secondary education decreased from 7.0 to 4.9; see appendix 1, table 1), illustrating the effects of increasing enrollments (largely among females) on declining quality.

As is the case in most of the Middle East and North Africa, the Egyptian education system and curricula predominantly prepare students for public sector work, yet most governments are working to retrench the public sector due to its inefficiencies and the large financial burdens the public sector places on the state (World Bank, 2004). However, due to the rigidities of the education system and its emphasis on rote memorization, most educated citizens are unqualified for private sector work. As a consequence, there are severe mismatches between education outputs and labor market needs in Egypt, as in the rest of the region (UNDP Arab Fund, 2002). As the Human Development Network aptly states:

“Education in region does not effectively impart the higher-order cognitive skills such as flexibility, problem solving and judgment needed by workers who will face frequently challenging tasks and challenges in increasingly competitive export markets. Instead, the systems teach students how to learn and retain answers to fairly fixed questions in problem situations with little or no meaningful context . . .” (1998).

The low rates of return to education also demonstrate the low quality of educational outputs, especially in regards to preparation for private sector employment (see appendix 1, table 1). These low rates of return may reflect both the poor quality of education and the weak labor demand in Egypt (Iqbal, 2006), illustrating the mismatches between education and employment. Additionally, Egypt’s rate of return to education, which in 1998 averaged between -11.2 percent and 10.9 percent, is comparatively low when looking at other developing countries (as are the rates of return for most MENA
countries); for instance, returns to investment in education average around 20 percent in Asia, 27 percent in Latin America and the Caribbean, and 38 percent in sub-Saharan Africa (Iqbal, 2006). Therefore, as many analysts and policy-makers agree, governments must improve the quality of their education systems, focusing more on improving analytical thinking skills and less on improving quantitative measures (World Bank, 2004).

**Education Policy**

Many policy-relevant avenues exist to improve education quality in Egypt (and in the MENA in general), although there is little direct analysis on the subject in the region. One proposed method focuses upon textbook reform; undoubtedly, this is a worthy and important goal, as textbooks containing outdated information and inciting doctrine counteract most measures to improve education quality. Another method concerns curricular reforms, which are also important since national curricula provide the basis for topics taught in the classroom. Focus on improvements in teaching methodology and improving the quality of teachers themselves (Mokhtar, 1997) are other avenues by which to enhance education quality in the region. Teacher pedagogy and emphasis on analytical thinking and problem-solving skills versus rote memorization likely strongly impact the qualitative outputs of any education system, as does the quality of the teachers themselves (their knowledge, motivation, skills, experience, certification, etc). However,

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the quality of teachers in the MENA generally declined in recent decades as schools hired less qualified teachers to fill the gaps created with school expansions (Iqbal, 2006).

This paper will explore teacher effects on education quality in Egypt, where mathematics achievement scores are proxies for education quality: the higher the achievement in mathematics (which is an important subject for international economic competitiveness), the higher the quality of education. Through rigorous quantitative analysis, this paper will attempt to determine which teacher pedagogical methods affect student mathematical achievement; thus, this paper will help fill the current analytical gap on education reform policies in the MENA and hopefully add to the knowledge pool so that policy-makers can effectively promote education quality improvements through better teaching methods.

**LITERATURE REVIEW**

Little research directly evaluates international education systems, especially in the middle-income countries of the Middle East and North Africa. Instead, the majority of published research on education quality and teacher relationships to student learning comes from the United States. Although cultural, political, and social differences may make U.S. research less relevant in the MENA context, it provides some guidance as to where we should look for policy-relevant variables that affect education quality.

Education researchers have identified numerous factors that influence student achievement. There are two classes of such factors: student background factors, which students bring to the classroom and are more difficult to influence through public policy,
and school-level factors, which are more readily influenced via public policy. Student background factors include household characteristics (i.e., family income, number of siblings, parental education) and individual student characteristics (i.e., innate ability, IQ, motivation, previous test scores); school-level factors include school characteristics (i.e., student-teacher ratio, school size, curriculum, administrative structure, funding, location), and teacher characteristics (i.e., experience, education, certification, motivation, teaching skill) (see for example Rivkin, et al., 2005; Leigh and Mead, 2005; Nye, et al., 2004; Rockoff, 2003; Goldhaber and Brewer, 1997; Darling-Hammond, 2000; Anderson, 2004; Heyneman, 1997; Glewwe and Kremer, 2005). This paper focuses specifically on teacher effects upon education quality as measured by student achievement in mathematics.

**Research on Teacher Effects on Student Learning in the United States**

Research on teacher effects dates back to James Coleman’s *Equality of Educational Opportunity* 1966 report, popularly known as the “Coleman report.” Although Coleman found that student background characteristics are the largest determinants of student outcomes, he also found that, of factors that schools and policymakers can control, teachers matter the most (Goldhaber, 2002). However, subsequent analyses largely failed to find any statistically significant effects of teachers on learning until the last decade. Due to improved data collection methods and the development of value-added methods that follow changes in student test scores over years (thus allowing researchers to control for variations in initial conditions and separate teacher effects from
innate student characteristics and systematic school differences) (Rivkin, et al., 2005; Leigh and Mead, 2005) recent education research overwhelmingly concludes that teachers significantly affect student achievement. One of the most influential studies in this area is Rivkin, Hanushek, and Kain’s (1998, 2005) evaluation of teacher effects, which finds statistically significant teacher effects on student learning. This study provides the basis for current analyses of teacher effects on student outcomes and was the first study to robustly prove that teachers do indeed matter.

However, the degree to which and reasons why teachers affect student achievement are still topics of much debate. Studies evaluating observable teacher characteristics, such as years of experience, training, education level, intellectual ability, and subject matter knowledge, produce varying results, leaving the policy community with confusing and sometimes conflicting research. The fact that some of the variation in student test scores is due to both observable and unobservable teacher characteristics explains these divergent research findings. Since unobservable characteristics, such as motivation and teaching skill, are directly unmeasurable, most studies are prone to omitted variable bias. Additionally, the fact that the majority of studies rely upon non-experimental data increases the chances for omitted variable bias (experimental studies, on the contrary, allow random assignment and thereby control for unobservable characteristics); for instance, the Nye, et al. study reviewed below is the only truly experimental study on teacher impacts that this author could find. Furthermore, while some studies attempt to measure the unobservable characteristics with different proxies, the variation of these proxies and the possibly low quality of their measurements also
explain divergent results. While current research sometimes produces varying results, it is still our guide for analyzing teacher effects on student achievement in Egypt, and so a review of the findings is appropriate.

**Overall Teacher Effects**

In their seminal work on teacher effects, Rivkin, Hanushek, and Kain (2005) conducted student test score analysis to find that teacher quality accounts for a minimum of 7 ½ percent of the total variation in student achievement. The authors also find that higher teacher quality results in higher student test scores, although the magnitude of this effect is not large (about one-tenth of a standard deviation of a test score distribution in both mathematics and reading). Rivkin, et al.’s results indicate that a one standard deviation improvement in teacher quality proves more beneficial than class size reductions, and that high quality instruction throughout primary school can negate the adverse effects of low socio-economic status on student achievement. Additionally, in finding that most of the variation in teacher quality exists within schools instead of between schools, Rivkin, et al. dismiss the commonly-held theory that any observed differences in student achievement, as related to teacher quality, are due solely to school characteristics such as neighborhood effects (i.e. average population income effects) and school funding. Rivkin, et al.’s finding further suggests that individual teachers do indeed matter in explaining student outcomes.

Additional research confirms that teachers significantly affect student outcomes (see for example Rockoff, 2003; Nye, et al., 2004; Goldhaber and Brewer, 1997; Darling-
Hammond, 2000). Rockoff (2003) finds that teachers account for 5.0% to 6.4% of student test score variation and, assuming that teacher effects on student outcomes are normally distributed, that a one standard deviation increase in teacher quality is associated with a 0.24 standard deviation increase in math scores and a 0.20 standard deviation increase in reading scores. Nye, et al.’s (2004) random experiment in which teachers and students were randomly assigned to classrooms finds that about 11 percent of the variation in student test scores is due to differences among teachers.

Both Nye, et al. and Rockoff also assign teachers to “quality percentiles” to determine if there are large differential effects on student achievement between the best and worst teachers. Their findings are significant: 75th percentile (better) teachers are associated with student test scores that are 0.26 (Rockoff, 2003) to 0.34 (Nye, et al., 2004) standard deviations higher in reading, and 0.31 (Rockoff, 2003) to 0.48 (Nye, et al., 2004) standard deviations higher in mathematics than the scores of students taught by a 25th percentile (worse) teacher. Additionally, the difference in student achievement gains between 50th percentile and 90th percentile teachers is 0.33 standard deviations in reading and 0.46 standard deviations in mathematics (Nye, et al., 2004), proving that teacher quality matters not just between the better and worse teachers, but also between the best and average teachers. It is important to note that the Nye, et al. study assesses a random experiment of student-teacher classroom assignments, thereby allowing for stronger and more valid inferences about teacher effects on student achievement.

While the majority of research today confirms that teachers matter, researchers still debate the specific methods by which and reasons why teachers influence student
outcomes. While some researchers find that certain factors (such as teacher certification) explain student outcomes, others find that the same factors are irrelevant. A short review of the findings will highlight both what factors could influence student achievement and the many gaps still present in the literature on teacher effects on learning.

Certification, Training, and Professional Development

Most school districts hire and compensate teachers based upon certification and training in the field. However, whether or not certified teachers perform better and produce higher student outcomes is a matter of debate. Many researchers find that certification has no statistically significant positive effect on student outcomes (Kane and Staiger, 2005; Leigh and Mead, 2005; Haycock, 1998; Goldhaber and Brewer, 1997; Raymond, Fletcher, and Luque, 2001⁴), other researchers find that certification has some, but small, effects on student outcomes (Jepsen and Rivkin, 2003), while still others find that the difference in performance between certified and uncertified teachers is the largest determinant of student outcomes (Darling-Hammond 2000; Evertson, Hawley, and Zlotnik’s review of various studies, 1985⁵).

In his review of the literature assessing certification, Goldhaber (2002) highlights the statistical difficulties in accurately assessing the relationship of certification to student achievement. Goldhaber asserts that statistical inefficiencies and aggregation bias plague studies that find that certification matters, and that correlations between certification and

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student achievement could actually reflect the influence of subject-matter knowledge or pedagogical training (two factors discussed below). Differences in state certification standards also threaten the external validity of study results, as Darling-Hammond (2000) concedes. Additionally, Goldhaber (2002) notes that the studies cited in the Evertson, Hawley, and Zlotnik (1985) review, which find that certified teachers are more effective than those with only provisional or emergency certification, were not based on student outcomes and therefore overstate the effects. While certification is often used as a measure for teacher quality and is required of teachers in American public schools, the true relationship of teacher certification to education quality is still largely unknown.

The Egyptian government requires that teachers possess some form of certification or formal training. The TIMSS 2003 teacher questionnaire (utilized in this study and described below) indicates that most Egyptian eighth grade mathematics teachers hold teaching licenses or certificates; additionally, certification partially determines teachers’ salaries (UNESCO, 2004). Therefore, knowledge about the relationship between teacher certification and student outcomes in Egypt is important to help this and other MENA governments improve teacher hiring standards by either demanding certification, if proven to be effective, or opening the profession to more potential candidates if certification has no statistically significant effect, which could help to alleviate the currently low supply of teachers in the region.
Teacher Experience

Teaching experience often determines teacher pay scales in both the United States and throughout the world. However, debates continue as to whether experience affects teacher quality and influences student outcomes. While findings on the effects of teacher experience on student learning vary widely, the most compelling assert that a steep learning curve exists in teaching, so after the first few years of teaching experiential effects on learning become statistically insignificant (Rivkin, et al., 2005; Rockoff, 2003). Even considering initial effects on student learning, the overall effects of experience on student outcomes are low. For example, Rivkin, et al. (2005) find that “quality differences between new and experienced teachers account for only ten percent of the teacher quality variance in mathematics and somewhere between five and twenty percent of the variance in reading,” (435), while Rockoff (2003) finds that more years of experience appear to lower mathematics test scores (however, these findings are mitigated by large standard errors). Other research finds that experience has either very small or no effects on student learning (Haycock, 1998; Goldhaber, 2002), although this research does not disaggregate years of experience into the first few years versus later years.

Therefore, while the evidence on experience is mixed, most researchers are starting to acknowledge that perhaps experience only matters up to a certain point, and after the first few years cannot explain teacher quality or student outcomes. This finding makes intuitive sense since most teachers develop their classroom curricula and form
their teaching skills within the first few years and after that follow their previously
designed methods.

While population growth rates in most of the MENA have slowed and stabilized
(World Bank, 2004), meaning that the era of extreme population growth is over,
education systems still must expand to accommodate the large youth populations and to
ensure increased access to education for the poor and for females (UIS, 2006).
Consequently, more teachers are needed to accommodate the educational demand, and
understanding how teacher experience affects student outcomes could help MENA
governments effectively increase their teaching forces without sacrificing education
quality. If, as in the United States, there is a steep learning curve in the first few years
with little to no effects afterwards then governments could simultaneously pursue two
policy options: (1) ensure low teacher turnover rates by increasing salary, working to
improve the social image of teachers, and ensuring pleasant working conditions; and (2)
implement teacher development programs for new teachers, perhaps matching new
teachers with more experienced ones so that newer teachers become more effective at a
faster rate.

*Education Level and Subject Matter Knowledge*

Many studies also assess whether a teacher’s education level (namely, Bachelor’s
degree versus Master’s degree) affects student achievement. Degree level plays a role in
determining teacher compensation, yet most studies find that teachers with Master’s
degrees do not outperform teachers with Bachelor’s degrees (Rivkin, et al., 2005;
Goldhaber, 2002; Haycock, 1998; Ehrenberg and Brewer, 1994; Jepsen and Rivkin, 2003), unless the advanced degree is in the teacher’s subject area (Goldhaber, 2002; Goldhaber and Brewer, 1997; Leigh and Mead, 2005; Monk 1994; Darling-Hammond, 2000). Nye, et al. ’s (2004) random experiment also finds little effect on student achievement: the study finds that the effects of teacher education on student outcomes are only significant for math in grade three, and are always smaller than teacher experience effects. While it should be noted that the experiment was not designed to determine individual teacher characteristic effects on learning, the results from this one of very few random experiments in education are still informative.

While teacher education level appears to be insignificant in determining student achievement, findings suggest that teacher subject matter knowledge plays a large role in determining student outcomes (Haycock, 1998), especially in mathematics and science (Goldhaber and Brewer, 1997; Monk, 1994). (While some studies suggest that knowledge matters in general, Goldhaber and Brewer (1997) find that advanced degrees in areas other than mathematics and science are irrelevant to student outcomes.) According to Goldhaber (2002), teacher degree, experience, and other observable characteristics combined account for only about three percent of teacher effects on student learning, but that subject matter knowledge (measured by degrees, courses and certification in that area) is highly associated with high student performance.

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Given that teachers are often undereducated in the MENA due to lower hiring standards and the poor outcomes of the education systems, the effects of subject matter knowledge on student achievement in this region are particularly important. If subject matter knowledge is found to be highly statistically significant in Egypt, as it is in the U.S., this should provide important policy direction to Ministries of Education, as teachers could be required to fulfill certain requirements to teach each subject, such as a mandatory Bachelor’s or Master’s degree in that subject. If heeded, this knowledge could allow Middle Eastern and North African countries to experience significant improvements in student outcomes.

**Intellect, Aptitude, and Verbal Skills**

Additional factors considered when assessing teacher effects on student learning include teacher intellect, aptitude and verbal skills, which also potentially determine teacher education levels. While most earlier studies, as reviewed in Schalock (1979) and Soar, Medley, and Coker (1983), find little relationship between teacher intelligence and teaching performance, more recent studies find that teacher academic skills (typically measured by a “selective undergraduate college” proxy) positively relate to student learning, as does teacher verbal ability (Ferguson, 1998; Greenwald, et al., 1996; Ehrenberg and Brewer, 1994; Ferguson and Ladd, 1996). Specifically, Ferguson (1998) finds that an increase of one standard deviation in teacher test scores (on a basic literacy
examination) results in a 0.17 standard deviation increase in student test scores (on a basic skills test), and that over a period of ten years teachers whose test scores are at least two standard deviations apart have students whose test scores are at least 1.70 standard deviations apart, a “large effect” in Ferguson’s words. Goldhaber (2002) also agrees that teacher intellect and verbal ability positively affect student outcomes.

Although not statistically proven, teacher academic ability may be more important in higher grades and more difficult subjects such as math and science, in which teacher subject matter knowledge improves student outcomes. Additionally, teacher intellect must combine with teaching skill in order to be effective: a highly intelligent person is not necessarily a good teacher, but good teachers must possess a clear understanding of the subject matter and be able to answer questions. Teacher intellect, therefore, may be necessary but not sufficient to produce high student achievement scores. Since teaching is not a well-respected profession in the MENA and since teachers are not paid well (for example, Egyptian teachers make 22% of GDP per capita) (UIS 2006(a)), knowledge on whether or not teacher intellect matters in explaining student outcomes is important for policy direction in the region. If teacher intellect truly does matter, then governments could create stricter entrance requirements into the teaching profession, work to improve the image of teachers, and increase teacher pay in order to attract better candidates.

Pedagogy

Another factor that potentially affects student achievement is pedagogy, or how teachers manage their classrooms and provide instruction to their students. Education
specialists assume that teaching methods affect students’ understanding of material and class engagement, and therefore student achievement. However, analytical results on pedagogical effects are minimal, partly because, as Goldhaber (2002) notes, many researchers simultaneously assess the effects of pedagogical training and teacher credentials, using credentials as proxies for pedagogy. The few studies that attempt to directly assess pedagogy (not via proxies) do, however, find that pedagogy matters in explaining student achievement (Leigh and Mead, 2005; Anderson, 2004). However, the magnitude of pedagogical effects on learning is unknown.

Although little definitive research on pedagogical effects on student learning exists (likely due to the fact that pedagogy itself is difficult to measure), knowledge on these effects could be very important factors for formulating education policy in Egypt and the Middle East and North Africa in general. Much of the education quality debate in this region revolves around students’ lack of analytical skills, an outcome which teacher focus on rote memorization likely produces. Therefore, evaluation of pedagogy and its effects on education quality is important for reforming education in the Middle East and North Africa.

Teaching Skill and Other Unmeasurable Characteristics

The effects of the factors discussed above (teacher education, experience, pedagogy, certification, knowledge, etc.) on student learning may be largely mediated by important but unmeasurable factors such as teaching skill, confidence, enthusiasm, and
leadership. Without the ability to engage students, and without the motivation and the desire to teach, most teachers are probably quite ineffective. In his aptly titled article, “The Mystery of Good Teaching,” Goldhaber (2002) acknowledges that observable teacher characteristics account for only about three percent of the variation in student learning while the remaining ninety-seven percent of teacher effects on student outcomes are due to unmeasurable teacher qualities and behaviors.

Although there will always remain important unmeasurable factors that mediate teacher influences on student achievement, truly random experiments that would allow us to control for these factors are difficult to implement and come with the burden of moral hazard. Since we do not have the luxury of conducting experiments for the most part, we as policy-makers must analyze the measurable factors available despite their shortcomings in order to make the best policy decisions possible. Additionally, public policy can hardly change teacher personalities and innate skill, so the unmeasurable characteristics themselves may be of little use in guiding policy formulation. Therefore, this study will analyze the effects of observable teacher attributes on student learning in Egypt so as to guide future policy aimed at improving the quality of education in the country and the MENA region as a whole.

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Research on Teacher Effects Internationally, excluding the Middle East and North Africa

Only a few international studies assess teacher effects on student outcomes. Instead, most published work focuses on quantitative and/or basic education improvements in developing countries, such as improving enrollment and literacy rates. However, the few studies that do address teacher effects on learning find that various teacher characteristics are statistically significant. As with U.S. research, these studies are important guides for evaluating teacher effects in the Middle East and North Africa as they add to our understanding of potentially significant variables. While U.S. research is obviously limited to the United States, a country with far different economic, political, and social contexts than MENA countries, research on developing countries allows us to observe teacher effects in different social, economic, and political contexts. Although neither the United States nor the developing countries studied (which are mostly in sub-Saharan Africa) are similar to most MENA countries in most aspects, the combined knowledge of teacher effects in these various settings gives us a more complete understanding of teacher effects globally and allows us to more adeptly apply current knowledge to the MENA. Therefore, the findings in the limited literature on teacher effects on student learning in the developing world are important.

Most findings on teacher effects in developing countries are similar to those in the United States. International studies reveal mixed results on the effects of teacher experience on student achievement. For example, a study in Ghana found that teacher experience positively influences grade attainment, thereby (indirectly) improving reading...
and math scores (Glewwe and Jacoby, 1994), while other studies in India (Kingdon, 1996) and the Philippines (Tan, Lane, and Coustère, 1997) find no statistically significant effect of teacher experience on student test scores.

Findings on the effect of teacher training (certification) also widely varies: a Jamaican study finds that of more than forty school and teacher variables examined, one of the few statistically significant factors explaining student outcomes is teacher training within the past three years (Glewwe, et al., 1995), while other studies in India (Kingdon, 1996) and the Philippines (Tan, Lane, and Coustère, 1997) reveal no statistically significant effects of teacher training on student outcomes. The divergent results in U.S. and international research on teacher experience and training therefore provide little insight as to these factors’ potential specific effects in the Middle East and North Africa, providing guides for what to study but adding to the need for country-specific research.

Mimicking U.S. study results, two important studies in India and the Philippines find positive effects of teacher content knowledge (as measured by subject exam scores) on student achievement scores in both mathematics and reading (Kingdon, 1996; Tan, Lane, and Coustère, 1997). However, it should be noted that Kingdon’s results are not robust when attempting to control for selection into schools (Glewwe and Kremer, 2005). The prevalence of positive findings regarding teacher content knowledge in both the U.S. and internationally indicates that this factor could be one of the most important variables in determining teacher effects on student outcomes, although the extent to which teacher knowledge matters is still under debate.
Converse to most U.S. findings, a study in India ascertains that teacher education levels are statistically significant and positive in determining student outcomes (Kingdon, 1996). Therefore, the effect of teacher education could vary between developed and developing countries, possibly due to the different social status attached to teaching and different requirements for teachers between developed and developing countries. Thus, it is difficult to determine from current research whether or not teacher education will affect student outcomes in the MENA.

International studies on teacher effects often result in statistically insignificant findings or in divergent findings. Glewwe and Kremer (2005) attribute this lack of statistical significance partly to small sample sizes (i.e. low statistical power to detect effects) and the use of non-experimental research methods that fail to properly account for (1) selection bias (since many children in developing countries do not attend school in the first place, only the best students are in schools), (2) important differences in student characteristics and parent motivation, (3) omitted school and teacher quality variables, and (4) measurement error. Therefore, while research commonly finds that teachers do matter, there are still major gaps in the literature regarding assessment of how and why teachers matter internationally.

**Research on Teacher Effects in the Middle East and North Africa**

The Middle East and North Africa region consists of mostly middle-income countries that cannot be readily compared to either the United States or the developing countries mentioned above. Research on education in the MENA is still in the early
stages, with most research focusing upon improving rural and female educational access. Unfortunately, literature on teacher effects on student outcomes, as related to improving educational quality, is minimal; therefore, there are few directly applicable previous studies to guide current education research in any MENA countries. For this reason, this study primarily relies upon findings from the United States and low-income developing countries to guide variable selection and the direction of this research.

Any literature assessing education quality in the MENA typically evaluates textbooks (the number of textbooks per class or student, the variety of textbooks available, and/or the availability of supplemental reading materials), hours of instruction, expenditure per pupil (Heyneman, 1997), and the highest grade in a school (Khandker, 1994) as measures of education quality. Such variables are often the only statistics available regarding education in Middle Eastern countries, along with student-teacher ratios, teacher education, teacher compensation, and basic teacher characteristics (Heyneman, 1997). The existing research in the MENA is therefore very basic. Of teacher related research, education levels are found to be positively associated with student attainment (the highest grade completed, not the student’s academic achievement) and female teachers are found to have negative effects on boys’ attainment (Khandker, et al., 1994). Overall, most literature provides little evaluation of teacher effects on student outcomes, and the lack of educational data in the region seriously limits evaluations.
**RESEARCH AND ANALYSIS METHODS**

This paper seeks to provide information on how to improve educational outcomes in Egypt and more broadly in the Middle East and North Africa by answering two research questions:

- What pedagogical methods significantly affect 8th grade students’ overall academic achievement in mathematics?
- What pedagogical methods affect 8th grade students’ analytical and problem solving skills?

The second question is particularly important because it addresses the acquisition of those skills most needed in the MENA to promote economic development and curb fundamentalist extremism. While cumulative test scores provide reliable and comparative indicators of educational outcomes, these overall scores are not a definitive measure of education quality, particularly in the Middle East and North Africa where schools emphasize rote memorization. Although many Middle Eastern students may score very high on tests measuring memorization and basic skills, they may not do as well on tests that assess the more important indicators of analytical, evaluative, and creative thinking skills, which are the primary skills highlighted in discussions of education reform in the region. Therefore, answers to the second research question will provide important guides to policymakers in the MENA who work to enhance education quality to promote development.
The Data Source

Data to address these questions come from the 2003 TIMSS (Trends in International Mathematics and Science Study) conducted by the International Association for the Evaluation of Educational Achievement (IEA). The TIMSS consists of mathematics and science tests administered globally to students in both the 4th and 8th grades near the end of the school year in 1995, 1999 and 2003, and will again be administered in 2007. Taken in forty-nine countries worldwide, the TIMSS tests a representative sample of students in each country via a two-stage sampling design: in the first stage, local educational authorities select at least 150 schools using probability-proportional-to-size sampling, with the ability to stratify by important reporting variables such as urbanicity or school type; in the second stage, one or two 4th or 8th grade classes are randomly sampled in each school. Sample selection in Egypt included stratification by school type (public, free private, private, experimental language, private language, and afternoon second shift), gender served (male-only, female-only, or mixed), and location (urban or rural), resulting in a total of 217 sampled schools, 217 teachers, and 7,095 students (Martin, et al., 2004). The resulting sample is nationally representative and the use of sampling weights allows the data to be extrapolated to the entire nation (the weights include adjustments for non-response).

The TIMSS database includes student responses to each math and science question, overall student achievement scores, student scores by domain (content or cognitive, see below), student questionnaire responses, teacher questionnaire responses, principal questionnaire responses (providing school-level data), and national research
coordinator’s responses to a curriculum questionnaire; data from teacher and school questionnaires and tests can be linked to individual students. This analysis focuses on the 2003 8th grade mathematics test results, mathematics teacher questionnaire, and student questionnaire data for Egypt.

The TIMSS 2003 mathematics test is particularly useful for examining teacher effects on education quality in the MENA via student outcomes because it allows examination of both overall achievement and student ability on particular mathematical skills. The test is divided into Content and Cognitive domains. The mathematics Content domain includes five categories: number, algebra, measurement, geometry, and data skills. The Cognitive domain includes three categories:

- Knowing facts, procedures, and concepts (focuses on necessary basic knowledge);
- Applying knowledge and understanding (focuses on the ability to apply knowledge to solve routine problems or answer questions);
- Reasoning (focuses on the ability to analyze and address unfamiliar situations, complex contents and multi-step problems) (Mullis 2005).

This analysis uses each student’s overall mathematics score, as well as each student’s score on the three Cognitive domain data subsets.

Administrators issued twelve variations of the TIMSS math test using a matrix-sampling technique to cover a wide range of content, but at the same time reducing the length of the test for any one student (a similar technique is used in the U.S. for the National Assessment of Educational Progress, the nation’s educational “report card”).

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11 Experts who developed the TIMSS 2003 Assessment Framework for Mathematics updated the original four categories to three due to overlaps) (Mullis, 2005).
Administrators used Item Response Theory (IRT) to generate individual student test scores with both a single score provided for each student as well as “plausible values” that acknowledge the uncertainty around a student’s score and provide instead several scores from the student’s estimated distribution of measured ability (Martin, 2005).

A small number of observations (72 cases) are deleted from the data set because they provide no student or teacher data. The remaining observations lack various degrees of data. In most situations, the amount of missing data on a particular variable is relatively small so the analysis drops these cases (a total of 1,408 cases are dropped out of 7,095 total observations)\(^\text{12}\); however, analyses were conducted to see if the dropped cases were systematically different from the retained cases and the results indicated that the missing observations on any variable are not systematically different from observations with valid data. For variables with the highest number of missing data an econometric procedure is used to retain all of the observations in the regression analysis.

For example, a significant number (743 students, 25 teachers) of missing observations exist on the tutoring variable, so the regression models include a dummy variable (Tutor Missing) equal to 1 if the observation is missing on that variable and equal to 0 otherwise. As part of the regression run, for all observations for which Tutor Missing equals 1 the value of tutoring is set to 0 (although technically any value could be used). This procedure allows all of the observations to remain in the analysis, but the inclusion of the

\(^{12}\) For each variable where the missing cases were allowed to drop out of the regression estimation, the number of missing cases is relatively small. However, since different cases are missing on different variables, the total amount of missing observations dropped from the analysis adds up to 1,408. For instance, the Independently Decide variable has only 137 missing cases, the Math Major variable has 32 missing observations, and the Experience variable has 207 missing observations. In order to keep the model as parsimonious as possible, these cases were allowed to drop, while the variables with the largest numbers of missing cases were adjusted to keep the missing observations in the model.
dummy variable for missing observations ensures that the estimation of the coefficient on tutoring in this example only uses the cases with “real” data; that is, it “segregates” the cases with the assigned artificial zero values.

**Analysis Methods**

The analysis consists of the estimation of OLS regression models with the appropriate student sampling weights and the use of the “robust standard error” option in Stata to account for the fact that students cluster within classes and schools (the robust standard error yields a more accurate estimate of standard errors and associated statistical significance). The general regression model is as follows:

\[
\text{Mathematical Achievement} = \beta_0 + \beta_1(\text{Classroom instructional measures}) + \beta_2(\text{Teacher background characteristics}) + \beta_3(\text{Student background characteristics}) + \epsilon
\]

A combination of theory, prior research (see literature review), and a review of correlations between possible independent variables and the dependent variables of interest formed the basis for the selection of variables included in the models. Additionally, only variables with enough variation in the data are included so that actual effects could be assessed. Thus, although an important factor explored in prior work, the models do not include teacher certification since Egypt requires that all teachers hold certification, and the models do not include education level since there is very little
variation in this variable (97.21% of teachers sampled completed a first degree in tertiary school). Additionally, the models do not control for teacher gender although this factor is hypothesized to affect student outcomes in the Middle East and North Africa since there is not enough variation in the data (approximately 85% of teachers are male). The variables used in the analysis are described below, and tables 3 to 6 in appendices 2 and 3 present descriptive statistics of the variables in the models.

- **Student Achievement**: the key dependent variables the analysis are four individual student achievement scores in mathematics, which are student’s overall test score and student test scores in the three separate cognitive domains noted above (applying knowledge, knowing concepts, and math reasoning ability). Each regression model is run five times using the five IEA-generated plausible values of each student score; the five coefficient results are then averaged, resulting in the final coefficients presented below.

- **Classroom Instructional/Pedagogy Variables** are the key independent variables in the models and if significant may indicate the types of teaching methods that should be stressed in teacher education programs in Egypt. These variables include the following:
  
  - *How often the teacher asks students to decide on their own procedures for solving complex problems.* This variable is coded into four categories:
    every or almost every lesson, half of the lessons, some of the lessons, and never. The three variables included in the models are compared to the baseline group of “every or almost every lesson.” It is likely that results
will indicate that emphasizing independent thought in the classroom positively affects student test scores, especially in the cognitive domains.

- **Textbook Use.** This variable indicates whether a teacher uses textbooks as a primary resource (textbook use = 1) versus as a supplemental resource (textbook use = 0) in teaching their mathematics class. It is likely that teachers who teach primarily out of the textbook have students with lower critical thinking abilities, since these types of teachers are perhaps less motivated and since textbooks alone cannot instill analytical thinking skills in students. If found that textbook use as a supplementary resource positively significantly affects student outcomes, then governments could mandate a certain (lower) level of textbook use in national curricula.

- **Homework Emphasis.** This variable indicates how much a teacher emphasizes homework. The variable equals 1 if homework emphasis is high, and 0 if homework emphasis is medium to low. Homework emphasis is a derived variable composed of information on whether or not the teacher assigns homework, how often the teacher assigns homework, and about how many minutes of homework the teacher usually assigns. Homework emphasis likely affects student test scores, as students who are assigned more homework should have a better understanding of the material, and teachers who assign more homework may be more motivated (since they are willing to spend time grading more homework).
If homework is found to be significantly positive, then governments could require more homework as part of the national curriculum.

- **Teacher Background Characteristics** consist of the following:
  
  o **Limiting Factors.** This variable indicates classroom and/or school quality, and how that quality limits a teacher’s ability to teach math class, thus mediating individual teacher effects on student outcomes. The variable is defined such that “limiting factors” equals one if the teacher perceives that there are some to many limiting factors in their classroom (i.e. many class disruptions), and equals zero if the teacher experiences virtually no limiting factors.
  
  o **Teacher Experience and Teacher Experience-Squared.** The models include these variables measuring the number of years the classroom teacher has been in the profession since most literature on teacher effects finds that experience matters, but only up to a certain point; i.e. the inclusion of the squared term intends to capture the declining marginal effect of teacher experience. If experience-squared is found to be significant, as in other literature, then the Egyptian government could modify teacher training curricula to include more student-teacher and mentorship programs.
  
  o **Post-Secondary Major in Math.** This variable equals 1 if the teacher majored in mathematics in their post-secondary education and 0 if not. The models account for this characteristic since a post-secondary major in
mathematics is theorized to influence student achievement in mathematics.
Although not a primary variable of interest in this study, since this study is concerned with the effects of instructional methods on student learning, a statistically significant positive coefficient on post-secondary major could provide guidance to MENA governments to mandate that mathematics teachers have degrees in that subject so as to improve student outcomes.

- **Student Background Variables** are included as controls in the models and consist of the following measures:
  - *Male* equals 1 if the student is male, and 0 if female. Gender is included to account for possible different outcomes between boys and girls since some literature on education in the MENA finds that girls have lower outcomes than boys; this is certainly possible considering the prevalent gender inequalities in Egypt.
  - *Tutor* equals 1 if the student received math tutoring every day, almost every day, or once or twice a week; and equals 0 if sometimes or never. This variable is included since tutoring could mitigate teacher effects on student outcomes.
  - *Native* equals 1 if the student is native to Egypt, and 0 if not. Previous knowledge acquisition in another country likely affects scores, as does non-native understanding of Arabic (which is more likely among non-native students), so this control variable is included in the analysis.
Father’s Education and Mother’s Education levels are also included in the models. Both Father’s and Mother’s education are coded as three categorical variables: basic level, indicating that the parent finished secondary school or less; tertiary level, indicating that the parent completed a college education and; unknown, indicating that the student did not provide information on this question. The results on the parental education variables are compared to the baseline category of tertiary level.

- **Proxies for Motivation** are also included as controls in the models. Ideally, any model estimating factors associated with student achievement should include a measure of motivation, both that of the teacher and the student, since motivation intrinsically affects student test scores. Motivation can alter the effects of some measurable teacher and student variables on test scores (i.e., very motivated students may have higher test scores than unmotivated students, and this motivation can limit the effect of teacher certification or experience, for example, on the student’s test scores). Unfortunately, motivation is largely unmeasurable and therefore the models cannot readily control for this important factor. The TIMSS questions do, however, provide a few viable proxies for motivation that will be included in the analysis. While these proxies certainly cannot completely capture motivation, their inclusion should help reduce the inaccuracy of the standard errors of the coefficients that typically results from omitted variable bias.

- **Discuss with Colleagues** is a proxy teacher motivation, indicating how often the teacher discusses how to teach math concepts with other
teachers. The variable equals 1 if daily, almost daily, or 1-3 times per week; and equals 0 if 2-3 times per month or never.

- **Values Math** is a proxy for student motivation, indicating how much the student values learning mathematics. The variable equals 1 if the student’s perceived value of math is high, and equals 0 if their perceived value is medium or low.

## Results

Table 7 below contains all statistical analysis results. The first column presents results of the regressions on students’ overall test scores, and the following columns present results where the dependent variable is the applying knowledge score, knowing concepts score, and math reasoning score, respectively. Each cell entry provides the estimated coefficient and robust standard error in parentheses (values are averaged across the five plausible value regressions).
### Table 7. Analysis Results

<table>
<thead>
<tr>
<th></th>
<th>OVERALL MATH SCORE RESULTS</th>
<th>APPLYING KNOWLEDGE SCORE RESULTS</th>
<th>KNOWING CONCEPTS SCORE RESULTS</th>
<th>MATH REASONING SCORE RESULTS</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Coefficient Estimate</td>
<td>Coefficient Estimate</td>
<td>Coefficient Estimate</td>
<td>Coefficient Estimate</td>
</tr>
<tr>
<td></td>
<td>(Robust Std Err)</td>
<td>(Robust Std Err)</td>
<td>(Robust Std Err)</td>
<td>(Robust Std Err)</td>
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<td>(7.65)</td>
<td>(7.69)</td>
<td>(6.91)</td>
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<tr>
<td>Procedures-Half classes</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Independently Decide</td>
<td>-11.56*</td>
<td>-12.11*</td>
<td>-11.94*</td>
<td>-6.97</td>
</tr>
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<td>Problem-Solving</td>
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<td>(6.32)</td>
<td>(6.36)</td>
<td>(5.81)</td>
</tr>
<tr>
<td>Procedures-Some classes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independently Decide</td>
<td>-33.48**</td>
<td>-32.09**</td>
<td>-32.32**</td>
<td>-24.41</td>
</tr>
<tr>
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<td>(16.47)</td>
<td>(16.37)</td>
<td>(16.23)</td>
<td>(15.16)</td>
</tr>
<tr>
<td>Procedures-Never</td>
<td></td>
<td></td>
<td></td>
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<td>Textbook Use as Primary</td>
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<td>-0.43</td>
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<td>(6.03)</td>
<td>(5.94)</td>
<td>(5.60)</td>
</tr>
<tr>
<td>Textbook Use-Missing</td>
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<td>15.04*</td>
<td>12.95*</td>
<td>12.74*</td>
</tr>
<tr>
<td>(7.63)</td>
<td>(7.82)</td>
<td>(7.56)</td>
<td>(7.44)</td>
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<td>Emphasize Homework</td>
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<td>-6.76</td>
<td>-6.98</td>
<td>-7.48</td>
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<tr>
<td>(6.23)</td>
<td>(6.16)</td>
<td>(6.09)</td>
<td>(5.81)</td>
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<tr>
<td>Ability to Teach Without</td>
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<td>-7.05</td>
<td>-6.00</td>
<td>-5.00</td>
</tr>
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<td>(6.71)</td>
<td>(6.53)</td>
<td>(6.02)</td>
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<td>Experience</td>
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<td>-0.91</td>
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<td>(2.01)</td>
<td>(2.00)</td>
<td>(1.97)</td>
<td>(1.87)</td>
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<td>Experience-Squared</td>
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<td>0.09</td>
<td>0.08</td>
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<td>(0.07)</td>
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<td>Discuss Teaching Concepts</td>
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<td>0.60</td>
<td>0.26</td>
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<tr>
<td>With Colleagues</td>
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<td>(7.58)</td>
<td>(7.51)</td>
<td>(7.45)</td>
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<tr>
<td>Post-Secondary Math Major</td>
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<td>14.08</td>
<td>13.54</td>
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<td>(9.45)</td>
<td>(9.46)</td>
<td>(9.24)</td>
<td>(9.08)</td>
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</tr>
<tr>
<td>Male Student</td>
<td>8.58*</td>
<td>15.32***</td>
<td>6.12</td>
<td>5.07</td>
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<tr>
<td>(4.88)</td>
<td>(4.92)</td>
<td>(4.75)</td>
<td>(4.66)</td>
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<tr>
<td>Native Student</td>
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<td>31.06***</td>
<td>28.61***</td>
<td>37.50***</td>
</tr>
<tr>
<td>(3.60)</td>
<td>(3.61)</td>
<td>(3.55)</td>
<td>(3.58)</td>
<td></td>
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<tr>
<td>Student Received Tutoring</td>
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<td>1.46</td>
<td>4.38</td>
<td>4.73</td>
</tr>
<tr>
<td>(2.90)</td>
<td>(3.17)</td>
<td>(2.97)</td>
<td>(2.97)</td>
<td></td>
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<tr>
<td>Tutoring-Missing</td>
<td>-50.44***</td>
<td>-52.34***</td>
<td>-46.38***</td>
<td>-44.27***</td>
</tr>
<tr>
<td>(8.16)</td>
<td>(9.23)</td>
<td>(8.59)</td>
<td>(9.90)</td>
<td></td>
</tr>
<tr>
<td>Student Values</td>
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<td>35.85***</td>
<td>30.25***</td>
<td>21.32***</td>
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<td>(5.05)</td>
<td>(4.88)</td>
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<td>Student Values Math-</td>
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<td>-26.65***</td>
<td>-35.72***</td>
<td>-44.75***</td>
</tr>
<tr>
<td>Missing</td>
<td>(8.12)</td>
<td>(7.98)</td>
<td>(7.64)</td>
<td>(7.86)</td>
</tr>
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<td>Father Completed Basic</td>
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<td>-46.22***</td>
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<tr>
<td>Education or Less</td>
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<td>(5.37)</td>
<td>(5.04)</td>
<td>(4.96)</td>
</tr>
<tr>
<td>Father's Education</td>
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<td>Mother Completed Basic</td>
<td>-37.44***</td>
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<td>Education or Less</td>
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<td>(5.86)</td>
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<td>-35.96***</td>
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<td>(6.73)</td>
<td>(6.90)</td>
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<td>Intercept</td>
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<td>426.63***</td>
<td>440.95***</td>
<td>407.87***</td>
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<tr>
<td></td>
<td>(19.89)</td>
<td>(19.84)</td>
<td>(19.71)</td>
<td>(18.32)</td>
</tr>
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</table>

R-squared = 0.218  Adj R-squared = 0.215  R-squared = 0.218  Adj R-squared = 0.218  R-squared = 0.167  Adj R-squared = 0.164
The Models

The expected signs on the coefficients are present for most key and control variables throughout all four regressions, indicating that the models function properly and that the regression results are robust. For instance, students who regularly independently decide problem-solving procedures are expected to have higher scores on average than students who do this irregularly or never, and the negative coefficients on these variables confirm this hypothesis. Also, for example, the sign on the Native Student variable throughout all four regressions is in the expected direction: on average, we predict that native students will score higher than non-native students.

Interestingly, all coefficients are of similar magnitudes and statistical significance throughout all four regressions, except for the coefficient on Male Student, which is significant in the overall score and applying knowledge score regressions but becomes insignificant in both the knowing concepts and math reasoning subtest regressions. These insignificant results could indicate that while we predict that males will score higher on tests measuring basic knowledge skills, student gender has no predictable effect on students’ knowing concepts and math reasoning abilities in Egypt. This is an interesting result that could indicate that girls and boys in Egypt have similar reasoning and knowledge application skills, but that males possess greater understanding of basic concepts.

Consistent with previous educational analysis work, student background variables are highly statistically significant and have large effects on student scores, further indicating that the regression results are robust and that the models are properly specified.
The significant results on the student characteristic variables support other educational research findings that students and their home environments significantly matter in determining student outcomes. Interestingly, all teacher background characteristic variables are statistically insignificant in all four models. Unfortunately, the data prevents us from making any conclusions about teacher effects on student test scores in Egypt. The insignificant results on two of the three pedagogical variables also support previous educational research concluding that pedagogical methods are difficult to measure and thus difficult to assess.

**Effect of Pedagogy on Overall Mathematics Achievement**

This study examined the effects of three pedagogical variables on student test scores: emphasizing independent student decisions about problem-solving procedures, using textbooks as primary versus supplemental teaching resources, and emphasis on homework. Both the *Textbook Use* variable and the *Emphasize Homework* variable are statistically insignificant, meaning that we cannot assess any effects of these teaching methods on student test scores in this study. However, the variables indicating how often teachers require students to decide problem-solving procedures independently are statistically significant and are of a significant magnitude, and thus are important findings.

Even after controlling for student and teacher background characteristics that are hypothesized to affect student outcomes, the variables indicating how often teachers ask students to independently decide problem-solving procedures are significant, and this
pedagogical method is shown to matter in determining student outcomes. The analysis suggests that students of teachers who regularly require independent decision-making in the classroom perform better on mathematics tests compared to students whose teachers do not regularly implement this pedagogical method. The magnitudes of the three categorical variable coefficients included in the model, which relate different implementation levels of this teaching method, are also significant and indicate that students’ test scores fall lower as teachers utilize this method less often. Especially significant is the finding that students of teachers who never require independent problem solving are expected to have test scores 33 points lower than students whose teachers always or almost always implement this method.

The effect sizes of the coefficients on the Independently Decide variables are of a magnitude that is important in education research. For instance, the effect of Independently Decide-Never versus Independently Decide-Every Class on the overall test score is 0.34 standard deviations; as a point of reference, large class size reductions are estimated to have an effect size of 0.15 to 0.20. Therefore, the effect sizes on Independently Decide show relatively large and educationally meaningful effects of this teaching method on student scores. Given the significant results on the Independently Decide variables, we can determine that this instructional method is important in raising students’ test scores, and thus, if test scores are a good measure of student learning and ability (as is assumed in this study) is important in providing a better education to students and producing better educated graduates in Egypt.
**Effect of Pedagogy on Students’ Analytical and Problem Solving Abilities**

The findings on the effects of the three different pedagogy-related variables (the *Independently Decide* group, *Textbook Use*, and *Emphasize Homework*) on the cognitive domain scores are similar to the results on students’ overall mathematics achievement scores. The *Independently Decide* variables are the only statistically significant pedagogical variables in the three cognitive domain regressions, and both the method of textbook use and the emphasis on homework are statistically insignificant. Thus no conclusions can be drawn about how these teaching methods affect students’ analytical and problem solving abilities.

Contrary to expectations, the three pedagogical methods studied do not have significantly different effects on overall test scores as compared to the cognitive domain scores of applying knowledge and knowing concepts, although the results are slightly smaller and less significant on the math reasoning subtest. The *Independently Decide* variables are statistically significant at similar levels and have similar magnitudes across the total score, applying knowledge score, and knowing concepts score regressions, indicating that while this teaching method positively and significantly affects student test scores, it does not have different effects on the different student abilities that the TIMSS test measures.

The *Independently Decide* coefficient estimates are consistently smaller for the regression where the math reasoning score is the dependent variable than for the other three regressions. Additionally, *Independently Decide-Some Classes* and *Independently Decide-Never* are statistically insignificant in the math reasoning score regression,
whereas they are significant in all other analyses. These results could indicate that it is much more difficult to influence students’ math reasoning abilities via pedagogical or teaching methods, and perhaps that reasoning is more of an inherent ability unaffected in the classroom. Also, past educational experiences likely strongly affect this ability, thus mitigating teacher effects as analyzed in this study.

Additionally, some coefficient estimates on the Independently Decide variables are smaller when the dependent variable is a cognitive domain score as opposed to the overall score, producing results that are contrary to expectations. While the coefficient differences are not of large magnitudes, the fact that independent problem solving is predicted to have a smaller effect on the cognitive domain scores than on the overall score is surprising and contradicts the theory that pedagogical methods such as this one might matter more for analytical abilities than for overall subject matter knowledge.

**DISCUSSION**

Given the highly centralized nature of Egypt’s education system and the nationally mandated eighth grade mathematics curriculum, we can expect that observed teacher pedagogy effects on student outcomes are largely due to individual teacher differences rather than innate curricular differences that could produce varying outcomes between schools. Given Egypt’s recent engagement in curricular reforms aimed at improving student outcomes, teacher effects on student test scores may be mitigated if the curriculum was adapted to prepare students specifically for the TIMSS questions (teaching to the test); however, pedagogical methods (i.e. the quality of teaching) should
still affect student outcomes, no matter how in-line the curriculum may be with the TIMSS test. Unfortunately, direct information about the mathematics curriculum content in Egypt is unavailable and the extent to which the curriculum teaches the TIMSS skills remains an unknown and potentially limiting factor in this study.

The analyses conducted in this study suggest that one pedagogical method (emphasis on independent problem-solving skills) directly matters in explaining student outcomes; this is an important and significant finding in this study. However, no significant findings on the effects of homework emphasis or textbook use were found. These insignificant findings do not necessarily mean that these methods do not matter; instead, this data set and sample do not allow us to determine the true effects. More study on these variables is merited since information on how textbook use and homework emphasis affect student learning can provide useful policy guides for the Ministry of Education's future textbook and curricular designs.

The extremely low hours of mathematics instruction in Egypt (only 2.25 hours per week) may partially explain why this study obtained insignificant results on pedagogical methods and teacher background characteristics. The limited mathematics instruction time inherently limits teacher effects on student outcomes. Students are exposed to so little mathematics instruction throughout the eighth grade curriculum that is difficult to find any large or significant instructional relationships to student scores. The nature of the national eighth grade curriculum limits insightful policy analysis into what factors influence student mathematics scores and abilities.
It is important to consider that other influential teacher characteristics, such as motivation or teaching skill, may be captured in the pedagogical variables. The inability of the TIMSS test or any other education policy research to measure student motivation, teacher motivation, or teaching skill confounds findings and leaves us with incomplete data to measure the true effect of any variable on student outcomes. It is difficult to accurately assess causality since we cannot reliably isolate the effect of a particular teaching method, or “treatment,” from other factors and since we cannot remove selection bias (these statistical problems motivate researchers to conduct experiments, although experiments are very difficult to implement in education research). For instance, teachers who consistently engage students and ask them to independently decide how to solve complex problems may be more motivated or may have better teaching skills, and the influence of these unmeasurable characteristics on student outcomes may show up in the Independently Decide coefficients. Therefore, while the positive, statistically significant effects of this teaching method on student scores is a noteworthy and important finding in this study, it is important to note that direct causality is not perfectly or easily assessed.

Nonetheless, policy-makers must still work to effectively improve educational outcomes and so must rely upon analytical findings that suggest potential policy avenues. Since this study (although crudely) attempts to control for student and teacher motivation and also nets out influential student and teacher background characteristics, the findings are robust and can serve as policy guides. The significant finding on one pedagogical method is important and provides one avenue by which Egyptian educational authorities can work to improve educational outcomes.
CONCLUSIONS AND POLICY RECOMMENDATIONS

The findings in this study apply to teachers and students throughout Egypt due to the inclusion of IEA-generated student weights. Therefore, these results provide actionable policy guidelines for the Egyptian Ministry of Education that standardizes curricula throughout the country. Given that Egypt is a regional leader in terms of education and education reform efforts, other MENA governments, especially those such as Morocco with similar top-down education system structures, can also learn from the results of this study and consider the following policy recommendations when formulating education policies.

First, the fact eighth grade students study mathematics for only 2.25 hours per week is an influential reason for Egypt’s comparably low student outcomes on the TIMSS mathematics test (with an overall average score of 406, Egypt ranks 36th out of 46 countries tested with valid results, falls significantly below the international average of 467, and among MENA countries tested ranks 4th out of 8). In order to improve the mathematical abilities of all Egyptian students, the Ministry of Education should raise the number of instructional hours in this subject. Policy guides could be taken from the curriculum of similar countries that have higher TIMSS results (such as Jordan or Lebanon) and that also include religious and Arabic studies as core parts of the national curriculum. The numerous subjects studied in Egyptian schools constrains the Ministry of Education in significantly altering the number of hours devoted to mathematics, but if the government wishes to improve student outcomes on these critical skills, some compromises will have to be made. For instance, the number of hours in Arabic
Language, Foreign Language, or “other” subjects (which currently have the most instructional time devoted to their study) could each be cut slightly in order to increase the number of hours devoted to mathematics study.

Although not the focus of this study, the analysis results confirm that student background characteristics largely and significantly affect student outcomes. While these familial background characteristics are difficult to influence via public policy, it is important to note that the models predict that students of parents with higher education levels will perform better on average. This finding suggests that the Egyptian government should work to increase educational attainment levels among the entire population, encouraging continued education through the university level for all citizens. Currently, higher education is a matter of privilege in Egyptian society; if the government uses public policy to make higher education available to all citizens (by subsidizing higher education, for example, or opening more universities), they can positively influence the educational outcomes of future generations, thus creating a cycle of improved education outcomes among their citizens.

The finding that students of teachers who require them to consistently independently decide problem-solving procedures for complex problems have higher test scores than students of teachers who implement this teaching method less often is a key result of this study. The statistical significance and meaningful magnitudes of the Independently Decide variables across the regressions suggest that this teaching method matters not only for content knowledge acquisition, but also for improving students’ analytical thinking abilities. Therefore, teacher education programs should promote
instructional methods that encourage students to consistently decide problem-solving procedures independently. Teacher education programs provide the best avenue for accomplishing this objective since utilizing this pedagogical method requires skill in ensuring that students are continually engaged and thinking about problems throughout classroom discussions.

Emphasizing this pedagogical method is one way through which Egypt, and perhaps other MENA countries, can improve student outcomes in mathematics and improve students’ analytical thinking abilities. Improvements in analytical and critical thinking abilities, encouraged through independent thought in the classroom, will facilitate economic development in Egypt and may also help to reduce recruitment of Egyptian youth into extremist groups that threaten Egypt’s current political order. Citizens with better analytical skills will attract more foreign direct investment to the country, and these citizens will also more adeptly critically judge the messages and tactics of extremist groups. Therefore, reforming the education curriculum and teacher education programs to stress this pedagogical method can result in improved workforce characteristics, an improved economic environment, and a more stable political and social order.
BIBLIOGRAPHY


APPENDIX 1: EDUCATION IN EGYPT

Table 1. Selected Rates of Return to Education  
(percent per year)

<table>
<thead>
<tr>
<th>Education level</th>
<th>Sector &amp; Gender</th>
<th>Egypt 1988</th>
<th>Egypt 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Public, male</td>
<td>8.2</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>Public, female</td>
<td>1.9</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>Private, male</td>
<td>2.3</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Private, female</td>
<td>0.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Lower Secondary</td>
<td>Public, male</td>
<td>7.0</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Public, female</td>
<td>7.7</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>Private, male</td>
<td>2.5</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Private, female</td>
<td>3.2</td>
<td>-11.2</td>
</tr>
<tr>
<td>University</td>
<td>Public, male</td>
<td>10.1</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>Public, female</td>
<td>8.9</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>Private, male</td>
<td>8.5</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>Private, female</td>
<td>9.1</td>
<td>10.9</td>
</tr>
</tbody>
</table>


Table 2. National Standardized Weekly Lesson Timetable, 8th Grade

<table>
<thead>
<tr>
<th>Subject</th>
<th>Weekly Periods (1 period=45 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religious Education</td>
<td>2</td>
</tr>
<tr>
<td>Arabic Language</td>
<td>7</td>
</tr>
<tr>
<td>Arabic Calligraphy</td>
<td>1</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>5</td>
</tr>
<tr>
<td>Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>4</td>
</tr>
<tr>
<td>Art Education</td>
<td>2</td>
</tr>
<tr>
<td>Physical Education</td>
<td>2</td>
</tr>
<tr>
<td>Music</td>
<td>1</td>
</tr>
<tr>
<td>Maintenance</td>
<td>1</td>
</tr>
<tr>
<td>Technology</td>
<td>3</td>
</tr>
<tr>
<td>Library</td>
<td>1</td>
</tr>
<tr>
<td>Practical Areas</td>
<td>2</td>
</tr>
<tr>
<td>Additional Subjects</td>
<td>5</td>
</tr>
<tr>
<td>Total Weekly Periods</td>
<td>39</td>
</tr>
</tbody>
</table>

*Table adapted from UNESCO, 2004.*
### Table 3. Key Variables

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
<th>TEACHER N / STUDENT N</th>
<th>MISSING N</th>
<th>PERCENT DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook Use as Primary Resource</td>
<td>=1 if teacher uses textbook(s) as primary resource in teaching mathematics; =0 if textbook(s) used as supplemental resource</td>
<td>192 / 6254</td>
<td>24 / 769</td>
<td>48.96</td>
</tr>
<tr>
<td>Emphasize Homework</td>
<td>=1 if derived index of teachers’ emphasis on mathematics homework is high; =0 if medium to low homework emphasis</td>
<td>214 / 6952</td>
<td>2 / 71</td>
<td>25.7</td>
</tr>
<tr>
<td>&quot;INDEPENDENTLY DECIDE PROBLEM SOLVING PROCEDURES&quot; VARIABLES</td>
<td></td>
<td>212 / 6887</td>
<td>4 / 136</td>
<td>---</td>
</tr>
<tr>
<td>Independently Decide Problem-Solving Procedures-Every Class</td>
<td>=1 if teacher asks students to decide on their own procedures for solving complex problems about every class <em>(Baseline Group)</em></td>
<td></td>
<td>24.53</td>
<td></td>
</tr>
<tr>
<td>Independently Decide Problem-Solving Procedures-Half Classes</td>
<td>=1 if teacher asks students to decide on their own procedures for solving complex problems about half of the classes</td>
<td></td>
<td>20.75</td>
<td></td>
</tr>
<tr>
<td>Independently Decide Problem-Solving Procedures-Some Classes</td>
<td>=1 if teacher asks students to decide on their own procedures for solving complex problems some of the classes</td>
<td></td>
<td>51.89</td>
<td></td>
</tr>
<tr>
<td>Independently Decide Problem-Solving Procedures-Never</td>
<td>=1 if teacher asks students to decide on their own procedures for solving complex problems never</td>
<td></td>
<td>2.83</td>
<td></td>
</tr>
</tbody>
</table>
### Table 4. Student Control Variables

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
<th>VALID N</th>
<th>MISSING N</th>
<th>PERCENT DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Student</td>
<td>=1 if male student; =0 if female student</td>
<td>7023</td>
<td>0</td>
<td>53.07</td>
</tr>
<tr>
<td><strong>MOTHER’S EDUCATION VARIABLES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother Basic Education</td>
<td>=1 if mother completed secondary school, primary school, or less</td>
<td>6651</td>
<td>372</td>
<td>---</td>
</tr>
<tr>
<td>Mother Higher Education</td>
<td>=1 if mother completed higher/tertiary education</td>
<td></td>
<td></td>
<td>54.26</td>
</tr>
<tr>
<td>Mother Unknown Ed</td>
<td>=1 if mother's education level is unknown</td>
<td></td>
<td></td>
<td>32.95</td>
</tr>
<tr>
<td><strong>FATHER’S EDUCATION VARIABLES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father Basic Education</td>
<td>=1 if father completed secondary school, primary school, or less</td>
<td>6659</td>
<td>364</td>
<td>---</td>
</tr>
<tr>
<td>Father Higher Education</td>
<td>=1 if father completed higher/tertiary education</td>
<td></td>
<td></td>
<td>49.02</td>
</tr>
<tr>
<td>Father Unknown Ed</td>
<td>=1 if father's education level is unknown</td>
<td></td>
<td></td>
<td>38.80</td>
</tr>
<tr>
<td>Tutor</td>
<td>=1 if student received math tutoring every day, almost every day, or once or twice a week; =0 if sometimes or never.</td>
<td>6571</td>
<td>452</td>
<td>58.13</td>
</tr>
<tr>
<td>Native</td>
<td>=1 if student native to the country; =0 if not</td>
<td>6587</td>
<td>436</td>
<td>78.62</td>
</tr>
<tr>
<td>Values Math</td>
<td>=1 if student has a high perceived value of math; =0 if medium or low perceived value (Proxy for motivation)</td>
<td>6670</td>
<td>353</td>
<td>81.38</td>
</tr>
</tbody>
</table>

### Table 5A. Teacher Control Variables: Continuous Variables

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
<th>TEACHER N / STUDENT N</th>
<th>MISSING N</th>
<th>RANGE</th>
<th>MEAN</th>
<th>STD DEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience</td>
<td>Teacher's Years of Experience</td>
<td>6714 / 207</td>
<td>9 / 309</td>
<td>2-28</td>
<td>13.88</td>
<td>5.28</td>
</tr>
<tr>
<td>Experience-Squared</td>
<td>Experience Squared</td>
<td>6714 / 207</td>
<td>9 / 309</td>
<td>4-784</td>
<td>224.11</td>
<td>155.15</td>
</tr>
</tbody>
</table>
Table 5B. Teacher Control Variables: Categorical Variables

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>DESCRIPTION</th>
<th>TEACHER N</th>
<th>STUDENT N</th>
<th>MISSING N</th>
<th>PERCENT DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limiting Factors</td>
<td>=1 if teacher must teach class with limiting factors (i.e. many disruptions); =0 if no limiting factors</td>
<td>214 / 6958</td>
<td>2 / 65</td>
<td>18.23</td>
<td></td>
</tr>
<tr>
<td>Discuss With Colleagues</td>
<td>=1 if teacher discusses how to teach math concepts with other teachers daily, almost daily, or 1-3 times per week; =0 if 2-3 times per month or never (proxy for teacher motivation)</td>
<td>214 / 6955</td>
<td>2 / 68</td>
<td>82.24</td>
<td></td>
</tr>
<tr>
<td>Math Major</td>
<td>=1 if teacher majored in mathematics during post-secondary education; =0 if did not major in mathematics</td>
<td>215 / 6991</td>
<td>1 / 32</td>
<td>85.58</td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX 3: STUDENT SCORES

Table 6. 2003 TIMSS Mathematics Scores-Egypt

<table>
<thead>
<tr>
<th>SCORE TYPE</th>
<th>COUNTRY TOTAL</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVERALL TOTAL SCORE¹</td>
<td>406 (3.5)</td>
<td>75 - 788</td>
</tr>
<tr>
<td>CONTENT DOMAINS SCORES²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>421 (3.0)</td>
<td>138 - 747</td>
</tr>
<tr>
<td>Algebra</td>
<td>408 (3.9)</td>
<td>53 - 814</td>
</tr>
<tr>
<td>Measurement</td>
<td>401 (3.3)</td>
<td>78 - 819</td>
</tr>
<tr>
<td>Geometry</td>
<td>408 (3.6)</td>
<td>20 - 839</td>
</tr>
<tr>
<td>Data</td>
<td>393 (3.2)</td>
<td>101 - 719</td>
</tr>
<tr>
<td>COGNITIVE DOMAINS SCORES¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowing Concepts</td>
<td>411 (3.4)</td>
<td>5 - 793</td>
</tr>
<tr>
<td>Applying Knowledge</td>
<td>404 (3.4)</td>
<td>41 - 780</td>
</tr>
<tr>
<td>Math Reasoning</td>
<td>400 (3.6)</td>
<td>68 - 785</td>
</tr>
</tbody>
</table>

Standard Errors are in parentheses

¹ Mullis, et al., 2005
² Mullis, et al., 2004