Teachers' Qualifications and Their Impact on Student Achievement Findings from TIMSS-2003 Data in Israel

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Abstract

Data collected as part of TIMSS-2003 in Israel make it possible to validate some assumptions regarding the relationship between some teachers' characteristics and students' achievements. This examination is needed for taking a stance in the hot debate in Israel and elsewhere, regarding the nature of necessary reforms in initial teacher education, opportunities for professional development and the reward mechanisms and incentives that affect the career structure of practicing teachers.

The findings in this study, which are in line with findings from many other studies, do support policy intervention aimed to provide more opportunities and incentives for participation in content-focused professional development.

Keywords: Teachers' qualifications, student achievement, teachers' policy

Introduction

In this paper I re-examine some common assumptions about the link between teachers' qualifications – representing desired teacher qualities – and their students' achievements. This is necessary if we want to take a stance in the hot debate, in Israel and elsewhere, regarding the type of reforms required in initial teacher education, opportunities for professional development and the reward mechanisms and incentives that affect the career structure of practicing teachers.

Viewing student achievement as evidence of learning, and linking student learning to the "effective" (Berliner, 1987; 2005) or "successful" (Fenstermacher & Richardson, 2005) teacher, is one way of defining quality teaching. This approach differs from that which identifies the quality teacher with the so-called "good teacher" – one who upholds the standards and norms of the profession. Fenstermacher and Richardson (2005) describe this distinction in the following way:

> By good teaching we mean that the content taught accords with disciplinary standards of adequacy and completeness and the methods employed are age appropriate, morally defensible and undertaken with the intention of enhancing the learner's competence with respect to content. By "successful teaching" we mean that the learner actually acquires some reasonable and acceptable level of proficiency from what the teacher is engaged in teaching (from Berliner, 2005, p. 207).

Because of psychometric difficulties in assessing teachers by their normative attributes – the logical, psychological, and especially the ethical, which tend to differ across cultures (Alexander, 2000) – the tendency to evaluate teacher qualities on the basis of student performance is further emphasized. With the increased demands for accountability in line with performance standards and with the growing demand for evidence-based policy making, students achievements are considered an accurate measure of effectiveness and has become a basis for value-added teacher assessment systems (Braun, 2005; McCaffrey, Lockwood, Koretz, Louis, & Hamilton, 2004; Sanders, 2000; Sanders & Rivers, 1996).

This approach also gained support from the point of view of the effectiveness of teacher education systems. In tracing teacher education development and reforms in terms of the major questions that have driven the field, Cochran-Smith, (2001) argues that it is currently "the outcome" question that motivates teacher education research and policymaking. She states three ways in which outcomes of teacher education are constructed: the long-term impact outcomes, teacher test scores and professional performance.

Long-term outcomes refers to the relationship between teacher qualifications (their test scores on licensure examination; level of degrees, years of experience, preparation in subject matter and in pedagogy; certification in their expertise area, and their ongoing professional development) and student learning (student gain scores on achievement tests). This relationship is taken to be the percentage of variance in student scores accounted for by teacher qualifications when other variables are held constant or adjusted (Cochran-Smith, 2001, p. 531) and is the focus of this study.

In many countries teacher qualifications that are considered to be related to student learning have become desirable targets of teacher education reform. Some of these reforms call for the professionalization of teacher education by making it longer, upgrading it to graduate programs, and regulating it through mechanisms of licensure, certification, and promotion aligned with standards (Darling-Hammond, 1998, 1999; Darling-Hammond, Berry & Thorenson, 2001; Darling-Hammond, Chung, & Frelow, 2002). The impact of these policies on student learning was explored in several meta-analytic studies mainly based on U.S. data, but also on the basis of other countries' data bases (i.e., Darling-Hammond, 1999; Greenwald, Hedges, & Laine, 1996; OECD, 2005, Santiago, 2002; Wayne & Youngs, 2003; Wilson, Floden, & Ferrini-Mundy, 2001) as well as on more specific policy-targeted or more local studies (Harris & Sass, 2006; Ingersoll, 2003; Wilson, Darling-Hammond, & Berry, 2001).

In Israel, too, teacher qualifications have become the target of several recent reforms such as those announced by different teacher unions (2004), the National Task Force for the Advancement of Education in Israel (Dovrat Report, 2005) and the Committee of the Commission for Higher Education (Ariav et al., Report, 2006).

All these reforms envision improvement of the candidate selection process, upgrading the disciplinary preparation of teachers, opening second degree programs for M.Ed. or M.Teach and providing opportunities for professional development.

In light of the relatively few studies conducted in Israel on the impact of these recommended policies on student learning, and conflicting results obtained from the many studies conducted elsewhere, this paper uses data obtained in the TIMSS-2003 study in Israel, to validate some of these policies, and, more specifically, to reexamine on the basis of the Israeli data, the extent to which advanced academic degrees, majoring in the field of teaching, years of experience and intensive participation in professional development activities, all assumed to be cardinal teacher qualifications, indeed have a positive impact on student learning.

Literature Review

The following section offers a summary of research findings related to each of the teacher qualifications dealt with in this study.

Teachers' Formal Education

Findings related to teachers' academic degrees (e.g., bachelors or masters, etc.) are in-conclusive. Some studies showed positive effects of advanced degrees (Betts, Zau, & Rice, 2003; Ferguson & Ladd, 1996; Wayne & Youngs, 2003), while others showed negative effects (Ehrenberg & Brewer, 1994; Kiesling, 1984). Some argue that the requirement of a second degree raises the cost in terms of teacher education and the time it involves and may prevent quality candidates from choosing this profession (Murnane, 1996).

Teacher Education in the Subject Matter of Teaching (in-field preparation)

This characteristic is related to the subject-matter knowledge teachers acquire during their formal studies and preservice teacher education courses. The evidence gained from different studies is contradictory. Several studies show a positive relationship between teachers' preparation in the subject matter they later teach and student achievement (Darling-Hammond, 1999, 2000; Goldhaber & Brewer, 2000; Guyton & Farokhi, 1987), while others have less unequivocal results. Monk and King (1994) find both positive and negative effects of teachers' in-field preparation on student achievement. Goldhaber and Brewer (2000) find a positive relationship in mathematics, but none in science. Also, Rowan, Chiang, and Miller (1997) report a positive relationship between student achievement and teachers' majoring in mathematics. Monk (1994), however, finds that having a major in mathematics has no effect, and a significant negative effect of teachers with more coursework in physical science. Recent studies in the USA on the widespread phenomenon of out-of-field teaching, Ingersoll (2003) portrays a severe situation where almost 42% - 49% of public Grade 7-12 teachers teaching science and mathematics actually lack a major or full certification in the field (1999-2000 data). In Israel, according to a recent survey (Maagan, 2007), these percentages are even higher for elementary teachers – 42% in mathematics and 63% in science (2005-2006 data).

Teacher Education in Pedagogical Studies

Studies have found somewhat stronger, and more consistently positive, influence of education and pedagogical coursework on teacher effectiveness (Ashton & Crocker, 1987; Everston, Hawley, & Zlotnik, 1985; Ferguson & Womack, 1993, Guyton & Farokhi, 1987). Some studies compare the effect of courses in pedagogical subject matter to that of courses in the subject matter itself and present evidence in favor of the pedagogical subject matter courses (Monk, 1994) in mathematics. Other studies reveal no impact of education courses on students' science achievement (Goldhaber & Brewer, 2000).

Duration of the Preparation Period

In spite of evidence that 5-year programs result in a higher retention rate and career satisfaction of their graduates than 4-year programs (Andrew, 1990), it has not been shown that these graduates become more effective teachers. Data collected in TIMSS-2003 in Israel cannot provide such evidence as the information regarding the question about duration of the preparation periods does not differentiate between those who attend consecutive teacher preparation programs at the universities (1-2 year programs after completing first degree in a discipline) and those who attend concurrent programs at teacher colleges (4-5 year integrated disciplinary and pedagogy program).

Certification and Licensing Status

Certified teachers are usually those who graduated accredited teacher education programs; some are also required to complete an induction program or to pass a national teacher examination test in order to obtain a license. There is debate in the USA between those who demand full certification (Darling-Hammond, 1999; Darling Hammond, Berry, & Thorenson, 2001) and others (Goldhaber & Brewer, 2000) who argue that pupils of teachers who hold full certification achieve similarly to those who study under teachers with temporary, “emergency” credentials. These authors also argue that relaxing requirements for certification is a way of attracting academically-talented college graduates to teaching and a way to recruit a more diverse pool of candidates needed for a diverse student population.

Data obtained in TIMSS-2003 in Israel did not allow to examine this issue as all participating teachers were fully certified.

Years of Experience

Studies on the effect of teacher experience on student learning have found a positive relationship between teacher effectiveness and their years of experience, but not always a significant or an entirely linear one (Kitgaard & Hall, 1974; Murnane & Phillips, 1981). The evidence currently available suggests that while inexperienced teachers are less effective than more senior teachers, the benefits of experience appear to level off after a few years (Rivkin, Hanushek, & Kain, 2000).

The relationship between teacher experience and student achievement is difficult to interpret since this variable is highly affected by market conditions or motivation to work during child rearing period. Harris and Sass (2007) point to a selection bias that can affect the validity of drawing conclusions about the effect of teacher's years of experience. If less effective teachers are more likely to leave the professions, this may give the mistaken appearance that experience raises teacher effectiveness. Selection bias could, however, also work in the opposite way as more able teachers with better opportunities to earn may be more likely to leave the profession.

Participation in Professional Development Activities

Professional development activities can be conducted by many different organizations, in schools and out of school, on the job or on sabbatical leave. On these occasions, practicing teachers update their content knowledge and teaching skills to adjust to the introduction of new curricula, new research findings on teaching and learning, changes in the needs of the student population, etc. Critique has been leveled against the episodic nature of these activities and the fact that very little is known about what they really consist of.

There is mixed evidence on the effect of teachers' participation in professional development activities on student outcomes. On the one hand there are some studies on inservice professional development, which found no effect (Angrist & Lavy, 2001, Jacob & Lefgren, 2004), while other studies found that higher levels of student achievement were linked to mathematics teacher participation in content-specific pedagogy activities related to the curriculum (Brown et al.,1995; Cohen & Hill, 1977; Wiley & Yoon, 1995). Wenglinsky (2000) found a positive effect of professional development activities that focused on the needs of special education students, on higher-order skills, and on laboratory skills in science. More recently Harris and Sass (2007) identified what they call the "lagged effect of professional development", i.e., the larger effect of professional development three years after taking place.

The correlation between student achievement and teacher professional development activities does not allow us to draw conclusions about a causal link, as this variable is confounded with other attributes of teachers, i.e., participating teachers are likely to also be more motivated and, usually, more specialized in the subjects they teach.

Sample

The sample of teachers who participated in TIMSS-2003 in Israel comprised 371 mathematics teachers and 317 science teachers who taught about 4,000 students in 149 sampled classes, each in every one of the sampled schools. It became evident that in many of the sampled classes, students were taught by more than one teacher. In only about one quarter of the mathematics classes and about one third of the science classes, all students were taught by one teacher. In the rest of the classes either all students were taught by more than one teacher, or students in one class were divided into groups each taught by one, or sometimes more than one, teacher. In the present study which examines the relationship between teacher characteristics and student achievement, it was essential to link teachers exclusively to the class or group of students they taught. Thus, a preliminary step in the analysis was the identification of those exclusive learning units. Very small units (with 8 or less students) were omitted from the analysis. Table 1 presents the distribution of the remaining learning units according to the number of teachers assigned to teach each such unit (group of students).

Take in Table 1 about here

The exclusion of students from small learning units resulted in a reduced student sample. The number of excluded students taught by mathematics teachers reached 1663 and in the case of science teachers, 1152. The representativeness of the reduced, post-exclusions, sample was tested by comparing the achievement of students who were included in the analysis and those who were excluded. The result of *t*-tests for independent samples showed a small though significant difference in favor of the students left for the analysis of 6 score points, only in mathematics, (.07 of a standard deviation). This difference was considered educationally meaningless, i.e., the exclusion process did not violate the representativeness of the sample. Table 2 presents the comparisons done.

Take in Table 2 about here

Data Source

Responses of teachers and principals to questions in the teacher and school questionnaires were used to determine the independent teacher variables. These were:

1. The ethnic affiliation of the teacher (ISRARB) as inferred from the language used by the teacher with his/her students: 0 – *Arabic speaking*; 1 – *Hebrew speaking*
2. Teachers' gender (TSEX): 0 – *male*; 1 – *female*
3. Seniority as inferred from the number of years of teaching (TAUT)- a continuous variable.
4. Teachers' highest levels of education (MA): 0 – *up to and including first university degree*; 1 – *beyond first university degree*.
5. Teachers' major areas of study in the field they teach (INFLD): 0 – *study other areas than the subject they teach*; 1 – *study the areas they teach* (in mathematics at least 1 of 2 relevant areas – mathematics and mathematics education, and in the sciences at least 1 of 5 relevant areas – biology, physics, chemistry, earth sciences, and science education).
6. Participation in professional development activities that focus on **pedagogy** (PEDAG) on a scale of 1 – *never* to 5 – *more than 10 times per year* (data from school questionnaire).
7. Participation in professional development activities that focus on the **content knowledge** (PDICK) on a scale of 1 – *never* to 5 – *more than 10 times per year* (data from school questionnaire).

The dependent variable used is one of the estimates of the plausible scores in mathematics or science. We used the first plausible score.

Method

Two main analyses were carried out in this study. The first one was breakdown of the group means of student achievement (dependent variable) by the categories of the different teacher variables (independent variables). Differences in achievement scores of students taught by teachers characterized by the extreme variable categories are used as measures of their effectiveness.

The second analysis conducted was a multilevel regression analysis using HLM6 Software (Raudenbush, Bryk, Cheong, & Congdon, 2000). The models that were specified for the analysis were two-level models of students nested in exclusive groups taught by one or more teachers.

The models specified contained, at their first level, three variables describing student characteristics. The first of these was *Number of books in student's home* (Book) on a scale of 1 – *few books* to 5 – *more than 200 books*. This variable is used as a proxy of the socio-economic and cultural background of the students' home. The second variable is *Student's self-confidence in learning the subject taught* (SCM/S1), a dummy variable derived from an index constructed in the TIMSS-2003 study (Martin, Mullis, Chrostowski, 2004), indicating whether the student has a lot of confidence (1) or not (0). The third variable describes the level of education students aspire to complete (ASPIR) on a scale of 1 – *finish high school* to 5 – *finish university beyond initial level*.

At their second level, the models contained the seven above-described teacher variables. It should be noted here that in cases where several teachers taught the same group of students, the values of their relevant variables were averaged and sometimes rounded.

To avoid problems of multicolinearity and maximize interpretability, the second-level teacher variables were centered and standardized around their grand mean (Aiken & West, 1991, p. 43). Thus their regression coefficients represent the change in achievement score points due to an increase by 1*SD* above the standardized mean of the relevant teacher variable.

The regression analyses were carried out separately for the two dependent variables. In each analysis, three models were specified. The first model was a "null" variance component model with no predictors. This model provides estimates of the variance components at each of the model’s levels, indicating an upper limit to the explanatory power of the different models specified later. The second model included only the student-level variables, and the third model also contained the second-level variables, i.e., teacher variables. The models specified for each dependent variable contained the same predictors at each level.

The most important outputs of this analysis were estimates of the regression coefficients of the predictors that indicate their effect on student achievement (the slope of the predictor regression lines). Allowing the coefficients of the first-level variables (student variables) to be modeled as random yields a "slope as outcome" model (Raudenbush & Bryk, 1986) in which the slope (regression coefficient) of a pupil-level variable is itself regressed over the higher-level teacher variables. This "slope as outcome" model is formally equivalent to an interaction model indicating the existence of an interaction between a student-level variable, which varies randomly among the second-level units of analysis, and relevant second-level teacher variables. The significant slope variation revealed in all student-level variables employed in our analysis, justified looking for interactions between them and the teacher variables - in other words to see whether student- level variables buffer the effect of teacher variables on achievement. In this study, I looked for interactions related to only one student-level variable – *Student’s aspiration to finish a high level of academic education* (ASPIR), which is usually associated with both a student's intellectual and socio-economical capabilities. The effects of the two other student variables were specified as fixed effects.

Results

Breakdown of Group Achievement Scores by Categories of Teacher Variables

Table 3 presents group's mean achievement and its standard deviation and the gaps in the mean achievement of groups of students taught by teachers belonging to the distal categories of each teacher variable. Large gaps indicate that the relevant teacher variable is associated with achievement (effective). Also appearing in this table is the number of groups that fit each category of the relevant teacher variables. In some cases, where there were only very few groups in the distal categories, these categories were collapsed with others to give a more accurate picture.

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Among mathematics teacher variables, the following ones are most effective:

- The *ethnic affiliation* variable (ISRARB): Students in groups taught by Hebrew-speaking mathematics teachers achieve almost one standard deviation of the group's mean mathematics scores (*SD* = .56) – more than students studying in groups taught by Arabic-speaking teachers.

- *Gender* (TSEX): Students taught by female teachers achieve almost half a group standard deviation more than students taught by male teachers.
- *Seniority* (TAUT): Students studying in groups taught by mathematics teachers with more than 15 years of experience achieve by about two-thirds of a group *SD* more than students studying in groups taught by mathematics teachers with less experience (5 years or less).

Students taught by mathematics teachers who have a second degree or by teachers who majored in at least one relevant subject area (mathematics or mathematics education, achieve (moderately), less (about 0.2 group *SD*) than students studying in groups taught by teachers with a first academic degree or not, or more than those taught by teachers who did not major in a relevant subject area.

Students taught by science teachers who have second degree or by teachers who have majored in at least one of five relevant subject areas and in pedagogical content-knowledge (science education, achieve (moderately) more than students studying in groups taught by science teachers with a first degree or less, or more than those taught by teachers who did not major in the field they teach. There is also no advantage to students in groups taught by more experienced science teachers. In fact they achieve even less.

There is a slight advantage in achievement in favor of students studying in groups taught by mathematics teachers who participated intensively (more than 10 times), during the last year, in **content**-oriented professional development activities, over students of mathematics teachers who did not, or participated only once or twice a year in this type of professional development activities.

However, no advantage in achievement exists; there even is a disadvantage for students studying with mathematics teachers who intensively participated in **pedagogical** issues and for those studying with mathematics teachers who have advanced academic degrees or a major in the field they teach.

In general terms, the effects of all science teacher variables are smaller than those detected in groups studying with mathematics teachers. The picture regarding the achievement of students taught by science teachers is only partially similar. Here too, students in groups taught by Hebrew-speaking science teachers attain more than students in groups taught by Arabic-speaking science teachers by about 0.6 standard deviation of the group's mean distribution of science scores (*SD* = 47). Students in groups taught by science teachers who participate more than 10 times per year in **content-oriented** professional development activities, attain about half a standard deviation more than students in groups taught by science teachers who do not participate at all, or only minimally, in such activities.

Students in groups taught by female science teachers achieve more, but only moderately so, than those who study with male science teachers (about 0.2 group *SD*).

Results of the Multi-Level Regression Analysis

Table 4 presents the results of HLM analyses. The upper part of the table presents estimates of the variance components of each of the following models – the "null" or "basic" model with no explanatory variable, the "student level" model and the "full" model which also includes teacher variables. The full model includes, in addition to its main effect part, a" slope as outcome" part where the coefficients of the student-academic-aspiration variable are regressed on all teacher variables.

The table also presents the added explained variance to the Between Group Variance (BGV), in percentages beyond that explained by the student model, and the cumulative percentage of BGV explained, indicating the total explanatory power of the models.

The lower part of the table presents the intercept of each regression equation, the estimated coefficients of all predictors, followed by the standard error of measurement. In the full models, the coefficients of the teacher variables appear first as indicating main effects and the second time indicating their effect on the slope of student academic aspiration.

Take in Table 4 about here

Here, statistically significant coefficients reveal the interaction effect between teacher variables and student variables that can explain the differential effect of teacher variables on students who differ in their academic aspirations. The deviance, a measure of lack of support of the model by the data, appears at the end of each model.

The percentage of the BGV out of the total variance in outcomes is higher in mathematics (41.8%) than in science (26.7%) suggesting that grouping in mathematics is mostly based on ability. Student variables explain, in both school subjects, about a quarter of the BGV component. The ratio between the added explanatory power of the BGV due to teacher variables versus that of student variables is 1:1.8 (13.9%:25:5%) in mathematics and 1:5.3 (4.1%:21.6%) in science. Teacher variables thus explain relatively more of the BGV in mathematics than in science.

The HLM findings support the findings of the breakdown analysis. Positive main effects of teachers' ethnic affiliation were found in both school subjects although they reached significance only in mathematics. Positive main effects of frequent participation in **content-oriented** professional development activities were also found in both school subjects; here too, they were statistically significant only in mathematics. In contrast, frequent participation in **pedagogy-oriented** professional development activities was found to have negative and significant effects in both school subjects.

Teachers' years of experience were found to have positive effect on student achievement in the case of mathematics teachers and negative effect with science teachers. However, in both cases, these effects are not significant. Advanced academic degrees of mathematics teachers and having majored in the field of teaching seem to have a significant negative effect on students' outcomes in mathematics, while in the case of science teachers, these variables show positive, though not significant, effect on students' science outcomes. Teacher's gender (0 – *male*; 1 – *female*), which was found to have a positive effect according to the breakdown analysis and also when fitted as a single predictor in a multilevel analysis, appears to have a negative effect on student outcomes, though not statistically significant, when fitted among other teacher level variables, indicating that this effect is probably mediated by other teacher variables.

The analyses reveal that some of the teacher variables - such as having second degrees, majoring in the field of teaching and seniority - which are taken as indicators of quality and considered desirable targets in teacher education reforms and in reward systems do not have a consistent positive effect in different school subjects.

However, some teacher variables do have a consistent impact. Frequent participation in **content-oriented** professional development activity seems to have positive and significant effects in both subject areas, while frequent participation in **pedagogically-oriented** professional development activities has a negative impact on student achievement in both subjects. Such findings could serve policy decisions that touch novice as well as in-service teacher education programs and the reward systems.

Interactions between Teacher Variables and Student Variables

Interesting significant interaction was found between teachers' participation in professional development activities and students' academic aspirations.

The negative effect of frequent participation in pedagogical-oriented professional activities and the positive effect of frequent participation in content-oriented professional development activities are more profound for students with low academic aspiration.

Plotting predicted science and mathematics group means at three levels of academic aspirations (maximal, mean and minimal) helps to understand these relationships.

The following figures represent the predicted outcomes in science and mathematics as a function of the levels (high, medium, and low) of teachers' participation in pedagogical (Figures 1 & 2) or in content-oriented (Figures 3 &4) professional development activities.

Take in Figures 1 to 4 about here

The figures help us visualize the interaction effect between students' characteristics and their teachers' participation in professional development activities.

Students who score low on the scale of academic aspirations, when taught by teachers who frequently participate in **pedagogically-oriented** professional development activities, achieve less than when taught by teachers who do not, or only rarely, participate in such activities. This negative effect is weak for students with mean academic aspirations and does not exist at all for students with high academic aspirations. Thus, intensity of participation in professional development activities increases the achievement gap between high and low academically motivated students.

In contrast, teachers' frequent participation in **content-oriented** professional development activities has an opposite effect on the achievement of students with different academic aspirations. Teachers' frequent participation in **content-oriented** professional development positively affects achievement of students with low or medium academic aspirations and has no, or a negative, effect on the achievement of students with high academic aspirations. Thus, intensity of participation in content-oriented professional development activities narrows the gap between high and low academically-motivated students.

A positive interaction effect (significant only in the case of mathematics) was found between level of student's academic aspiration and another teacher variable – gender: achievement of students with high academic aspirations is fostered by female teachers. This interaction effect buffers the negative main effect of teachers' gender variable found in the full multilevel regression model.

Discussion

Results of these very thorough analyses are disappointing. Many of those teacher variables regarded as qualifications or as indicators of quality, such as advanced academic degrees, majoring in the field of teaching and years of experience, which were adopted as reform targets in teacher education programs and as criteria for remuneration, have only marginal and statistically non-significant positive effects on student achievement. These effects are also inconsistent in the two subject areas.

Two variables were found to have opposite effects in the two subject areas: *having an advanced degree* and *majoring in the field of teaching*. These variables were found to be positively associated, though not significantly, only in science, while in mathematics and contrary to other findings (Wayne & Youngs, 2003), these variables have a negative and significant effect (only in the case of advanced degree). Similar findings concerning the effect of advanced degrees are reported by Rowan, Correnti, and Miller (2002). They found no effect of either teachers' mathematics certification or advanced degree in mathematics (as compared to first degree) on student achievement. Struggling to interpret their findings, the authors raise the possibility that advanced academic training in mathematics somehow interferes with effective teaching, either because it comes on account of professional pedagogical training or because it produces teachers who somehow cannot simplify and clarify their advanced understanding of mathematics for school students.

In an attempt to explain the different effects of advanced studies, major in the subject of teaching and years of experience, for mathematics vs. science teachers, the possibility to relate it to fundamental differences between these disciplines can be considered. In science, a constantly developing domain, science teachers with advanced education in their field of teaching may be at a greater advantage. In mathematics, by contrast, which is regarded a classic domain of knowledge, the contents taught in school are basic and teaching experience is more important than sophisticated knowledge of the domain.

Other variables such as teachers' ethnic affiliation and gender, although similarly affecting achievement in both subject areas, are attributes that cannot be manipulated. These attributes might, however, be linked to some latent qualities that should be explored in order to understand their effect.

The only teacher variable found to have a significant and consistent effect on student achievement in both subject areas and to be open to policy manipulation is the opportunity and support given to participation in professional development activities. While such participation in the content areas of teaching shows positive effects on student learning in both mathematics and science, though it reaches significance only in science, frequent participation in inservice activities focusing on pedagogical skills and knowledge actually has significant *negative* effects on student learning in both school subjects.

These effects are more profound for students with low academic aspirations. Thus, teachers' intensive participation in pedagogically-oriented professional development activities has some negative results in increasing outcome inequality among students with different academic aspirations, which usually are accompanied by differences in socio-economic status. The opposite occurs with teachers' participation in content-oriented professional development activities that narrow the achievement gap between students with different academic aspirations.

The different effects of the two types of professional development opportunities on the achievement of student who differ in their academic aspiration can be interpreted in the following way. Highly motivated students (usually more able) are less sensitive to teachers' input. In many cases they can manage on their own. The problems that students with low academic aspirations (usually less able) face required thorough understanding of the content teachers teach. This understanding cannot be replaced by instructional strategies.

The different main effects of the two types of professional development activities might also point to initial differences among teachers – those who prefer to upgrade their content knowledge versus those who prefer to learn new pedagogical tools. Preference for content might indicate higher teacher qualifications as referred to in this paper.

The findings in this study, which are in line with those of many of the studies cited earlier, do support policy intervention aimed to provide more opportunities and incentives for participation in content-focused professional development.

The findings on the negative effects of participating in pedagogically-focused professional development activities, which are a very popular, call for investigating what actually happens in such inservice training and how the knowledge gained in these courses is translated into action in classrooms.

This is the time to offer a methodological explanation for the disturbing findings regarding the ineffectiveness of many highly regarded teacher variables. One possible explanations refers to the lack of variability in some teacher variables, which results in underestimation of their correlation with achievement. This is the case, for instance, with level of certification, which was not found - in Israel - to be correlated with student achievement, since here all teachers are fully certified.

Nonlinear effects or the low threshold effect that some teacher variables exhibit is another explanation. For instance, while teacher's possessing a first academic degree is much more associated with student achievement than non-university education, teachers' further education - for a second academic degree in mathematics - has no effect on student achievement.

These explanations should caution those policy-makers who tend to conclude that teachers' formal education, certification, or having majored in the subject of teaching, are not indicators of quality. Such conclusions would be unwarranted. The qualifications which the present study dealt with should be treated as necessary but insufficient. Other important and more sensitive indicators of quality should be sought. Another conclusion stemming from our study, is that policies related to recommended reforms in teacher education, rather than being broad and rigid, will need to account for differences in their effects that vary across subject area and across types of students.

References

Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and interpreting interactions.* London, Newbury Park, New Delhi: Sage.

Alexander, R. (2000). *Culture and pedagogy: International comparisons in primary education.* Oxford, UK: Basil Blackwell.

Andrew, M.D. (1990). Difference between graduates of 4-year and 5-year teacher preparation programs. *Journal of Teacher Education, 41*, 45-51.

Angrist, J.D., & Lavy, V. (2001). Does teacher training affect pupil learning? Evidence from matched parings in Jerusalem public schools. *Journal of Labor Economics, 19* (2), 343-369.

Ariav, T. et al., (2006). *Committee for guidelines for teacher education. Report on programs in higher education institutions in Israel*. Council for Higher Education, Jerusalem. (Hebrew)

Ashton, P., & Crocker, L. (1987). Systematic study of planned variation: The essential focus of teacher education reform. *Journal of Teacher Education,* May-June, 2-8.

Berliner, D.C. (1987). Simple views of effective teaching and a simple theory of classroom instruction. In D.C. Berliner & B. Rosenshine (Eds.), *Talks to teachers* (pp. 93-110). New York: Random House.

Berliner, D.C. (2005). The near impossibility of testing for teacher quality. *Journal of Teacher Education, 56* (3), 205-213.

Betts, J., Zau, A., & Rice, L. (2003). *Determinants of student achievement: New evidence from San Diego*. San Francisco: Public Policy Institute of California.

Braun, H.J. (2005). *Using student progress to evaluate teachers: A primer on value-added models.* ETS, Princeton. Available at: http://www.ets.org/research/pic

Brown, C.A., Smith, M.S., & Stein, M.K. (1995). *Linking teacher support to enhanced classroom instruction*. Paper presented at the AERA Conference, New York.

Cochran-Smith, M. (2001). The outcomes question in teacher education in teacher education. *Teaching and Teacher Education, 17,* 527-546.

Cohen, D.K., & Hill, H. (1977). *Instructional policy and classroom performance. The mathematics reform in California.* Paper presented at the AERA, Chicago, IL.

Darling-Hammond, L. (1998). Teachers and teaching: Testing hypotheses from a national commission report. *Educational Researcher, 27* (1), 5-15.

Darling-Hammond, L. (1999). *Teacher quality and student achievement. A review of state policy evidence.* Research Report R-99-1, Center for the Study of Teaching and Policy, University of Washington.

Darling-Hammond, L. (1999). Education policy analysis. *Archives, 8.* Available at: http://epaa.asu.edu/epaa/v8nl/

Darling-Hammond, L. (2000). Reforming teacher preparation and licensing: Continuing the debate. *Teachers College Record, 102* (1), 5-27.

Darling-Hammond, L., Berry, B., & Thorenson, A. (2001). Does teacher certification matter? Evaluating the evidence. *Educational Evaluation and Policy Analysis, 23* (1) 57-77.

Darling-Hammond, L., Chung, R., & Frelow, F. (2002). Variation in teacher preparation: How well do different pathways prepare teachers to teach? *Journal of Teacher Education, 53* (4), 286-302.

Dovrat Committee, Israel – Task Force for the Advancement of Education in Israel (2005). *National plan for education*. Jerusalem: Israel Government.

Ehrenberg, R.G., & Brewer, D.J. (1994). Do school and teacher characteristics matter? Evidence from high school and beyond. *Economics of Education Review, 13,* 1-17.

Everston, C.W., Hawley, W., & Zlotnik, M. (1985). Making a difference in educational quality through teacher education. *Journal of Teacher Education, 36* (3), 2-12.

Fenstermacher, G.D., & Richardson, V. (2005). On making determinations of quality in teaching. *Teachers College Record, 107* (1), 186-213.

Ferguson, R.F., & Ladd, H.F. (1996). How and why money matters: An analysis of Alabama schools. In H.F. Ladd (Ed.), *Holding schools accountable: Performance-based reform in education* (pp. 265-298). Washington, DC: Brooking Institution.

Ferguson, P., & Womack, S.T. (1993). The impact of subject matter and education coursework on teaching performance. *Journal of Teacher Education, 44* (1), 155-163.

Goldhaber, D.D., & Brewer, D.J. (2000). Does teacher certification matter? High school teacher certification status and student achievement. *Educational Evaluation and Policy Analysis, 22* (2), 129-145.

Greenwald, R., Hedges, L.V., & Laine, R.D. (1996). The effect of school resources on student achievement. *Review of Educational Research, 66* (3), 361-396.

Guyton, E., & Farokhi, F. (1987). Relationships among academic performance, basic skills subject matter knowledge and teaching skills of teaching education graduates. *Journal of Teacher Education, 38,* 37-42.

Harris, O. & Sass, T.R. (2006). *Value-added models and the measurement of teacher quality.* Unpublished manuscript.

Ingersoll, R.H. (2003). O*ut of field teaching and the limits of teachers' policy.* A research report. Washington: Center for the Study of Teaching and Police, University of Washington.

Jacob, B.A., & Lefgren, L. (2004). The impact of teacher training on student achievement: Quasi-experimental evidence from school reform efforts in Chicago. *Journal of Human Resources, 39* (1), 50-79.

Kiesling, H.J. (1984). Assignment practices and the relationship of instructional time to the reading performance of elementary school children. *Economics of Education Review, 3,* 341-350.

Kitgaard, R.H., & Hall, G.R. (1974). Are there unusually effective schools? *Journal of Human Resources, 10* (3), 40-106.

Maagan, D. (2007). Teaching staff survey (2007) in elementary schools 2005/6) . Jerusalem: Israel Central Bureau of Statistics. (Hebrew)

Martin, M.D., Mullis, I.V.S., & Chrostowski, S.J. (2004). *TIMSS-2003 Technical Report.* Boston: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College, USA.

McCaffrey, D.F., Lockwood, J.R., Koreetz, D., Louis, T.A., & Hamilton, L. (2004). Models for value-added modeling of teacher effects. *Journal of Educational and Behavioral Statistics*, *29* (1), 67-101.

Monk, D.H. (1994). Subject area preparation of secondary mathematics and science: Teachers and student achievement. *Economic of Education Review, 13,* 125-145.

Monk, D.H., & King, J. (1994). Multilevel teacher resource effects on pupil performance in secondary mathematics and science. In R.G. Ehrenberg (Ed.), *Contemporary policy issues: Choices and consequences in education* (pp. 29-58). Ithaca, NY: ILR Press.

Murnane, R.J. (1996). Staffing the nation's schools with skilled teachers in improving America's schools. In E. Hanushek & D. Jorgenson (Eds.), *The role of incentives.* Washington, DC: National Research Council, National Academy.

Murnane, R.J., & Phillips, B. (1981). Learning by doing. Vintage and selection: Three pieces of the puzzle relation teaching experience and teaching performance. *Economics of Education Review.*

OECD (2005). *Attracting, Developing and Retaining Effective Teachers - Final Report: Teachers Matter*. OECD Publishing.

Raudenbush, S.W., & Bryk, A.S. (1986). A hierarchical linear model: A review. *Sociology of Education, 59,* 1-17.

Raudenbush, S.W., Bryk, A.S., Cheong, Y.E., & Congdon, R. (2000). *Hierarchical linear and nonlinear modeling.* Lincolnwood, IL: Scientific Software International.

Rivkin, S.G., Hanushek, E.A., & Kain, J.F. (2000). *Teachers, schools and academic achievement.* Working paper 6691 (revised). Massachusetts: National Bureau of Economic Research.

Rowan, B. Chaing, F.S., & Miller, R.J. (1997). Using research on employees' performance to study the effects of teachers on students' achievement. *Sociology of Education, 70,* 256-285.

Rowan, B., Correnti, R., & Miller, R. (2002). What large scale survey research tells us about teacher effects on student achievement: Insights from the prospects study of elementary schools. *Teachers College Record, 104* (8), 1525-1567.

Sanders, W.L. (2000). Value-added assessment from student achievement data: Opportunities and hurdles. *Journal of Personnel Evaluation in Education, 14* (4), 329-339.

Sanders, W.L., & Rivers, J.C. (1996). *Cumulative and residual effects of teachers on future academic achievement*. Knoxville, TN: University of Tennessee, Value-Added Research and Assessment Center.

Santiago, P. (2002). *Teacher demand and supply: Improving teaching quality and addressing teacher shortage*. OECD Education Working Paper No. 1. OECD Head of Publication Service.

Wayne, A.J., & Youngs, P. (2003). Teacher characteristics and student achievement gains: A Review. *Review of Educational Research, 73* (1), 89-122.

Wenglinsky, H. (2000). *How teaching matters; Bringing the classroom back into discussion of teacher quality policy.* Place: Information Center Report, October, Educational Testing Services.

Wiley, D., & Yoon, B. (1995). Teacher reports of opportunity to learn analyses of the 1993 California learning assessment system. *Educational Evaluation and Policy Analysis, 17* (3), 355-370.

Wilson, S.M. Darling-Hammond, L.D., & Berry, B. (2001). Steady work: The story of Connecticut's reform. *American Educator*, *25* (3), 34-39, 48.

Wilson, S.M., Floden, R.E., Ferrini-Mundy, J. (2001). *Teacher preparation research: Current knowledge, gaps and recommendations.* A research report. Washington: Center for the Study of Teaching and Policy, University of Washington.

Table 1: Learning Units by Number of Teachers Teaching Them

Type of Group According to No. of Teachers Assigned to Teach	Mathematics		Science	
	No. of Groups	No. of Students	No. of Groups	No. of Students
Groups taught by one teacher	130	2310	93	1813
Groups taught by two teachers	12	315	38	910
Groups taught by three (or more) teachers	1	30	13+(2)	377+(66)
Total	143	2655	146	3166

Table 2: Comparing Achievement of Included and Excluded Students

The Comparison Groups	Science Scores	*t*-Value & Sig.	Mathematics Scores	*t*-Value & Sig.
Students in the groups left for the analysis	484 (84) *n*=3166	1.9	497 (83) n=2655	-2.2*
Students excluded from the groups	490 (87) *n*=1152		491 (88) *n*=1663	

Table 3: Breakdown of Group Mean Achievement in Mathematics and Science by the Categories of Teacher Variables

Teacher Variables	**Mathematics** *n* = 143		**Science** *n* = 146	
	No. of Groups 143	**Group Mean and *SD***	**No. of Groups**	**Group Mean and *SD***
Ethnic Affiliation (ISRARB)				
0 Arabic-Speaking	36	457 (46)	34	463 (40)
1 Hebrew-Speaking	107	507 (54)	112	491 (47)
Gap: Hebrew- vs. Arabic-Speaking		**50**		**28**
Teacher's Gender (TSEX)				
0 Male	30	475 (55)	24	477 (45)
1 Female	113	500 (56)	122	486 (47)
Gap: Female vs. Male 2nd Degree (MA)		**25**		**9**
0 lst degree or less	109	497 (54)	100	481 (44)
1 2nd degree or more	34	488 (63)	46	493 (52)
Gap: 2nd Degree vs. 1st Degree		**-9**		**12**
Seniority (TAUT)				
Up to 5 years	17	469 (48)	20	496 (34)
5-15 years	59	488 (52)	45	473 (45)
15+ years	67	507 (59)	81	488 (49)
Gap: High vs. Low Seniority		**38**		**-8**
Participation in Content-Oriented Prof. Development (PDICK)				
Never / Once or twice a year	19	485 (57)	16	465 (39)
3-5 times a year	46	490 (51)	48	483 (46)
6-10 times a year	42	506 (63)	41	490 (50)
More than 10 times a year	36	494 (52)	41	487 (47)
Gap: More than 10 times a year vs. Never		**9**		**22**
Participation in Pedagogical-Oriented Prof. Development (PEDAG)				
Never / Once or twice a year	51	503 (52)	56	487 (42)
3-10 times a year	57	488 (57)	37	485 (42)
More than 10 times a year	35	493 (65)	53	481 (54)
Gap: More than 10 times a year vs. Never		**-10**		**-6**
Major in Subject-Area they Teach (INFLD)				
0 No major	8	508 (86)	36	484 (50)
1 majoring in at lest one relevant content area	60	493 (53)	86	482 (48)
2 majoring in at least one relevant content area and in ped. content knowledge	75	495 (56)	24	494 (30)
Gap: Major in Content & Pedagogical Content Knowledge vs. No Major		**-13**		**10**

Table 4: Results of the Multi-Level Regression Analysis of Mathematics and Science Outcomes

	Mathematics	*N* = 2499 pupils in 135 groups		Science	*N* = 3166 pupils in 146 groups	
	Null Model	Students	Teachers	Null Model	Students	Teachers
Variance Components						
• Between group variance	2911 (41.8%)	2167 (40.2%)	1763 (35.4%)	1904 (26.7%)	1493 (25.9%)	1419 (24.9%)
• GHFSG1 Slope	-	48	46		40	39
• Within group variance	4055	3180	3175	5217	4240	4243
• Total variance	6966	5395	4984	7121	5773	5701
• % of BSV explained beyond Model 1			18.6%			5.2%
• % of added BGV explained			13.9%			4.1%
• Cumulative % of BGV explained		25.5%	39.4%		21.6%	25.7%
Final Estimation of Effects						
Intercept	495.1 (4.7)***	415.4 (6.0)***	400.0 (12.3)***		406.0 (5.7)***	400.0 (12.4)***
Book slope # No. of books at home		6.6 (1.2)***			8.0 (1.1)***	
SCM1 slope # Student self confidence as a learner		44.9 (2.9)***			42.5 (3.2)***	
GHFSG1 slope – Student academic asp.		8.7 (1.1)***			7.9 (1.1)***	
MA – Teacher's highest level of education			-22.0 (12.8)*			12.0 (11.6)
ISRARB – Teacher's ethnic affiliation			37.6 (14.6)*			20.0 (13.2)
T_SEX – Teacher's gender			-11.0 (13.7)			-16.0 (11.0)
ZTAUT_M – Teacher's years of experience			4.8 (5.1)			-3.3 (5.5)
ZMPEDG_M –Teacher's participation in pedagogical prof. development activities			-25.9 (8.4)*			-12.9 (6.4)*
ZGPDIK_M – Teacher's participation in content knowledge prof. develop. activities			18.1 (9.1)*			5.3 (7.6)
ZNSINFLD – Teacher's major in the field they teach			-7.2 (5.0)			4.1 (4.5)
For Book Slope Intercept			6.4 (1.2)***			42.0 (1.1)***
For SCM1 slope Intercept			44.8 (2.9)***			8.3 (1.1)***
For GHFSG1 Slope Intercept			3.2 (2.1)			4.8 (2.8)
MA – Teacher's highest level of education			0.7 (2.6)			-1.5 (2.8)
ISRARB – Teacher's ethnic affiliation			1.0 (3.0)			0.9 (2.7)
T_SEX – Teacher's gender			6.1 (2.8)*			3.8 (2.3)
ZTAUT_M – Teacher's years of experience			0.8 (1.1)			0.4 (1.2)
ZMPEDG_M –Teacher's participation in pedagogical prof. development activities			4.5 (1.7)**			2.8 (1.4)*
ZGPDIK_M – Teacher's participation in content knowledge prof. develop. activities			-3.8 (1.8)*			-0.8 (1.6)
ZMIFLD – Teacher's major in the field they teach			0.5 (1.1)			-0.8 (0.9)
Deviance	29955	23737	23621	36386	28413	28331

Note: BGV = "Between Group Variance"; * = $p \le .05, .06$; ** = $p \le .01$; *** = $p \le .001$

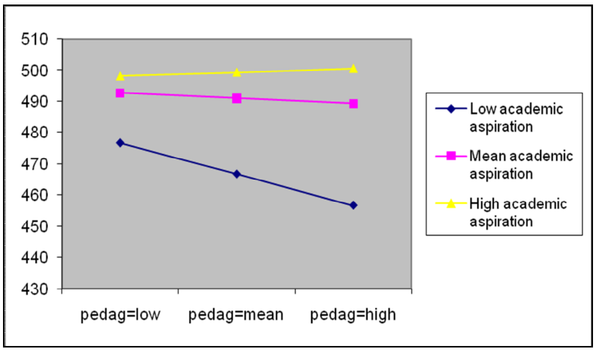

Figure 1: The Effect of Frequent Participation in Pedagogically-Oriented Professional Development Activities on Students Differing in Academic Aspirations (GHFSG1) –Science

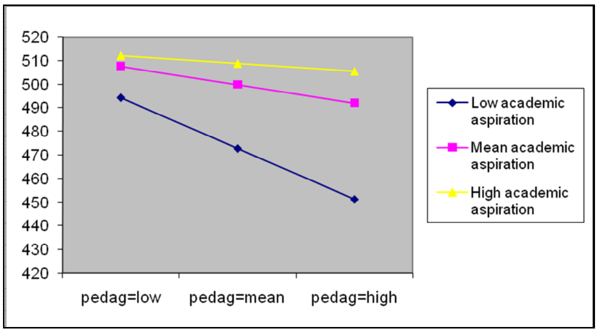

Figure 2: The Effect of Frequent Participation in Pedagogically-Oriented Professional Development Activities on Students Differing in Academic Aspirations (GHFSG1) –Mathematics

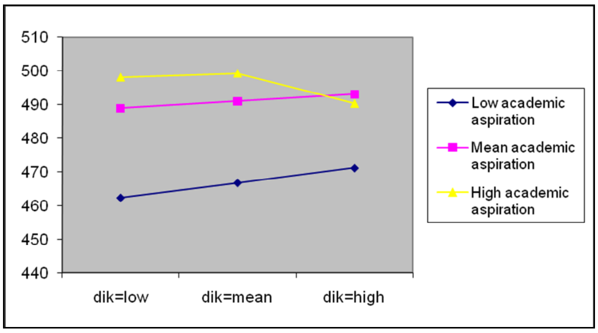

Figure 3: The Effect of Frequent Participation in Content-Oriented Professional Development Activities on Students Differing in Academic Aspirations (GHFSG1) –Science

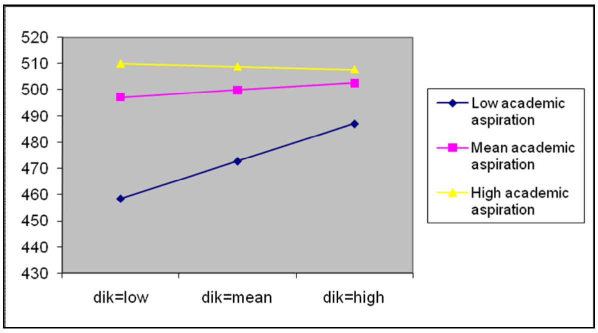

Figure 4: The Effect of Frequent Participation in Content-Oriented Professional Development Activities on Students Differing in Academic Aspiration (GHFSG1) – Mathematics