Teacher Characteristics and Student Mathematics Achievement in Taiwan's Junior High Schools

Yu-Chen Kuo*

Abstract

The government in Taiwan recently announced a series of policies aimed at improving teacher quality. This major policy initiative includes encouraging teachers to pursue an advanced degree and in-service education. The central issue of this project is to investigate the relationship between traditional human capital measures of teacher characteristics and student achievements. Using newly released data from the Taiwan Education Panel Survey (TEPS), which allows students to be linked to particular teachers and classes, we can precisely estimate the effect of teacher characteristics on student outcomes while controlling for students' family background. Based on different specifications, our empirical results show that traditional human capital measures have few robust associations with students' test scores. Regarding teacher behavior variables, we find that teachers spending more time on students and class preparation tend to be more effective. As a result, we argue that it is not very likely to identify the quality of a teacher simply based on the traditional human capital characteristics. Our suggestion is, instead of highlighting the importance of an advanced degree or certification, emphasis should be put on the curriculum, class preparation and teaching skills.

Keywords: Teacher Characteristics, Teacher Quality, Student Achievement
JEL Classification: C23, I21

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I. Introduction

It is commonly believed that education is crucial to sustain a nation's growth. On the website of Taiwan's Ministry of Education (MOE), there is the following section about the essence of good teachers.

Good teachers are the key to good education. Good education ensures that the country has a promising future. It is the ministry's goal to maintain quality teacher cultivation and raise the country's competitiveness.[1]

In order to improve teaching quality and competitiveness, the Teacher Cultivation Act was announced in 1994. It set a target to move from planned training to reserve training and changed teacher training from one training method to diverse training methods.[2] Since then, normal schools were no longer the only institution to train elementary and junior high school teachers, and students graduating from normal school were no longer assured of a teaching position.

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[1] See http://english.moe.gov.tw/ct.asp?xItem=7219&ctNode=818&mp=11

[2] In 1932, the national government announced the Normal School Act, establishing the status of the normal educational system. Tuition and fees of normal schools were funded by the government. Graduates were assigned to serve at designated locations. Normal schools were still the mainstream of teacher cultivation even after the government moved to Taiwan.

In July 2002, the act was amended to add a new requirement for certification of teachers. The original certification of teaching credentials is more of a conventionally inspection of documents. The new system requires college graduates to pass qualifications certification exams to be a teacher. Furthermore, the government took some measures to promote teachers' in-service and advanced education. The MOE encourages universities to offer in-service education curricula and subsidized teachers for further education, including advanced degrees. As shown in figure1, the percentage of elementary school teachers with master degree has increased from 1.8% in 1996 to 17.6% in 2007 and the percentage of junior high school teachers with master degree also has risen from 4.9% to 20.8% over the same period. While the higher educational expansion partly accounts for increasing portion of teachers with advanced degrees, there is no doubt that more teachers have master degrees on campus now and schools could select candidates from a better pool in terms of teachers' education attainment.

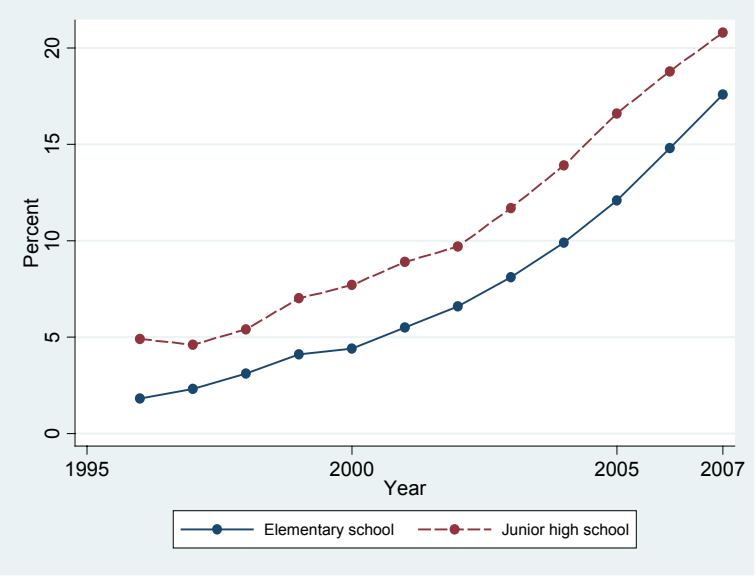

Figure 1 Percent of teachers with Master Degrees, 1996-2007

Source: MOE, Department of Statistics

Despite the fact that those new measures taken by MOE will enhance teachers' ability in terms of their human capital investment, the presumption of all these policies is that a teacher with an advanced education degree or certificate is a better and more effective teacher. In other words, a teacher with an advanced degree or certificate is more able to help students to improve their academic achievement than a teacher without such further education. Therefore, the central issue of this project is to investigate the relationship between teacher human capital traits and students' achievement.

Since the Coleman report on U.S. education was released in 1966, much research has been conducted to explain why such a big gap exists in academic achievement among students, particularly what are the roles of family background, school, and teacher factors in explaining this difference. Most studies in Taiwan focus on the link between students' personal background and their education achievement. Few studies explore discussing the influence of teacher characteristics on student performance because a representative sample was lacking. As a result, there is no consensus on this issue. This study plans to use the newly released longitudinal data set from Taiwan Education Panel Survey (TEPS) which collected comprehensive information about students and their teachers. We are interested in the influence of some traditional human capital measures, including teacher education and experience, as well as some teacher behavior variables which intend to capture some unobserved teacher traits. Using data from TEPS, which allows students to be linked to particular teachers and classes, we can precisely estimate the effect of teacher characteristics on student outcomes. With these empirical results, we can provide policy implications for future reform of education policy in Taiwan. In addition, Taiwan has its own distinguishing features of education system and culture such as normal school system and cram schooling. This study provides a cross-country comparison basis regarding this teacher quality issues.

In next section, we will review the literature most related to this paper. Data description and empirical strategy are given in section III; Econometric analyses are in section IV; and section V concludes the paper.

II. Literature Review

Since the Coleman report on U.S. education was released in 1966, many researchers devoted their attention to study the relationship between the education inputs and student attainment. Early studies borrowed from the concept of production function in Economics and considered that the improvement in school resources or teacher quality, similarly to more inputs in production process, will help to increase the output. The output here may refer to students' academic attainment in the short-run, improving probability to attend better universities, or have better labor market prospects and ultimately higher income in the future. The improvement in school resources can be captured by the increase in average spending per student, space, pupil-teacher ratios, etc. Teacher quality is often measured by some human capital factors such as subject major, certification type, degree level, and years of teaching experience.

Among economists using micro-level data to explore the connection between teacher characteristics and student achievement, Hanushek is one of the pioneers. Hanushek (1971) utilized the data from elementary schools in California and found no significant evidence of the impact of either teacher's degree level or teaching experience on student performance. Later on, after more data with improving quality were released, increasing studies contributed to the literature. Several papers including Hanushek (1986, 2003), Hanushek and Rivkin (2006), Darling-Hammond (2000) and Wayne and Youngs (2003) reviewed relevant issues based on a rich body of research; most of them concluded that there is no strong consensus about the relationship between teacher attributes and student achievement. A summary of some of the findings regarding teacher attributes which are more related to this paper are presented in the following section.

A. Degrees and major

A teacher with a master degree does not necessarily make him a better teacher and most

of the literature seems to agree with this viewpoint. Hanushek (1986) showed that only about 10 percent of related studies found a statistically significant positive impact of teacher education on student achievement. Other studies either found no connection or a negative relationship. It appears that a teacher's advanced degree is not clearly associated with increased student learning. However, further analysis indicated that it is more likely to find a positive relationship if a teacher's advanced degree is closely related to his teaching subject. Goldhaber and Brewser (1997) found no evidence that teachers with a master degree help students to score better than those students whose teachers had only a bachelor degree. However, having a master degree in math and science for math and science teachers does benefit their students and seems to make them a more effective teacher. Goldhaber and Brewer (2000) used data for older students and also came to similar conclusion.

B. Years of experience

In general, experience and tenure are considered as essential human capital factors and affect one's productivity. There is no reason why this concept cannot be applied to education. A teacher with more experience should be more familiar with the subject and have more control of students' learning than a new teacher. Nevertheless, quite a few previous studies did not find this positive effect of teacher experience on student outcomes. As a matter of fact, some studies even found a significant negative effect. Hanushek (1986) pointed out this negative or no effect is connected with selection bias in the sample. Oftentimes a more experienced teacher is more likely to be assigned to a class whose overall performance is lower than average in the school. Therefore, it is a mistake to reach the conclusion that no relationship was found between teacher experience level and student achievement if we ignore this causal relationship. Taking this causality into consideration or control, most people agree that inexperienced teachers are typically less effective than more senior teachers, although the influence of years of experience on student outcome is not entirely linear. For instance, Rivkin et al. (2005) used the nonparametric estimation of experience and found that learning effects for new teachers are concentrated especially in the first few years of teaching.

C. Teachers' education

Some studies seek to determine whether students benefit from teachers who graduate from "better" schools, but the findings are indeterminate. Summers and Wolfe (1977) used samples of students in Philadelphia and found a positive relationship between student achievement and the ratings of 8th grade social teachers' undergraduate institutions. Murnane and Phillips (1981), however, could not find any link between students' vocabulary score gains and teachers' college ratings in Indiana. Ehrenberg and Brewer (1994) reached the results that having a teacher from a better-rated college increased White and Black students' academic performance, but not so for Hispanic students.

The normal school system remained the sole teacher education in Taiwan until 1994 much later than was the case in western countries. Some research in Taiwan was aimed to explore whether teachers' training background makes a difference in students' academic achievement in Taiwan. Wang (2005) used data from 80 teachers and 1,572 elementary school students in Taitung and showed that students taught by intern teachers performed worse in terms of math and Chinese scores than those taught by teachers who graduated from normal schools. However, the study found no difference between teachers from normal college and other institutions. Guo (1995) conducted his survey in Kaohsiung County and reached similar conclusion in terms of math scores. Lee and Lu (2007) evaluated the professional performance of the novice elementary school teachers from different education systems. They found new teachers graduated from normal colleges outperformed those trained in post-bachelor teacher training classes in terms of student guidance and educational attitude.

Most related literature in Taiwan centered on the influence of personal and family background on students' academic achievement.[3] Few studies were able to use large and representative sample to systematically analyze this relationship between teacher characteristics and student achievement simply owing to a lack of data. Yang (2001) examined a small sample from Taitung County and found a negative correlation between teachers'

[3] See e.g. Huang (2008), Lin and Wu (2007), Chen et al. (2007), Chou (2006), and Wu (1999).

education attainment and pupils' achievement. He also indicated that teachers' belief of internal control had positive effects on student achievement, which was parallel to what Wu (2007) found by using the data drawn from Taitung Educational Survey. Wu's additional finding was negative teacher-student relationship was negatively related to student performance.

Cheng (2006) and Lin and Wu (2007) both analyzed only the first wave of TEPS to access the relationship between teacher characteristics and student academic achievements. They reached a mixed conclusion regarding the correlation between teacher characteristics and student achievements. The main problem of these two papers is the lack of control for previous ability which may bias the estimation and led to ambiguous results.[4] With the new data set available, this paper intends to fill the gap and provide a more complete analysis.

III. Data and Empirical Strategy

The data used here are derived from the first two waves of the TEPS which is a project by the Academia Sinica, the MOE, and the National Science Council in Taiwan. TEPS is a clustered multistage stratified probability sample and a nationally representative survey of about 20,000 7^{th} grade students first conducted in 2001. Most students were revisited in 2003 when they were in 9^{th} grade (the follow-up rate is 94%) and some of them were surveyed again after they entered senior high school. This survey collected comprehensive information about students and their family background, supplemented by a parental survey. Subject teachers and

[4] Cheng (2006) used the first wave public release version of TEPS which only includes less than 50% of teacher observations and there is no direct link between the students and teachers. In this paper, our data is drawn from the restricted release sample which each teacher and student can be perfectly matched and has larger sample size.

homeroom teachers were also asked to fill out questionnaires with reference to personal and teaching information. The sample we analyze is the on-spot restricted release computer file which includes the most complete available sample.

For each wave of students, TEPS administered a standardized test with an aim to assess students' reading, math and analytical abilities. Because students took the tests in each surveyed year, this data permits the estimation of value-added production functions which control for past inputs (as measured by test scores). The use of the prior achievement as a control variable mitigates problems of omitted variables bias resulting from the lack of historical information.[5]

In this paper, we confine our attention to only math scores because the link between math scores and math teacher is relatively clear-cut, whereas there is no link between reading scores with Chinese or English teachers. In addition, it is well established that students with advanced math qualifications perform better on a range of important labor market performance measures in the future.[6] We use the 3-item parameter (3PL) in the Item Response Theory (IRT) as the indicator of students' performance in math.[7]

Teachers with students surveyed were required to fill out the questionnaire including questions about personal background and teaching behaviors. The key advantage of TEPS is that it collected detailed information about teachers that are tied directly to individual students. Namely, we are able to match a student with his teacher and discern the teacher's characteristics. Matching student and teacher records allows us to statistically examine the impact of a teacher's human capital traits and teaching behavior variables on student

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[5] See Hanushek and Rivkin (2006), Rivkin et al. (2005), and Todd and Wolpin (2003).

[6] See e.g. Altonji (1995) and Rose and Betts (2004).

[7] TEPS provides 1PL and 3PL math ability scores. 3PL considers difficulty, discrimination and guessing probability of items in estimating ability scores. Thus, it should provide us more precise measure of students' ability. Regardless of different measures, those ability indexes are all highly correlated. See Yang et al. (2003) for details.

achievement. In contrast, many studies can only match students to the average teacher in grade or school. This feature of the data makes the TEPS the best available study to conduct educational production analysis in Taiwan.

Improvement in teacher quality is the key to current education policy. This study starts from the conventional concept of educational production, which focuses on the correlation between the output and inputs. In literature, the fundamental setup of educational production function is as follows:

$$Y^g = f(F_g, P_g, T_g, S_g; A) \tag{1}$$

where Y^g refers to the outcome for a student in grade *g*; *F*, *P*, *T*, and *S* represent family, peer, teacher and school cumulative inputs from birth respectively; *A* is innate ability. It is a general agreement that the backgrounds that students come from have a significant impact on current student performance. To study the influence of school and teacher on student achievement, it is critical to control for various background factors. However, it often leads to vague and unexplainable results if one only analyzes the correlation between current academic achievement and background related variables. Numerous factors in the past of students compound the estimation of the effects of teacher characteristics on current achievement. Therefore, a value-added model which uses prior achievement as a control is more appropriate and mitigates problems of omitted variable bias due to the lack of historical information. The underlying statistical model is therefore:

$$Y_{ijk} = \beta_1 X_{ijk} + \beta_2 T_{jk} + \beta_3 S_j + \varepsilon_{ijk} \tag{2}$$

where Y_{ijk} refers the academic performance of student *i* at school *j* at classroom *k*, *X* is the vector of individual student's personal and family characteristics including prior achievement (here we use the student's math scores in 7th grade), *T* is the vector of observed variables related to teacher quality of teaching effectiveness. *T* contains those typical teacher human capital characteristics including teacher's degree level, major, experience, whether the teacher

participated in in-service education, and whether the teacher graduated from normal school or some other college or university. We may add some measures which intend to capture teacher's devotion to teaching such as whether he is a teacher and whether he has an administrative position, and how often he counsel students individually. In addition, we can discuss the influence of teaching styles by adding variables such as whether he was a frequent class manager to have classroom discipline, whether he often adopts his own-designed material, and whether he utilized an inquiry-based teaching method. In the previous equation, S represents the school resources which should be identical for all students at the same school. Unfortunately, TEPS does not provide specific information about school as such information is considered confidential in Taiwan. To circumvent this problem, we adopt a school fixed effects model and assume the effect of school on students is universal for students at the same school. In other words, we can write our model as:

$$Y_{ijk} = \beta_1 X_{ijk} + \beta_2 T_{jk} + \alpha_j + \varepsilon_{ijk} \tag{3}$$

α_j is the specific school-level fixed effects and ε is an error term that captures the effects of unobserved individual or teacher characteristics. Restricting the source of teacher variation to within school differences should result in more consistent, but less precise estimates of teacher characteristics variables.[8]

An alternative version of this fixed effects model treats the total effect of teachers as constant across students in the same math classroom. This model is then

$$Y_{ijk} = \beta_1 X_{ijk} + \alpha_j + \delta_k + \varepsilon_{ijk} \tag{4}$$

[8] The inclusion of fixed effects accounts for possible unobserved school characteristics and heterogeneity. However, it may lead to the problem that most of the cross-school variation is washed away. If enough information about school resource is included, school fixed effect setup is not necessary. Unfortunately, due to data limitation, we don't have such information.

With the additional assumption $E(X'\delta) = 0$, it becomes a standard teacher random effects model. If the assumption is violated, a teacher fixed effects model is more appropriate. The disadvantage of a teacher fixed effects specification is that the effects of particular observable teacher characteristics (*T*) that are of interest cannot be ascertained. One way to fix the problem is to estimate an auxiliary regression in which the estimates of δ_k are regressed on observable teacher characteristics to obtain consistent of β_2. That is,

$$\delta_k = \beta_2 T_k + u_k \tag{5}$$

A generalized least square estimation is necessary to ensure unbiased standard errors of the coefficient. We apply the two-stage method by Borjas and Sueyoshi (1994) and Lewis and Linzer (2005) to make the adjustment when the dependent variable is based on estimates.

In our study, student records were used only when they can be linked with teacher records. We restricted the sample to teachers with data about at least five of their students to improve the precision of estimation of teacher fixed effects. We also confine our analysis to non-Aboriginal teachers to avoid the complication of the nonrandom assignment of students to Aboriginal teachers, who make up less than 1 percent of the sample regardless. There is an average of 13 students per teacher and three teachers per school in the sample. Our final analytic sample consists of 10,423 records on students who were both in grade 7 from 2001-2002 and grade 9 though 2003-2004. We use IRT 3PL ability score as the indicator of students' performance in math.

IV. Results

A. Descriptive statistics

Our data set closely reflects the various features of junior high school students in Taiwan.

Table 1 first shows average math ability scores when students were in 7th and 9th grade.[9] The Kernel distribution of the ability score is displayed in Figure 2. The average gain is 0.59 or 0.60 standard deviation of score in 7th grade despite of increasing dispersion in 9th grade.[10] There were almost equal proportion of boys and girls in the sample. More than half (56%) of sampled students were from cities and 88.5% of students were in public schools. Based on either father's or mother's ethnicity, Minnan students comprised a majority of the population, followed by Hakka, Mainlander and Aboriginal students, who comprised about 12%, 11% and 3% of the student body respectively. The average parents' education level is high school and roughly 10% of parents have a bachelor or above degree. The average monthly family income falls into the category of NT$ 50,001 to 100,000. About three-quarters of the students have one or two siblings and 82% of students live with both parents. We also had some other variables related to family resources and innate ability, such as 46% of students had math tutors or went to cram school, and 20% of students reported that they were currently on the academic track.[11]

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[9] All the numbers reported in Table 1 are unweighted. The weighted results according to the sample weight provided by TEPS do not change much.

[10] The shift in distribution basically results from the originally median students move toward the two sides of distribution, and this is especially profound for male students. This change may be related to prevalent cram schooling in Taiwan.

[11] A student currently on the academic track refers to a student who plans to pursue higher education (most often universities) and not vocational schools or dropout school. Whether a student can stay on the academic track is usually determined by his past academic performance.

Table 1 Descriptive statistics for the student data

Sample size:	
2001	10,423
2003	10,423
Math test scores:	**Mean**
7th grade	0.05 (0.99)
9th grade	0.65(1.41)
Gains	0.59
Female	50.29%
School type:	
Public	88.51%
Township:	
Country	7.91%
Town	36.54%
City	55.55%
Family Background:	
Father’s ethnicity:	
Minnan	73.39%
Hakka	11.92%
Mainlander	10.59%
Aboriginal and others	4.11%
Mather’s ethnicity:	
Minnan	72.25%
Hakka	12.16%
Mainlander	11.04%
Aboriginal and others	4.55%

Table 1 Descriptive statistics for the student data (continue)

Father's education:	
Less than senior High School	35.27%
Senior High School	37.61%
Some College	15.12%
University and above	12.00%
Mother's education:	
Less than senior High School	38.65%
Senior High School	42.87%
Some College	10.93%
University and above	7.55%
Annual family income (In NT$):	
Less than 20,000	12.88%
20,001～50,000	41.94%
50,001～100,000	31.29%
100,001～150,000	8.75%
150,001～200,000	2.57%
200,001and above	2.58%
Numbers of sibling:	
0	5.02%
1	40.30%
2	37.15%
3 and above	17.44%
Family type:	
Both Parent present	81.96%
One-parent present	14.09%
Others	3.94%
Have a math tutor or go to cram school	46.04%
Currently on academic track	20.03%

Note: The numbers in parentheses are standard deviation.

After deleting Aboriginal teachers and teachers with less than five students, there are a total of 796 math teachers; characteristics of these math teachers are summarized in Table 2.[12] Three-quarters of these teachers are of Minnan origin and 52% of these math teachers are female. Dee (2005) shows that when students were assigned to teachers who do not share the same race or ethnicity, those students were more likely to be seen as disruptive and performed worse. In this paper we include a variable about whether students have the same ethnicity as their teachers to capture this effect. In our sample, 63% of students share the same ethnicity with their math teachers.

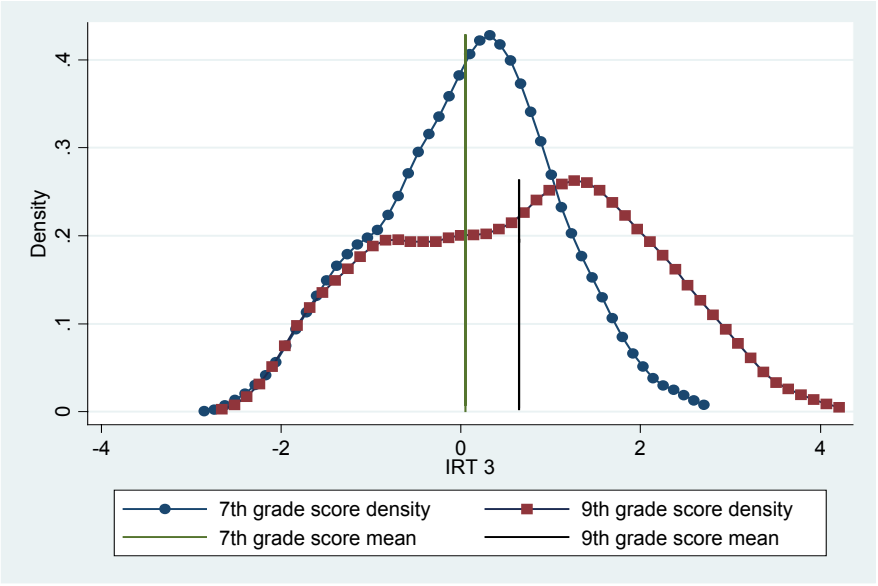

Figure 2 Kernel distribution of 7th and 9th grade math scores

[12] Again all the numbers reported in Table 2 are unweighted. The random design of TEPS is on the basis of students. Therefore, it is inappropriate to infer any population characteristics of all teachers according to this table.

Table 2 Descriptive statistics for the teachers data

Sample size:	
2001	796
2003	796
Teacher characteristic variables:	**Percent (%)**
Female	51.76
Father's ethnicity:	
Minnan	76.26
Hakka	9.80
Mainlander	13.94
Have an master degree	18.47
Major in math	91.83
Graduate from normal college	58.54
Teaching experience:	
Below 1 year	4.90
1~9 years	33.17
Over 10 years	61.93
In-service education type1	63.07
In-service education type2	33.67
Adjunct Teacher	16.58
In an administrative position	13.82
Spend more than 6 hours on this class per week	16.96
Inquiry-based teaching	18.22
Use own-designed materials	20.48
Active classroom manager	26.01
Give quizzes frequently	19.47
Often counsel students individually on homework	16.07
Years with the students:	
Less than 1	40.95
1 and less than 2	23.12
2 and More than 2	35.93

Most teachers reported that math is their major and 19% of them have a master degree. Before the 1990s, the majority of teachers graduated from normal school colleges or universities. After the enactment of the Teacher Cultivation Act, it is possible for students from regular universities to receive teaching training. In our sample, 59% of teachers indicted that they received their bachelor or master degree from a normal college or university. Teaching experience is another important trait to measure a teacher's human capital. New teachers (less than 1 year of experiences) comprised 5% of the sample, teachers with experience 2 to 9 years' experience comprised 33%, and teacher with experience more than ten years' experience constituted 62% of total teachers.[13] In-service education is another way to increase a teacher's human capital investment. Nearly two-thirds (63%) of teachers participated in an accredited teacher training program (in-service education type I) provided by regular universities or normal colleges and universities. One-third of teachers enrolled in other types of advanced study (in-service education type II) in the past three years. Some other measures, including whether the teacher is an adjunct teacher in this school (17%), whether the teacher works in an administrative position (14%), and whether the teacher spent more than six hours per weeks on class including teaching, counseling and guidance (17%),[14] are all associated with a teacher's time inputs devoted to students.

Some useful information on teacher behavior is provided in TEPS. We selected some variables with an eye to capturing some unobservable characteristics of teacher. For instance, 18% of teachers used an inquiry-based teaching method and 21% of teachers frequently used their own-designed materials in class.[15] Twenty-seven percent of teachers reported that they

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[13] Teaching experience refers to the number of years since the teacher began his/her teaching career, but excluding the years as a substitute or adjunct teacher.

[14] The original question is "How many hours do you spend on this class (including counseling and guidance class)?".

[15] The original question asked: "How often do you adopt inquiry-based teaching method?" If the teacher's answer is "often", we categorize him as a teacher using an inquiry-based teaching method. Similar classification applied to other teacher behavior variables.

often disciplined students in class and ninety percent of teachers reported that they gave quizzes very often. In addition, sixteen percent of teachers often counseled students privately on study skills and how to do homework. Lastly, the number of semesters that a student with the same teacher ranges from one to five semesters in our sample. Hence, it is necessary to add this variable, years with the student, to control for the period that a student was taught by the same teacher. It is anticipated that a teacher with the same teacher longer should have stronger effect on the student's performance.

B. Regression results

Table 3 presents the basic regression results. We began our estimation with the ordinary least squares in Column 1 of Table 3. Column 2 shows a model with school fixed effects and Column 3 shows the results when teacher behavior variables are added to the model given a school fixed effects setup. We don't report the coefficients individual and family background variables in the table for simplicity. The complete outcomes are showed in the appendix and we only summarize the result below. In all specifications of regression, the standard errors are adjusted for clustering sample by school in order to take the grouped structure of the error term into consideration. Most of the estimated coefficients of these individual and family background variables which are statistically significant are in the expected direction. Level of parental education is positively related to test score, and so is the family income despite the fact that this positive relationship is not increasing with the income levels.[16] Students with

[16] While the increase in economic resource appears to benefit students' academic achievement, it may only help to a certain level. As shown in Table A1 or A2, the positive effect of family income falls after the income exceeds NT$ 150,000. This could mean that wealthy parents tend to devote less time to their children. Instead, parents' education seems to play a more important role in determining students' performance. Even after we control for family income, the coefficients of parents' education still show their significance.

Aboriginal mothers or with Mainlander fathers relative to Minnan parents appear to have lower scores on average and so do those from single-parent families or families without parents present.[17] The effects of the number of sibling are less clear. A student with no sibling in the household is more likely to have lower average scores than the one who has one or two siblings, but it is not the case when there are more than three siblings. As indicators of innate ability, it is no surprise that previous test scores are significantly positively related to current scores.

Students currently on the academic track still gain test scores even when their prior scores are taken into consideration. Whether having a tutor or going to cram school has a positive effect on math scores is linked to family background because these variables partly reflect the economic resources of the students' families. Since our main focus is on teacher characteristics, we will not discuss these individual and family background variables from now on.

As shown in Column 1 of Table 3, our naïve OLS estimated coefficients of teacher characteristics do not all have the expected sign according to their investment on human capital. Furthermore, only a few estimated coefficients are statistically significant. Either a teacher with a master degree or a teacher trained in a normal school doesn't reveal significance. The coefficients of whether the teacher has a degree in math, whether the teacher enrolled in an accredited teacher training program or other type of advanced are all not significant. The results of teacher experience among are the few exceptions with significant estimates. Teachers with less than one year of experience are significantly less effective than experienced teachers despite that we don't find a clear pattern of the effect of years of experience since these coefficients are quite close. Devotion to teaching appears to be important since we find teachers in an administrative position have a significantly negative influence on student performance. However, not enough evidence indicates that full-time teachers benefit their students more than adjunct teachers do in terms of math achievement. The regression results

[17] We found that students with Mainlander fathers performed worse than the ones with Minnan fathers. This is an interesting finding since the previous studies (see e.g. Luoh, 2004) regarding the academic performance difference in ethnic group generally agree that Mainlanders have an advantage over Taiwanese in terms of educational attainment.

also indicate that a student who shares the same ethnicity with his/her teacher doesn't benefit from that. In Taiwan today is not surprising since the ethnic differences are minimal.

Within-school variation in teacher characteristics is preferred as it eliminates potential school factors which may incur inconsistent estimates. Column 2 of Table 3 reports the results controlled for school-level influence. The estimated effects of teacher characteristics are mostly insignificant and declines in coefficient magnitudes. Those coefficients of levels of experience are the exception for significant results. This partly reflects the presence of the correlation between teacher and school characteristic variables.

We also try to add some teacher behavior variables into the regression and Column 3 of Table 1 indicates that the coefficients of the teacher characteristic variables do not vary drastically when the behavior variables are added. The still significant set of variables is teaching experience. It is worth noting that several behavior variables affect student achievement gains. Teachers spending more than six hours per week on class,[18] using their own-designed materials and giving quizzes frequently help to improve students' scores substantially. However, a teacher who is an active classroom manager will impair students' performance. This may result from the fact that this variable captures some unobservable traits of the teacher such as bad temper or impatience which consequently have a negative influence on student learning. Nevertheless, it is also possible that teachers with good discipline are more likely to be assigned to a class with below-average academic performance or more behavioral problems. As a result, we observe this negative relationship between teachers' behavior and students' performance.

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[18] One of the reasons that a math teacher may spend extra time on class is because he/she is also the homeroom teacher of the class. In order to separate the homeroom teacher effect from the extra time effect (whether they spend more than six hours per week on class), we can control for the homeroom status of the teacher in the regression. We find that controlling for the homeroom status does not affect significance of the extra-time variable. The coefficient of homeroom status is small and insignificant. Thus, the additional time that a teacher spent on the class seems to be more crucial than whether or not a teacher is a homeroom teacher.

Table 3 Educational production functions with teacher variables

	(1) OLS		(2) School Fixed Effects		(3) School Effects + Teacher Behavior Variables	
Teacher characteristics:						
Female teacher	0.022	(0.025)	0.007	(0.031)	0.003	(0.031)
Ethnicity:						
Hakka	0.057	(0.035)	0.039	(0.047)	0.030	(0.047)
Mainlander	–0.002	(0.039)	0.026	(0.044)	0.016	(0.042)
Teacher of the same ethnicity	–0.007	(0.029)	–0.006	(0.028)	0.000	(0.027)
Have an master degree	0.011	(0.034)	0.005	(0.039)	–0.008	(0.040)
Major in math	–0.030	(0.045)	–0.005	(0.053)	0.010	(0.052)
Graduate from normal college	0.027	(0.030)	–0.003	(0.038)	–0.007	(0.037)
Teaching experience:						
1~9 years	0.206	(0.062) **	0.201	(0.066) **	0.175	(0.064) **
Over 10 years	0.210	(0.064) **	0.237	(0.065) **	0.202	(0.062) **
In-service education type1	–0.032	(0.032)	–0.032	(0.040)	–0.023	(0.040)
In-service education type2	–0.003	(0.029)	0.037	(0.037)	0.022	(0.035)
Adjunct Teacher	0.003	(0.033)	0.002	(0.038)	0.013	(0.036)
In an administrative position	–0.051	(0.035)	0.001	(0.048)	0.015	(0.049)
Spend more than 6 hours on this class per week	—		—		0.216	(0.056) **
Use inquiry-based teaching method	—		—		–0.039	(0.038)
Use own-designed materials	—		—		0.087	(0.041) **
Active classroom manager	—		—		–0.140	(0.033) **
Give quizzes frequently	—		—		0.101	(0.037) **
Often counsel students individually on homework	—		—		–0.023	(0.038)
Years with the students:						
1 and less than 2	0.020	(0.031)	–0.002	(0.036)	0.002	(0.035)
2 and More than 2	0.063	(0.029) **	0.042	(0.034)	0.043	(0.035)
R-squared	0.610		0.605		0.606	

Notes: 1. Regressions control for students' personal and family background variables.

2. * represents significant at the level 10% and ** represents significant at the level 5%.

3. Robust cluster standard errors are reported in parentheses.

An alternative version of specification can include teacher-level fixed effects in regression, but the problem is that all the effects of teacher characteristic and behavior variables are wiped out during the operation. In contrast, if the unobserved individual effects are uncorrelated with the regressors, then it is appropriate to apply the teacher-level random effects model and estimate those coefficients of interest. Hausman tests suggest that fixed effects models are appropriate relative to random effects specifications and unobservable school and teacher effects do play a role in determining student outcomes.[19] The *F* test also shows the highly joint significance of the teacher dummies, which indicates the importance of teachers.[20] Teachers, indeed, affect students academic performance, but through unobserved traits. Although the results show preference to the teacher fixed effects model, the effects of those teacher observable variables that are of interest for this study cannot be ascertained. To obtain explicit and consistent estimates of teacher observable variables, we retrieve our estimates of teacher fixed effects and regress them on the set of the observed teacher characteristic variable as addressed in the previous section.

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[19]The Hausman test statistics led to $\chi^2 = 227.31$ or p-value = 0 at the 5% significant level, so a random effects model is rejected and the result suggests a fixed effects model. Regardless of the unrealistic assumption of the random effects model, we present our results in the appendix A2 and A3.

[20]The joint *F* test yields *F* =2.41 or p-value = 0 at the 5% significant level, which implies that the teacher dummies are jointly significant.

Table 4 Impact of observable characteristics on teacher fixed effects

	(1)		(2)	
Female teacher	–0.002	(0.028)	0.004	(0.028)
Father's ethnicity:				
Hakka	0.046	(0.036)	0.043	(0.035)
Mainlander	0.021	(0.036)	0.018	(0.035)
Have an master degree	0.036	(0.036)	0.012	(0.035)
Major in math	0.015	(0.049)	0.011	(0.048)
Graduate from normal college	–0.018	(0.032)	0.005	(0.033)
Teaching experience:				
1~9 years	0.188	(0.067)**	0.151	(0.065)**
Over 10 years	0.183	(0.068)**	0.152	(0.065)**
In-service education type1	–0.026	(0.032)	–0.018	(0.033)
In-service education type2	–0.010	(0.032)	–0.011	(0.031)
Adjunct Teacher	–0.022	(0.035)	–0.030	(0.035)
In an administrative position	–0.079	(0.040)*	–0.047	(0.039)*
Spend more than 6 hours on this class per week			0.204	(0.038)**
Use inquiry-based teaching method			0.013	(0.030)
Use own-designed materials			0.059	(0.034)*
Active classroom manager			–0.084	(0.030)**
Give quizzes frequently			0.043	(0.034)
Often counsel students privately on homework			–0.047	(0.035)
Years with the students:				
1 and less than 2	0.053	(0.035)	0.066	(0.035)*
2 and More than 2	0.098	(0.033)**	0.096	(0.034)**
Constant	–0.523	(0.117)**	–0.544	(0.111)**

Notes: 1. Regressions control for students' personal and family background variables.

2. * represents significant at the level 10% and ** represents significant at the level 5%.

3. Robust cluster standard errors are reported in parentheses.

Table 4 relates the estimates of teacher fixed effects to observable characteristics. Column 1 and 2 of Table 4 list the results without and with teacher behavior variables. In line with our previous findings, the level of experience and whether a teacher has an administrative position are statistically significant and have the expected signs. Rookie teachers and teachers serving concurrently as administrators are negatively related to estimated teacher-specific effects. Including teacher behavior variables helps to increase the explanatory power of the model. Similarly to previous findings, teachers spending on class preparation more than six hours and using their own-designed materials are positively associated with teacher-specific effects, but giving quizzes frequently seems to lose its significance slightly. Again a teacher reported to be an active classroom manager signifies some negative characteristics.

C. Additional robustness checks

We use prior achievement to mitigate problems of omitted variable bias resulting from the lack of historical information. However, the use of value-added model is not immune to the influences of contemporaneous factors which are not captured by prior achievement. For instance, parents who pay more attention toward their children‘s education should enhance students’ performance; meanwhile, they are also more likely to send their children to cram school or hire a tutor. Thus, math cram schooling is the most likely variable among all family background variables in this study, which may suffer from potential endogeneity problems and contaminate our estimates.

We tackle this potential endogeneity problem by implementing a probit two-stage least square estimation (probit 2SLS) first proposed by Heckman (1979). In the first stage, the reduced form treatment equation of the binary decision on math tutor/cram schooling is estimated based a standard probit estimation. From the estimation, the selectivity correction factor (λ) for each student can be calculated. In the second stage, we include this selectivity correction factor as an additional explanatory variable and estimate the math achievement production function under different specifications. In other words, we first estimate a binary

probit regression which accounts for the self-selected nature of participation, and compute the hazard rate, λ, to serve as a proxy to correct the bias in the model of math achievement (Maddala, 1983; Green, 2008).

The binary decision on math tutor/cram schooling is assumed to be a function of the vector of student's personal and family background variables that we used previously. We add other indicators including highest education expectation that parent has for their child, whether parents consider math as a difficult subject, whether students spend more time on math than all other subjects, and students' past cram school experiences. Highest education expectations that parents have for their children are categorized into four: no expectation, high school, college, and graduate school and above. The students' math tutor/cram schooling experiences are separated into three types: math tutor/cram schooling in elementary school, during the first year of junior high school and no cram school experience. These variables presumably help to explain students' tendency toward cram schooling.

The significant coefficients of λ under various specifications as seen in Table 5 imply that math cram schooling appears to be an endogenous decision. Moreover, the effect of math cramming is still positive and significant in all setups.[21] In spite of these findings, new estimates continue to confirm our previous associations reported in Table 3. Most variables of interest in this study remain as their original signs or statistical significances except that the coefficient of in-service education type 1 now reveals the statistical significance, but the sign of this coefficient remains negative. Traditional human capital measures, except for teacher experience, still have few robust associations with students' test scores. Results from teacher behavior variables continue to indicate that teachers who spend more time on students and class preparation tend to be more effective. Thus, our estimates do not change much due to the potential endogeneity problem from math tutor/cram schooling.

[21] The average treatment effect of math cramming on math achievement ranges from 0.57 to 0.65 or equivalent to 0.41 to 0.46 standard deviation depending on different specifications.

Table 5 Educational production functions with teacher variables: probit 2SLS estimation

	(1)	(2) School Fixed Effects	(3) School Effects + Teacher Behavior Variables
Teacher characteristics:			
Female teacher	0.027 (0.019)	0.006 (0.024)	0.003 (0.024)
Ethnicity:			
Hakka	0.088 (0.034) **	0.067 (0.043)	0.057 (0.043)
Mainlander	0.006 (0.032)	0.033 (0.039)	0.024 (0.039)
Teacher of the same ethnicity	0.004 (0.028)	0.002 (0.029)	0.008 (0.029)
Have an master degree	0.007 (0.025)	0.009 (0.030)	0.001 (0.030)
Major in math	−0.025 (0.033)	−0.000 (0.040)	0.018 (0.041)
Graduate from normal college	0.022 (0.023)	−0.016 (0.029)	−0.020 (0.029)
Teaching experience:			
1~9 years	0.191 (0.048) **	0.164 (0.063) **	0.135 (0.063) **
Over 10 years	0.208 (0.048) **	0.215 (0.063) **	0.176 (0.063) **
In-service education type1	−0.044 (0.022) **	−0.055 (0.026) **	−0.046 (0.027) *
In-service education type2	−0.003 (0.020)	0.035 (0.025)	0.018 (0.025)
Adjunct Teacher	−0.009 (0.025)	−0.009 (0.031)	−0.023 (0.031)
In an administrative position	−0.046 (0.028) *	0.006 (0.037)	0.020 (0.037)
Spend more than 6 hours on this class per week			0.212 (0.038) **
Use inquiry-based teaching method			−0.048 (0.031)
Use own-designed materials			0.076 (0.031) **
Active classroom manager			−0.153 (0.026) **
Give quizzes frequently			0.109 (0.032) **
Often counsel students individually on homework			−0.034 (0.032)
Years with the students:			
1 and less than 2	0.025 (0.024)	−0.004 (0.030)	−0.001 (0.030)
2 and More than 2	0.057 (0.022) **	0.039 (0.028)	0.038 (0.028)
λ (selectivity correction factor)	−0.281 (0.050) **	−0.245 (0.049) **	

Notes: 1. Regressions control for students' personal and family background variables. Two extra dummy variables are also included in the regressions. The first variable is a dummy which indicates whether the parents had moved to other school districts for better school options. The other variable is whether the parents made efforts to arrange for their child to be placed in a better class.
2. * represents significant at the level 10% and ** represents significant at the level 5%.
3. Standard errors are reported in parentheses.

TEPS does not provide information about characteristics of the classes such as class size or average class scores. It is not appropriate to estimate a class fixed effects model since 86% of students share the same class code and math course code. Thus, it may cause biased regression results if one suspects some of the omitted class variables are correlated with teacher characteristics. A related problem is nonrandom assignment of a teacher to a class. We also leave this possibility out of the picture in this analysis. If one thinks the teacher's assignment of class is somehow related to a teacher's characteristics, then this would also lead to an ambiguous result.

V. Conclusion

The current education reform in Taiwan addresses the importance of teachers and initiates much effort to enhance teaching quality. So far, the measures taken by the MOE focus on the improvement in quality of teachers through new teacher qualifications certification and the encouragement of in-service education and advanced degrees for teachers. The central issue of this project is to investigate the relationship between student achievements and teacher characteristics using traditional human capital measures. Using data from TEPS, we first estimate the standard education production function models and then use the auxiliary regression model in which we regress estimated teacher fixed effects on observable teacher characteristics to further confirm our results.

There is widespread belief that a teacher with an advanced education degree is a better and more effective teacher. Our empirical results, however, show a very weak but positive association between teachers with a master degree and student performance. There is also no enough evidence to show that teachers who graduated from normal colleges or universities, and teachers with majors in math strengthen students' test performance. Teachers who participated in accredited teacher training programs or other types of advanced study in the past three years also do not reveal more effectiveness. Experienced teachers, however, outperform new teachers

in terms of students' test outcomes. We also do not have enough evidence to support the assertion that adjunct teachers are less effective. Our results do suggest that teachers serving concurrently as administrators tend to be less concentrated on teaching and negatively affect students' test outcomes. Notice that our teacher-level fixed effects model reveals strong significance of teacher effects. This implies that teachers still have a strong influence on students' outcome, but through unobserved attributes; and this is consistent with more recent findings by Rockoff (2004), Rivkin et al. (2005) and Aaronson et al. (2007).

In terms of policy implication, most scholars suggest that tying teacher' salaries to students' performance should stimulate teachers' efforts. However, it is not practical to implement such a paying scheme in Taiwan. Our findings regarding teacher behavior imply that a teacher spending more time on students and class preparation tends to be more effective. Traditional human capital measures, however, have few robust associations with student test scores. As a result, we argue that it is not very likely to identify the quality of a teacher simply based on the observable characteristics. Thus, our suggestion is, instead of highlighting the importance of an advanced degree, the MOE should put emphasis on improving the curriculum, encouraging teachers to prepare their own teaching materials, increasing class preparation time and enhancing teaching skills.

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Appendix

Table A1 Educational production functions with student-background variables

	(1) OLS		(2) School Fixed Effects		(3) School Effects + Teacher behavior Variables	
Math scores in 2001	0.918	(0.013)**	0.908	(0.013)**	0.899	(0.013)**
Female student	−0.012	(0.018)	−0.013	(0.018)	−0.014	(0.018)
School type:						
Public	0.243	(0.046)**	—		—	
Township:						
Town	−0.009	(0.058)	—		—	
City	−0.009	(0.057)	—		—	
Family background:						
Father's ethnicity:						
Hakka	−0.054	(0.045)	−0.056	(0.039)	−0.049	(0.038)
Mainlander	−0.051	(0.037)	−0.069	(0.035)**	−0.066	(0.034)*
Aboriginal & other	−0.044	(0.073)	−0.036	(0.069)	−0.036	(0.068)
Mother's ethnicity:						
Hakka	−0.006	(0.035)	−0.025	(0.034)	−0.025	(0.033)
Mainlander	−0.009	(0.032)	−0.028	(0.032)	−0.026	(0.031)
Aboriginal & other	−0.139	(0.067)**	−0.138	(0.067)**	−0.130	(0.067)*
Father's education:						
Senior High School	0.005	(0.026)	0.004	(0.025)	0.003	(0.025)
Some College	0.139	(0.033)**	0.108	(0.032)**	0.108	(0.032)**
University and above	0.273	(0.043)**	0.223	(0.044)**	0.222	(0.044)**
Mother's education:						
Senior High School	0.022	(0.023)	0.026	(0.022)	0.023	(0.022)
Some College	0.111	(0.038)**	0.086	(0.037)**	0.085	(0.037)**
University and above	0.205	(0.052)**	0.160	(0.052)**	0.162	(0.052)**

Table A1 Educational production functions with student-background variables (continue)

	(1) OLS		(2) School Fixed Effects			(3) School Effects + Teacher behavior Variables	
Annual family income (In NT$):							
20,001～50,000	0.072	(0.029)**	0.060	(0.030)	**	0.057	(0.030)*
50,001～100,000	0.146	(0.032)**	0.125	(0.033)	**	0.122	(0.032)**
100,001～150,000	0.160	(0.045)**	0.119	(0.043)	**	0.113	(0.043)**
150,001～200,000	0.064	(0.064)	0.032	(0.061)		0.028	(0.061)
200,001and above	0.092	(0.056)	0.025	(0.055)		0.027	(0.056)
Numbers of sibling:							
1	0.078	(0.044)*	0.079	(0.044)	*	0.084	(0.044)*
2	0.074	(0.044)*	0.073	(0.043)	*	0.078	(0.043)*
3 and above	0.005	(0.044)	0.006	(0.043)		0.010	(0.043)
Family type:							
One-parent present	–0.119	(0.028)**	–0.104	(0.028)	**	-0.098	(0.028)**
Others	–0.130	(0.043)**	–0.129	(0.044)	**	-0.127	(0.044)**
Math tutor or go to cram school	0.222	(0.020)**	0.209	(0.020)	**	0.205	(0.020)**
Currently on academic Track	0.377	(0.029)**	0.420	(0.031)	**	0.379	(0.031)**

Notes : 1. * represents significant at the level 10% and ** represents significant at the level 5%

2. Robust cluster standard errors are reported in parentheses.

Table A2 Educational production functions with student-background variables

	(1) Teacher Fixed Effects		(2) Teacher Random Effects		(3) Teacher Random Effects + Teacher Behavior Variables	
Math scores in 2001	0.877	(0.014) **	0.911	(0.012) **	0.903	(0.012) **
Female student	–0.015	(0.018)	–0.014	(0.018)	–0.012	(0.018)
Family background:						
Father's ethnicity:						
Hakka	–0.029	(0.041)	–0.049	(0.041)	–0.044	(0.040)
Mainlander	–0.073	(0.035) **	–0.069	(0.035) *	–0.067	(0.034) *
Aboriginal & other	–0.030	(0.072)	–0.049	(0.070)	–0.049	(0.070)
Mother's ethnicity:						
Hakka	–0.029	(0.034)	–0.021	(0.033)	–0.022	(0.033)
Mainlander	–0.023	(0.031)	–0.019	(0.031)	–0.016	(0.031)
Aboriginal & other	–0.129	(0.068) *	–0.140	(0.066) **	–0.135	(0.066) **
Father's education:						
Senior High School	0.003	(0.025)	0.011	(0.025)	0.008	(0.025)
Some College	0.093	(0.033) **	0.129	(0.032) **	0.126	(0.032) **
University and above	0.206	(0.046) **	0.255	(0.043) **	0.253	(0.043) **
Mother's education:						
Senior High School	0.023	(0.022)	0.031	(0.022)	0.028	(0.022)
Some College	0.084	(0.039) **	0.111	(0.038) **	0.107	(0.038) **
University and above	0.160	(0.053) **	0.191	(0.052) **	0.188	(0.052) **

Table A2 Educational production functions with student-background variables (continue)

	(1) Teacher Fixed Effects		(2) Teacher Random Effects		(3) Teacher Random Effects + Teacher Behavior Variables	
Annual family income (In NT$):						
20,001～50,000	0.046	(0.029)	0.061	(0.028) **	0.059	(0.028) **
50,001～100,000	0.119	(0.032) **	0.140	(0.031) **	0.139	(0.031) **
100,001～150,000	0.109	(0.043) **	0.152	(0.043) **	0.148	(0.043) **
150,001～200,000	0.052	(0.062)	0.080	(0.061)	0.070	(0.061)
200,001and above	0.011	(0.055)	0.084	(0.054)	0.081	(0.054)
Numbers of sibling:						
1	0.069	(0.044)	0.066	(0.044)	0.070	(0.044)
2	0.065	(0.044)	0.061	(0.043)	0.063	(0.043)
3 and above	0.003	(0.045)	–0.004	(0.044)	–0.001	(0.044)
Family type:						
One-parent present	–0.093	(0.028) **	–0.108	(0.027) **	–0.104	(0.027) **
Others	–0.097	(0.044) **	–0.119	(0.043) **	–0.117	(0.043) **
Math tutor or go to cram school	0.207	(0.020) **	0.210	(0.019) **	0.213	(0.019) **
Currently on academic track	0.230	(0.034) **	0.318	(0.028) **	0.294	(0.028) **

Notes: 1. * represents significant at the level 10% and ** represents significant at the level 5%

2. Robust cluster standard errors are reported in parentheses.

Table A3 Educational production functions with teacher and teacher behavior variables

	(1) Teacher Random Effects		(2) Teacher Random Effects + Teacher Behavior Variables	
Teacher characteristics:				
Female teacher	0.000	(0.026)	0.007	(0.026)
Ethnicity:				
Hakka	0.042	(0.036)	0.039	(0.035)
Mainlander	0.014	(0.039)	0.014	(0.038)
Teacher of the same ethnicity	–0.015	(0.028)	–0.012	(0.027)
Have an master degree	0.025	(0.035)	0.009	(0.034)
Major in math	–0.012	(0.046)	–0.009	(0.046)
Graduate from normal college	–0.033	(0.031)	–0.012	(0.032)
Teaching experience:				
1~9 years	0.183	(0.064) **	0.146	(0.063) **
Over 10 years	0.181	(0.065) **	0.151	(0.064) **
In-service education type1	–0.043	(0.031)	–0.040	(0.032)
In-service education type2	0.002	(0.030)	–0.004	(0.029)
Adjunct Teacher	–0.016	(0.032)	–0.023	(0.033)
In an administrative position	–0.062	(0.036) *	–0.060	(0.036) *
Spend more than 6 hours on this class per week	—		0.191	(0.039) **
Use inquiry-based teaching method	—		0.008	(0.030)
Use own-designed materials	—		0.032	(0.030)
Active classroom manager	—		–0.117	(0.031) **
Give quizzes frequently	—		0.042	(0.032)
Often counsel students individually on homework	—		–0.040	(0.034)
Years with the students:				
1 and less than 2	0.008	(0.034)	0.016	(0.034)
2 and More than 2	0.073	(0.030) **	0.070	(0.030) **
Constant	0.198	(0.126)	0.193	(0.121)
R-squared	0.607		0.609	

Notes: 1. Regressions control for students' personal and family background variables.

2. * represents significant at the level 10% and ** represents significant at the level 5%.

3. Robust cluster standard errors are reported in parentheses.

教師特質對國中生數學學習成就影響之研究

*郭祐誠**

摘　要

1998 年教育部推動「健全師資培育與教師進修制度計畫」，鼓勵教師進修取得學分及學位；2002 年修改師資培育法，規定新進教師須透過通過考試取得教師證，政府冀望透過制度提升現有師資水準。但這些政策後面皆隱含著：教師進修學位或較嚴格的資格審定，可提升師資素質，促使學生有較佳的學習表現。教師某些可衡量的特質，是否與學生的學習成就有所關連，是本研究的中心議題。本研究計畫利用自 2001 年開始進行的台灣教育長期追蹤資料庫 (Taiwan Education Panel Survey，簡稱 TEPS) 進行分析，在控制學生家庭背景及學校的相關條件下，探討教師的某些可觀察到的特質與學生學業成就之間的關連爲何。由於 TEPS 資料爲一追蹤資料，可清楚連結某一教師與學生，這將有效減少估計時所可能產生之誤差。實証結果發現，許多與人力資本相關之指標諸如：是否具有碩士學位、主修是否爲數學及是否爲師範學院畢業等，並未發現與學生表現有關。但某些隱含教師對學生付出較多時間之變數則對學生成績有正面影響。研究結果顯示要用傳統人力資本指標衡量教師之素質有其難度，教育改革應將重心置於如何改善課程設計，增進教師課前準備與教學技巧。

關鍵詞：教師特質、教師素質、學習成就

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