

The Impact of Mathematics Teacher Quality on Student Achievement in Oman and Taiwan

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ABSTRACT

Following the educational reform trend around the world, Oman and Taiwan emphasize teacher quality to improve student learning. This study investigated the relationship between teacher quality and eighth-graders mathematics achievement in Oman and Taiwan by utilizing TIMSS 2011 data. The research question examined to what extent teacher quality, as defined by the measurable variables (teacher qualification, teaching practices, and professional development) impacts student achievement in Oman and Taiwan. The study employed Ordinary Least Square (OLS) statistical analysis to examine the relationship between teacher quality and eighth-grade student math performance in both countries. The results show that teacher quality indicators in Oman and Taiwan have a positive impact on eighth-graders' mathematics achievement. However, teacher quality variables that influence student achievement in both countries vary depending on the education context, student characteristics, and school factors. The study findings support policy intervention aimed at improving teacher quality and recommends providing more opportunities for participation in content-focused and pedagogical-focused professional development.

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1. Introduction

With the growing demand for evidence-based policymaking, student's achievement is considered an accurate measure of effectiveness. The Coleman Report established school as an important influence on student outcomes [1]. Moreover, international research has consistently shown that home background and teaching quality are the two most significant influences on student learning achievement. An OECD study concluded, "of those variables which are potentially open to policy influence, factors to do with teachers and teaching are the most important influences on student learning" [2]. International evidence has suggested a string of good teachers can erase the deficits associated with poor preparation for school [3]. Other studies have shown that student achievement is more strongly related to teacher education quality and teaching than to class size, overall spending levels or teacher salaries [4].

Which factors that contribute to teacher effectiveness, however, has been a subject of debate among researchers. Nevertheless, teacher background characteristics were found to be related to and influence the way teachers facilitate student learning. The variables indicative of teachers' quality includes measures of academic ability, years of education, years of teaching experience, measures of subject matter and teaching knowledge, certification status, and teaching behaviors in the classroom

[5 & 4]. 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 [6]. In this study, we compared two countries, Oman and Taiwan, that invest heavily in teacher education reform to improve student achievement.

However, the two countries differ in terms of their student achievement, as measured by TIMSS 2011. For Oman, the average score of grade 8 mathematics students was 423 well below the international average and below most of the countries that may have a similar economic and cultural context. Furthermore, the country is currently experiencing a hot debate on educational issues related to the quality of teaching and learning process as a result of this ranking in TIMSS findings. On the other hand, Taiwan's result of TIMSS 2011 showed that there was an excellent average performance. The average score of grade 8 mathematics students was 561 and Taiwan ranked the second.

Nevertheless, the proportion of low achievers was high, and the overall students' learning interest and self-efficacy were quite low. Moreover, the gap between high socioeconomic status (SES) students and low-SES students was big [7]. Hence, Taiwan emphasizes on improving teacher quality to bridge the gap between high and low SES students and minimize the over-reliance on tests [8].

Countries need to look carefully into teacher-related variables so that meaningful conclusions can be formulated and consequently establish plans to improve student achievement. Therefore, in this study, we attempted to investigate how teacher quality is associated with student achievement in both countries as they represent examples of high and low achieving countries in TIMSS 2011. This type of comparative results will aid in informing policymakers and educators in both countries on the criteria of teacher quality that serve as predictors of student achievement. Given the critical need to improve the academic achievement of students and the importance of having an effective teacher for increasing student achievement, the purpose of this study is to examine the relationship between teacher quality and student achievement. We hypothesize that teacher quality indicators in Oman and Taiwan have a positive impact on eighth graders mathematics achievement in TIMSS 2011 when controlled for socioeconomic backgrounds and school characteristics. To investigate our hypothesis and to what extent teacher quality (as defined by the measurable variables) influences students' achievement in both countries, the research question that guided the inquiry is: How is teacher quality associated with eighth-graders mathematics achievement in Oman and Taiwan?

2. Theoretical Framework

2.1. Teacher Quality

Teacher quality is hardly defined. The literature on teacher quality shows a wide range of qualifications, characteristics, practices, and outcomes and analyzed their relationships with students learning [9]. Despite a huge emphasis on teacher quality, educators and policymakers often disagree over the definition of teacher quality, how it should be evaluated and how it should be interpreted and used [10]. One reason to explain this disagreement is that teacher quality is defined differently for different purposes. For example, the indicators of quality relevant to hiring decisions are different from the indicators used in granting tenure or identifying support needs [9].

Teacher quality is a complex phenomenon for which no general and absolute agreement exists concerning an appropriate and comprehensive definition. Two areas typically have been considered by researchers and policymakers as candidates for describing teacher quality: (a) teacher inputs including teacher characteristics, professional preparation, and license and (b) classroom effectiveness, frequently measured in terms of student performance on standardized tests [11]. Reference [9] recommended the use of teacher quality framework in defining teacher quality. The framework includes two inputs (teacher qualifications and teacher characteristics), a process measure (teacher practices) and an outcome measure (teacher effectiveness).

Moreover, [12] in his chapter discussed the characterizations of teacher quality as addressed in the literature and how they varied according to the perspectives and interests of the researcher. He grouped the definitions according to their focus: the qualifications of the teacher as a reflection of competence (e.g., degree, quality of college, exam scores, certification, subject-matter credential,

experience), the personal or psychological qualities of a teacher (such as love of children, honesty, compassion, fairness), the pedagogical standards that a teacher exhibits (use of certain teaching strategies, classroom management skills, establishment of a positive classroom climate), or the teacher's demonstrated ability to raise student learning (successful or effective teaching).

2.2 Impact of Teacher Quality on Student Achievement

Recent research addressing teacher quality emphasized that teachers' contribution to student academic development varies depending on many variables such as teachers' academic and professional background, classroom practices, and years of experience. The empirical literature analyzing predictors of student achievement has addressed the issue of teacher quality impact by measuring the impact of distinct teacher variables and measuring the impact of the overall teacher quality [13]. Further, empirical studies that link teacher quality and student achievement are limited to the U.S. literature. Few studies have examined teacher quality characteristics associated with higher student achievement in other countries [14]. The following section sheds the light on previous research findings related to teacher quality variables that had proven to positively influence student learning. These variables also captured the primary concern of TIMSS 2011, the focus of this study. We emphasized on distinguished research in the U.S. literature and research employing international tests.

Many empirical studies in the United States have identified the characteristics of teacher quality that are associated with higher student achievement. Two types of studies have been conducted to study the impact of teacher quality [10]: (a) studies that investigated variation in teacher effects by measuring differences between classes in achievement gains after controlling for background characteristics [15 & 16] and (b) regression studies that investigated the relationship between teacher characteristics and student achievement after controlling for background characteristics [1 & 17]. However, the findings have been inconsistent. Teacher certification, subject matter knowledge, pedagogical knowledge, and teaching experience have been identified as significantly associated with higher student achievement [14, 5, 18, 19, 20 & 21].

Reference [4] conducted a state-level analysis using the National Assessment of Educational Progress (NAEP) data set and found that measures of teacher certification and subject matter were the strongest correlates of student achievement in reading and math after controlling for poverty and language status. She further contended that teacher subject certification matters in secondary schools but not in elementary schools [4 & 20]. Among variables assessing teacher quality, the percentage of teachers with full certification, a major in the subject, and certification status are powerful predictors of student achievement than teachers' formal education levels [4]. Another predictor of teacher quality is teacher pedagogical preparation. It was consistently reported to have a positive influence on student learning [22 & 23]. On the other hand, [24] found no effect of pedagogical courses on students' science achievement. Interestingly, different tools have measured subject matter and pedagogical knowledge: subject major, number of courses taken, and National Teacher Examination (NTE) scores and have been used to establish a relationship with student achievement [14].

Moreover, a teacher's years of experience have a positive relationship with student learning, but it is not always significant or linear [25]. While many studies have established that inexperienced teachers (those with less than three years of experience) are typically less effective than more senior teachers, the benefits of experience appear to level off after about five years, especially in non-collegial work settings [26]. To ensure high teacher quality levels, some countries mandated certification procedures and set high standards for teachers to enter the profession such as to graduate from an accredited teacher education program, to complete an induction program; or to pass a national teacher test in order to obtain a license [27]. Studies conducted in the USA contended that teacher's scores on national licensing tests had a strong influence on student performance [4, 23]. On the contrary, [4] argued that students of teachers who hold full certification achieve similarly to those who study under uncertified teachers. Additionally, [4] asserted that research indicates that the kind and extent of professional development matter for teaching practice and student achievement. Several studies concluded that mathematics teachers' participation in sustained professional development linked to the curriculum they are teaching was associated with higher levels of student achievement [28 & 29].

Given the above, with the variance in the methods used to determine the relationship between teacher quality characteristics and student achievement in the U.S. literature, it is not surprising that the findings are inconsistent, contradictory, and often controversial in interpretation [21]. Here we

address the empirical studies that employed international data (TIMSS) to investigate the relationship between teacher quality and student learning. Reference [14] conducted a cross-national study of 46 countries by using TIMSS 2003 data. They found that the higher-achieving countries in TIMSS 2003 in mathematics had a higher percentage of students taught by teachers who had met their country's criteria for full certification, had majored in mathematics or mathematics education, and had accumulated at least three years of teaching experience. They recommended national investment on teacher qualification for achievement improvement.

Another study conducted by [27] on the relationship between some teachers' characteristics and students' achievements in Israel by using TIMSS 2003 data. The findings showed that many of the teacher variables regarded 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. Furthermore, a study focused on comparing science teachers' qualifications, and practices between Saudi Arabia and Singapore used TIMSS 2007 data conducted by [5]. The comparison between the two countries revealed that there were significant differences in teachers' preparation for teaching science topics, teachers' licenses, teaching experience, professional development programs, and teaching practices [5].

They are guided by our literature review and in light of the relatively few studies conducted on the impact of teacher quality variables on student learning in Oman and Taiwan. This paper will contribute to existing literature by providing a comparison between two countries that emphasize teacher quality reforms using evidence from international studies. This paper intends to highlight the extent to which teacher qualification (mathematics major, mathematics education major, and teaching experience), teaching practices, and participation in professional development activities, all assumed to be cardinal teacher quality variables, indeed have a positive impact on mathematics achievement of eighth-graders. We believe by providing comparison between high and low achieving countries on TIMSS 2011 will aid policymakers and educators from both countries and in general to adjust their reforms based on empirical findings.

3. Methods

3.1. Sample and Data Source

We used data from TIMSS 2011 for this study in particular student achievement results and responses of mathematics teachers to questions in the teacher questionnaire [30]. The target and assessed student population and achievement in TIMSS 2011 at the eighth grade are shown below in table as obtained from reference 30. The sample of mathematics teachers who participated in TIMSS 2011 in Oman comprised 368 and in Taiwan comprised 162.

Table 1. Student sample size and achievement in TIMSS 2011 at the eighth grade [30]

Country	Average Scale Score	Average Age at Time of Testing	Target population coverage	Within-school Student Participation (Weighted Percentage)	Number of Sampled Students in Participating Schools	Number of Students Assessed	Overall participation before replacement	Overall participation after replacement
Chinese Taipei (Taiwan)	609	14.2	100%	99%	5,166	5,042	99%	99%
Oman	366	14.1	100%	98%	9,947	9,542	97%	97%

3.2. Independent Variable and Dependent Variable

In this study, we focused on the relationship between teacher quality and student achievement. Accordingly, teacher quality and student achievement are the independent and dependent variables, respectively. Regarding teacher quality, it has three critical aspects (summarized in Table2): teacher qualification, teaching practices, professional development. First, with respect to teacher qualification, we used measurable characteristics of teacher qualification, which are rather common

requirements across countries and are related to student achievement: (a) teachers' highest level of formal education (b) mathematics major (c) mathematics education major, (d) teaching experience of three or more years. Compared to TIMSS 2003, TIMSS 2011 does not include a question of teaching certificate. Hence, based on findings of relationship between academic degree of teachers and student achievement, we instead chose the highest level of formal education as one item of teacher qualification. We recoded it as a dummy variable (e.g. 1=Bachelor's degree and higher and 0=lower than bachelor's degree). We also measured mathematics major and mathematics education major separately in that to differentiate the effect of teachers trained by mathematics courses only from those trained by both mathematics and pedagogical courses [14 & 21]. Moreover, given the findings from previous research, three years of teaching experience is a threshold related to student learning outcomes [14]. We thus used it as a criterion to recode the variable (1= 3 or more years of teaching experience, 0= less than 3 years).

Second, regarding teaching practices, we used the items that ask how often the teacher ask the students to do the following things: (a) listen to him/her explain how to solve problems, (b) memorize facts, (c) work problems (individually or with peers) with my guidance, (d) work problems together in whole class with him/her direct guidance, (e) work problems while she/he was occupied, (f) apply facts and concepts to solve problems, (g) explain answers, (h) relate what they are learning to real life, (i) decide their procedure to solve problems, and (j) work on problems without solutions immediately. We first reversed the code of these items and then used factor analysis to predict two indexes of teaching practice: the first one is traditional-oriented method with a-d items; the second one is inquiry-oriented method with e-j items following [5] categorization. Last, for professional development, we constructed two indexes of it: (a) collaborative interaction predicted by factor analysis with the following items: discuss teach strategies, collaborate in planning and preparing instructional materials, share learned experience, observe teaching models, and work together to try out new ideas, (b) participation in math professional development generated by summing total following items mathematics content, instruction, curricula, and assessment.

In terms of student achievement, we focused primarily on the math performance of eighth-grade students. Because math skills in lower secondary education is an important proxy for future success regarding academic performance and job rewards [31 & 32]. The measures for math performance are five plausible values of math achievement with an international mean of 500 and an international standard deviation of 100.

Table 2. Summary of the independent variables

indicator	Category	TIMSS 2011 Questionnaire Items
Teacher qualification	Teachers highest level of formal education	What is the highest level of formal education you have completed?
	Mathematics major	During your <post-secondary> education, what was your major or main area(s) of study?
	Mathematics education major	
	Years of teaching experience	By the end of this school year, how many years will you have been teaching altogether?

Teaching practice	Traditional-oriented method	In teaching mathematics to this class, how often do you usually ask students to do the following? a) Listen to me to explain how to solve problems b) Memorize rules, procedures, and facts c) Work problems (individually or with peers) with my guidance d) Work problems together in the whole class with direct guidance from me
	Inquiry-oriented method	In teaching mathematics to this class, how often do you usually ask students to do the following? e) Work problems (individually or with peers) while I am occupied by other tasks f) Apply facts, concepts, and procedures to solve routine problems g) Explain their answers h) Relate what they are learning in mathematics to their daily lives i) Decide on their own procedures for solving complex problems j) Work on problems for which there is no immediately obvious method of solution
Professional Development	Collaboration with colleagues	How often do you have the following types of interactions with other teachers? a) Discuss how to teach a particular topic b) Collaborate in planning and preparing instructional materials c) Share what I have learned about my teaching experiences d) Visit another classroom to learn more about teaching e) Work together to try out new ideas
	Participation in mathematics professional development	In the past two years, have you participated in professional development in any of the following? a) Mathematics content b) Mathematics pedagogy/instruction c) Mathematics curriculum f) Mathematics assessment

3.3. Control Variables

Family Background

Students' family socioeconomic status (SES) and school characteristics are both important factors associated with student achievement. Thus, in order to examine the net relationship between teacher quality and student achievement, we control for students' family background data and school background from TIMSS 2011. First, the family SES variable includes (1) parental highest education level, (2) the number of books at home, and (3) home resources. Compared to 2003 and 2007 adopting the International Standard Classification of Education (ISCED) of UNESCO, TIMSS 2011 created a new measure of parental highest education level, which was divided into five categories: (1) university or higher, (2) post-secondary but not university, (3) upper secondary, (4) lower secondary, and (5) some primary, lower secondary or no school. We reverse the code, which makes the higher education level with higher scores. The number of books at home was categorized as follows: (1) 1=0-10 books, (2) 2=11-25 books, (3) 3=26-100 books, (4) 4 =101-200 books, and (5) 5 =more than 200 books. Finally, an indicator of home educational resources was constructed by summing a total of the following four items at home: (1) computer, (2) student desk, (3) own room, and (4) internet connection.

School Background

In addition to family SES, we also controlled for school background by school location. By the income level of people living in urban and suburban areas in Oman and Taiwan is relatively high, we recoded the items of school location (e.g., urban and suburban=1 and others=0).

3.4. Analysis

Before approaching our research questions, we used multiple imputations to deal with missing data. There were 23.6% and 9.4 % missing data in the indicator of parental highest education level in Oman and Taiwan, respectively. Also, there were 5.8% missing data in the indicator of school background in Oman. Hence, it is inappropriate to use listwise deletion method, which may lead to biased results. The multiple imputations is the rather convincing method that re-estimate unknown parameters with observed data as a best guess and filling in missing data. To address the research question (How is teacher quality associated with eighth-graders math achievement in Oman and Taiwan?), first we created descriptive statistics of the teacher quality indicators: teacher qualification, teaching practices, and professional development. Second, we conducted ordinary least squares (OLS) predicting eighth-grade student math achievement by teacher quality with the control variables.

4. Results and Discussion

We adopted OLS to examine the relationship between teacher quality and eighth-grade student math performance.

4.1. Descriptive statistics of teacher quality in Oman and Taiwan

Teacher quality contained three critical dimensions: first, teacher qualification; second, teaching practices; and last, professional development. Table 3 and Table 4 show the descriptive statistics of teacher quality indicators in Oman and Taiwan.

Table 3. Descriptive statistics of teacher quality indicators in Oman

Variable	Observation	Mean	SD	Minimum	Maximum
<i>Teacher qualification</i>					
Teachers highest education	9542	0.99	0.07	0.00	1.00
Mathematics major	9542	0.87	0.34	0.00	1.00
Mathematics education major	9542	0.62	0.49	0.00	1.00
Years of teaching experience	9542	0.96	0.19	0.00	1.00
<i>Teaching practices</i>					
Traditional-oriented method	9542	0.00	1.00	-2.31	7.78
Inquiry-oriented method	9542	0.00	1.00	-2.54	8.34
<i>Professional development</i>					
Collaboration	9542	0.00	1.00	-1.70	8.52
Participation in PD	9542	1.88	1.45	0.00	4.00
<i>Control variables</i>					
Parental highest education	9542	2.92	1.46	1.00	5.00
Number of books	9542	2.52	1.19	1.00	5.00
Home resources	9542	2.24	1.25	0.00	4.00
School location	9542	0.45	0.50	0.00	1.00

Table 4. Descriptive statistics of teacher quality indicators in Taiwan

Variable	Observation	Mean	SD	Minimum	Maximum
<i>Teacher qualification</i>					
Teachers highest education	5042	1.00	0.00	1.00	1.00
Mathematics major	5042	0.90	0.30	0.00	1.00
Mathematics education major	5042	0.55	0.50	0.00	1.00
Years of teaching experience	5042	0.97	0.16	0.00	1.00
<i>Teaching practices</i>					
Traditional-oriented method	5042	0.00	1.00	-2.21	4.91
Inquiry-oriented method	5042	0.00	1.00	-2.21	4.91
<i>Professional development</i>					
Collaboration	5042	0.00	1.00	-1.25	7.19

Participation in PD	5042	2.40	1.34	0.00	4.00
<i>Control variables</i>					
Parental highest education	5042	3.56	1.06	1.00	5.00
Number of books	5042	3.03	1.33	1.00	5.00
Home resources	5042	3.40	0.78	0.00	4.00
School location	5042	0.52	0.50	0.00	1.00

Dimension 1: Teacher qualification

Teacher qualification comprises four indicators: Teachers' highest level of formal education, mathematics major, mathematics education major, and years of teaching experience. Because each variable of teacher qualification is a dichotomous index, the mean of each variable indicates the percentage of eighth-graders who were taught by teachers with that characteristic. Overall, students from Oman and Taiwan are taught by a teacher with a bachelor's degree (99.46% and 100%, respectively). Then, regarding majors of teachers, on the one hand, the percentage of Omani students taught by teachers with math major is three percentages less than Taiwanese student percentage (about 86.7% to 89.75%). On the other hand, the percentage of Omani students taught by teachers with math education major is about seven percentages higher than the Taiwanese students' percentage (about 61.77% to 54.8%). Last, at least 95 % of students in both countries were taught by teachers with teaching experience of three or more years (96% in Oman, and 97% in Taiwan).

Dimension 2: Teaching practices

We used factor analysis to reduce the items and to predict two types of teaching practices. The results show that the mean of traditional-oriented method and inquiry-oriented method for both countries is 0, and the standard deviation is 1.

Dimension 3: Professional development

We categorized the items of professional development into two categories collaborating with colleagues and opportunities to participate in professional development programs. On the one hand, the results of factor analysis for collaborating with colleagues show a mean of 0 and a standard deviation of 1 in both countries. On the other hand, in terms of participation in professional development programs, the results of factor analysis show that the mean for Oman is 1.88 (SD 1.45), and the mean for Taiwan is 2.40 (SD 1.34). Specifically, on average, Omani math teachers participated at least in one of the four types of mathematics professional development activities, whereas Taiwanese math teachers had the opportunity to participate in two types.

For control variables, first, the mean of parental highest education for Oman was 2.92 (1.46), the mean for Taiwan was 3.56 (1.06). Second, the mean of a number of books for Oman was 2.52 (1.19), and the mean for Taiwan was 3.03 (1.33). However, it might not be realistic to calculate a mean for above two ordinal variables. As they were ordered, we may not know whether the distance between the categories is the same at every scale point. Third, the mean of home resources for Oman was 2.24 (1.25), the mean for Taiwan was 3.40 (0.78). In other words, on average, Omani eighth-graders had two of four resources at home, while Taiwanese eighth-graders had three. Last, the mean of school location also showed the percentage of schools surveyed in TIMSS 2011 located in urban or suburban areas. Hence, there was 45% (0.50) Omani eighth-grade student studying in schools located in urban or suburban areas. However, there was 52% (0.78) Taiwanese eighth-grade students studying in schools built in urban or suburban areas.

4.2. Teacher quality and eighth-graders' mathematics achievement

To investigate the relationship between teacher quality and eighth-grade students' math achievement in Oman and Taiwan, we employed the Ordinary Least Squares (OLS) statistical method (Table 5). By Model 1, which uses indicators of teacher quality only to predict student math achievement, no significant coefficients reveal that there was no linear relationship between each indicator of teacher qualification and Omani students' math performance. However, regarding teaching practices, there is a statistically significant and positive relationship between Omani eighth-grade students taught by teachers using inquiry-oriented method and their math performance. Also, when we look at the indicators of professional development, our results show that Omani eighth-grade students taught by teachers who endeavored to participate in professional math development achieved better in mathematics.

Once we included family background factors in Model 2, both indicators of inquiry-oriented method and math professional development participation are still significantly and positively

associated with eighth-graders math achievement. When we too family background factors into consideration, they are all statistically and positively related to student math performance. Also, the increased value of R^2 —from 3% to 17%—suggests that the family background certainly plays an important role in explaining academic achievement. Last, when we include school factors in Model 3, most coefficients and significances of indicators remain similar to those in Model 2.

Compared to the results for Oman, in Taiwan, there is no variance in achievement of eighth-grade students who were taught by teachers with bachelor's degrees, so we don't have values in the regression models. With respect to Model 1, we can see strongly positive and significant coefficients favoring eighth-graders who were taught by teachers with at least three years of teaching experience. Once we included family factors in Model 2, we can see that the coefficient of years of teaching experience decreases significantly more than half. In other words, the dropping coefficients of teaching years reflect the indicator is more likely explained by other factors, such as student family SES, school types, or school location. Interestingly, similar to Oman results, all coefficients of control variables of family background are positive and significant. The R^2 increases greatly of 19 % (from 2% to 21%), which means family background matters for explaining eighth-grade student math achievement. Finally, when we included the school factors in Model 3, the coefficient of teaching experience increases slightly, and coefficients of other indicators of teacher quality remain insignificant. Moreover, the indicator of school location is significantly and positively associated with eighth-grade student math achievement.

Table 5. The impact of teacher quality on student achievement in Oman and Taiwan

	Oman			Taiwan		
	<i>M1</i>	<i>M2</i>	<i>M3</i>	<i>M1</i>	<i>M2</i>	<i>M3</i>
Teacher Qualifications						
Bachelor's degree	9.78 (16.87)	6.93 (11.68)	6.46 (11.57)	- -	- -	- -
Math major	-6.14 (11.01)	-4.23 (9.59)	-4.36 (9.70)	12.32 (16.41)	11.40 (10.49)	12.02 (9.92)
Math education major	-13.14 (8.49)	-10.80 (7.29)	-10.75 (7.28)	10.31 (9.41)	8.39 (6.57)	7.19 (6.32)
3 or more years of teaching experience	-26.43 (24.93)	-17.14 (20.16)	-16.30 (20.32)	36.54*** (7.93)	17.58** (6.36)	19.50** (7.22)
Teaching Practice						
Traditional-oriented method	-5.53 (4.38)	-4.93 (3.64)	-5.09 (3.66)	1.51 (4.11)	-0.35 (2.84)	-0.95 (2.81)
Inquiry-oriented method	10.86* (4.43)	8.94* (3.64)	9.03* (3.63)	5.16 (4.70)	2.85 (3.24)	2.26 (3.18)
Professional Development						
Collaboration	0.86 (5.36)	-0.68 (4.54)	-0.84 (4.53)	1.46 (4.06)	0.97 (3.01)	1.03 (3.11)
Participation in PD	10.16*** (2.88)	8.65*** (2.42)	8.65*** (2.43)	4.59 (3.32)	2.44 (2.36)	1.69 (2.34)
Constant	376.59*** (29.79)	262.29* (23.21)	260.95 (24.65)	545.92 (17.57)	405.13 (13.11)	402.78 (13.71)

	Oman			Taiwan		
	<i>M1</i>	<i>M2</i>	<i>M3</i>	<i>M1</i>	<i>M2</i>	<i>M3</i>
Family factors						
Parental education		12.51*** (1.56)	12.44*** (1.53)		23.26** * (2.00)	22.11*** (1.90)
Number of books		15.54*** (1.39)	15.57*** (1.39)		22.15** * (1.28)	21.82** * (1.28)
Home resources		14.45*** (1.62)	14.34*** (1.58)		5.41** (1.98)	5.05** (1.95)
School factors						
School location			3.22 (6.68)			17.03** 5.97
R-Squared	0.03	0.17	0.17	0.02	0.21	0.21
Number of observations	9,054	9,054	9,054	5,042	5,042	5,042

Note: ***p<.001, **p<.01, *p<.05

4.3. Discussion

The results show that teacher qualification variables regarded as indicators of teacher quality such as teachers' highest level of formal education and majoring in mathematics, which are areas of focus as reform targets are not associated with student achievement in Oman and Taiwan. This could be because in both countries, prospective mathematics teachers must have at least a bachelor's degree in mathematics education. Therefore, all Taiwanese mathematics teachers and almost all Omani mathematics teachers have a degree in mathematics major and mathematics education. Furthermore, we observed that the questionnaire item that asks for the major of study reflects an overlap between different majors (During your <post-secondary> education, what was your major or main area(s) of study?).

With respect to years of teaching experience, it is positively and significantly associated to student achievement in Taiwan. This verifies [14 & 25] findings that teacher's years of experience have a positive relationship with student learning. However, in Oman, we found no correlation between years of experience and student achievement. This finding is consistent with [27] who found only marginal and statistically non-significant positive effects of years of experience on Israel student achievement in mathematics and science. The case of Oman could be because all mathematics teachers graduate from the same teacher education university, which emphasizes on content knowledge. Another factor could be due to the insufficiency of in-service teacher training and mentoring in schools.

Interestingly, inquiry-oriented teaching methods are significantly associated with student achievement in Oman. This result reflects the educational context in Oman, which focuses on a student-centered approach to teaching and learning, life skills, real-life applications in the curriculum, and continuous assessment [33]. On the contrary, we found teaching practices to have no significant influence on Taiwanese mathematics students' achievement. We attribute this finding to the over-reliance on tests and memorization in Taiwan [8]. The educational system in Taiwan draws inspiration from Confucian models of learning [34]. As a consequence, policymakers have attempted to address this perceived shortcoming through a series of recent educational reforms.

The teacher quality variable that we found to be open to policy manipulation is the opportunity to participate in professional development activities. While such participation shows positive and significant effects on student learning in Oman, it actually has non-significant effects on student learning in Taiwan. The results of Oman align with [4] and other researchers' assertion that quality and extent of professional development matter for teaching practice and student achievement. We attribute our findings for Taiwan's case to dramatic variance in teacher preparation among the different teacher education institutions. Moreover, the same institutions that provide pre-service

teacher education are also responsible for the professional development of teachers [35]. Nevertheless, local bureaus of education now regulate teacher professional development programs. Further, teachers are required to complete a minimum of 90 hours of professional development courses every five years [35]. However, we argue that although teachers have opportunities to participate in professional development programs, the quality of such programs has to be revised and improved.

On the other hand, the Omani teachers share similar teaching preparation quality, as they are prepared in the same institution. Hence, in-service professional development programs are more likely to influence their classroom practices. Furthermore, most of the professional development programs are regulated at the national level in terms of financial support and administration. They also focus on the curriculum and student learning assessment. Our findings are aligned with some studies that concluded that mathematics teachers' participation in sustained professional development was associated with higher levels of student achievement when it was linked to the curriculum they are teaching [28 & 29].

Consistent with previous research findings, our study shows a positive impact of family factors on student learning in both countries. With respect to the school factor, no significant influence is found on student performance in Oman. However, it significantly impacts student learning in Taiwan. Our interpretation of this finding could be linked to school resource availability. In Oman, all instructional materials and resources are provided to schools through a central warehouse system. Student texts, workbooks, lab manuals, and multimedia resources are written, produced, and distributed free of charge by the Ministry of Education [36]. While in Taiwan, schools get basic educational supplies from the Government [8]. Hence, schools depend on parent's contribution, which is determined by the socioeconomic status of the parents. This results in different resources available for schools in urban and suburban areas. In addition, teacher's recruitment occurs at the provincial level and often varies based on each province's priorities and needs.

5. Conclusion

In concluding the paper, the findings of this study are in line with those of many of the studies cited earlier in our theoretical framework section. Moreover, it supports our hypothesis that teacher quality indicators in Oman and Taiwan have a positive impact on eighth-graders' mathematics achievement. Teacher quality variables that influence student achievement in both countries vary depending on the education context, student characteristics, and school factors. As a consequence, this study supports policy intervention aimed to improve teacher quality and recommends providing more opportunities for participation in content-focused and pedagogical-focused professional development. The findings also call for investigating what happens in such in-service training and how the knowledge gained in these courses is translated into action in classrooms. One limitation of this study is that teacher quality definition could not only be defined by measurable variables. There are factors that contribute positively to student achievement but cannot be measured like classroom environment and teachers after school efforts. There are multiple factors that interfere with the quality of teaching and learning in addition to teacher quality such as classroom composition, parental support, the school culture, and available learning resources. Therefore, teacher quality should not only be measured by student test scores because students learning, social, emotional, and intellectual development and engagement are more important than test scores.

Further, student's scores on international measures like TIMSS is attributed to many factors (like educational system, school leadership, curriculum, and assessment) in addition to teacher quality. Therefore, we suggest that future studies to investigate how teacher quality is influenced by factors such as pre-service preparation, school environment, quality of the curriculum, and student characteristics. In addition, we could not find the truly "growth" of student achievement explained by indicators of teacher quality. It is because TIMSS data are a cross-sectional dataset, we can trace the student achievement within same students taught by same teachers throughout years. It is also the reason that we couldn't find a great predictive power of teacher quality. Last, we recommend comparing countries with similar educational and social contexts. For example, Oman and United Arab Emirates, or Hong Kong, South Korea, Singapore, and Taiwan.

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