Context Matters: Exploring the Drivers of Adolescent Reading Achievement Through Teacher and School Factors

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Abstract

This study examined relationships between teacher characteristics, school, and average school reading achievement using 2018 PISA data from U.S. schools. Multiple regression analyses revealed that teaching experience and formal teacher education were positively associated with school-level reading scores, while part-time teacher status unexpectedly showed positive associations. Among school variables, the percentage of teachers with master's degree demonstrated strong positive associations with reading achievement, whereas the percentage of certified teachers showed a negative trend. School variables collectively explained substantially more variance (13.1%) than teacher characteristics (3.3%), with combined model explaining 15.9%. These findings highlight the complex interplay between teacher attributes and school contexts in relation to reading achievement, though ecological limitations prevent causal inferences. The results highlight the importance of considering both individual teacher factors and broader school characteristics when examining adolescent literacy development.

Keywords: teacher factors, school characteristics, reading achievement, PISA data, adolescent literacy

Introduction

Reading achievement among adolescents is a cornerstone for academic success, cognitive development, and future employment opportunities. Researchers have extensively studied the role of teachers and their attributes in relation to these outcomes. Specifically, teacher characteristics such as educational qualification, certification status, years of experience, and gender have been examined for their relationship with students' academic outcomes. This research examines the associations between teacher characteristics, school, and adolescent reading achievement, contributing to the discourse on teacher attributes and reading instruction.

Despite former U.S. Secretary of Education Arne Duncan's 2010 statement suggesting minimal connection between a teacher's educational attainment and student performance, various research studies have presented mixed findings (Croninger et al., 2007). Substantial attention has been given to teacher characteristics such as degree and experience, given their measurability and role in determining teacher salaries. However, the literature presents conflicting views on the relationship between these factors and elementary level reading achievement (Ferguson & Ladd, 1996; Murnane & Phillips, 1981; Rowan et al., 2002).

Research suggests that teacher attributes like degree level might be meaningful under specific circumstances, particularly when considered alongside other factors such as subject matter knowledge, pedagogical skills, and instructional time (Kiesling, 1984; Monk & King, 1994; Rice, 2003). Similarly, the quality of student-teacher relationships (Jordan et al., 2010) and teachers' ability to connect classroom content to everyday life, recognize student differences, and reflect on their own teaching appear to be related to effective teaching practices (Darling-Hammond, 1998).

Studies indicate that teacher experience, measured by their years in the profession, shows positive associations with student achievement in reading (Goldhaber et al., 2019; Etim et al., 2020; Madigan & Kim, 2021). The study by Podolsky et al. (2019) supports this perspective, with findings showing correlations between teacher experience and student achievement. Likewise, teachers with strong literacy knowledge tend to have students with higher reading achievement scores (Ghimire et al., 2022; Goldenberg, 2020; Nutta et al., 2012).

The relationship between teacher education, training, and student achievement represents an important yet complex aspect of teacher characteristics. Research findings are inconsistent, with some studies showing positive associations (Carlisle et al., 2009) and others finding evidence of relationships (Harris & Sass, 2011). However, the professional development of teachers and its connection to improved student outcomes is broadly supported in the literature (Darling-Hammond, 2008; Darling-Hammond & McLaughlin, 1995; Foorman & Moats, 2004).

Teacher qualifications, certifications and advanced degrees have been studied in relation to students' academic performance. Research by Clotfelter et al. (2007) demonstrates a significant relationship between teacher credentials and students' achievements, especially in mathematics. This is supported by Wayne and Youngs (2003) and Darling-Hammond and Youngs (2002), who note the positive associations between teachers' academic backgrounds, including degrees, coursework, and certification status, and student learning outcomes. Additionally, Lankford et al. (2002) identify disparities in the distribution of qualified teachers, noting that urban and low-income schools often employ teachers with fewer formal qualifications.

Beyond individual teacher characteristics, school-level variables may also influence student achievement. These include student-teacher ratios, proportions of teachers with various educational credentials, and percentages of teachers with different certification statuses. Such school factors potentially create contexts that facilitate or hinder student learning (Darling-Hammond, 2000; OECD, 2019).

This study used a quantitative, non-experimental design to examine the relationship between teacher characteristics, school, and reading achievement among 15-year-old students in the United States. The research utilized secondary data from 2018 Porgramme for International Student Assessment (PISA), focusing on two primary research questions:

    A. How did the specified teacher variables (e.g., gender, employment status, teacher education, initial qualifications, professional development, and specialization in reading) relate to the reading assessment scores of 15-year-old students in the US as per the 2018 PISA data?

    B. To what extent was variation in school associated with average reading scores of schools in the PISA 2018 assessment?

These findings from this study may offer valuable insights for educational policy and practice, particularly in areas such as teacher recruitment, retention, and professional development.

2. Literature Review

Reading achievement constitutes a fundamental skill with significant implications for academic success, cognitive development, and future career prospects among adolescents. This review synthesizes the existing research on how teacher characteristics and school relate to adolescent reading achievement.

2.1 Teachers' Educational Attainment and Experience

Despite Arne Duncan's 2010 assertion that teachers' educational attainment had minimal association with student performance, subsequent research has demonstrated a more complex relationship between teacher qualifications and student outcomes in reading (Croninger et al., 2007; Ferguson & Ladd, 1996). These relationships appear to be conditional, with some studies reporting non-significant or even negative associations between teacher qualifications and student achievement (Murnane & Phillips, 1981; Rowan et al., 2002).

The significance of teacher qualifications often emerges when considered alongside other factors such as subject matter expertise, pedagogical knowledge, and student-teacher relationships (Jordan et al., 2010; Kiesling, 1984; Monk & King, 1994). Effective teachers demonstrate abilities to connect classroom instruction to real-world contexts, adapt to student differences, employ diverse teaching strategies, and engage in reflective practice (Darling-Hammond, 1998).

Recent literature reinforces the value of teacher experience, linking it to enhanced student achievement in reading (Etim et al., 2020; Goldhaber et al., 2019; Madigan & Kim, 2021). Experienced teachers typically employ more effective instructional and classroom management strategies. A meta-analysis by Podolsky et al. (2019) confirms positive correlations between teacher experience and student achievement, highlighting benefits of continuity and collegial support in teaching practice.

Teachers with specific educational backgrounds in teaching methodologies, curriculum development, and assessment techniques often demonstrate enhanced classroom effectiveness (Darling-Hammond, 2020; Konig et al., 2020). Such qualifications are associated with teachers' abilities to design engaging lesson plans, implement research-based teaching practices, and create supportive learning environments (Beers, 2003; Brew & Saunders, 2020; Matsumoto-Royo & Ramirez-montoya, 2021; Nutta et al., 2018).

2.2 Teacher Knowledge and Professional Development

Teachers' literacy knowledge shows significant associations with students' reading achievement. Nutta et al. (2012) and Ghimire et al. (2022) found that teachers with strong literacy proficiency tended to have students with better reading performance. Goldenberg (2020) noted that teacher knowledge benefits both English learners and non-English learners, particularly when teachers implement targeted interventions in phonological awareness, phonics, fluency, vocabulary, and comprehension.

Carlisle et al. (2009) explored the relationship between early reading knowledge of elementary teachers and student test improvements, suggesting that while content knowledge in reading is important, it alone does not ensure effective instruction, highlighting the vital role of professional development in enhancing teacher quality.

Harris and Sass (2011) examined the associations between teacher education, training, and student achievement using Florida school administrative records. Their findings revealed that content-focused professional development showed positive associations with productivity in math instruction at secondary levels, while more experienced teachers demonstrated stronger effectiveness in elementary reading and math. However, they found limited evidence supporting associations between pre-service training or teacher aptitude and student achievement.

Professional development achievement opportunities represent an important element in teacher effectiveness. Drawing on international comparisons from countries like Finland, and Japan, Darling-Hammond (2008) emphasized the need for integrated professional development in school models. Professional development that encourages teacher self-assessment, collaborative examination of student achievement, and peer evaluation appears particularly promising for building effective teaching models (Darling-Hammond & Mclaughlin, 1995; Foorman & Moats, 2004).

2.3 Teacher Characteristics and Credentials

Clotfelter et al. (2007) conducted comprehensive research on how various teacher characteristics relate to student performance in grades three to eight. Using a ten-year administrative dataset, they found positive associations between teacher experience and student achievement, contrasting with non-significant relationships between holding master's degrees and student outcomes. Additionally, provisional, temporary, or emergency teacher licensures often showed negative associations with student achievement scores. Their findings suggest that experience-based learning may play a more substantial role in enhancing student achievement than formal academic qualifications alone.

The Measurement of Effective Teaching (MET) project, funded by the Gates Foundation, examined multiple measures of teacher effectiveness including student surveys, classroom observations, and student achievement gains (Kane & Staiger, 2012). The project found that combining these measures provided more reliable assessment of teacher effectiveness than any single measures. Student perceptions of teachers' classroom management, instructional engagement, and feedback quality showed strong correlations with achievement gains. The project's emphasis on multiple measures of teacher effectiveness has influenced teacher evaluation systems nationwide.

Beyond individual teacher characteristics, school variables, including student-teacher ratios and proportions of teachers with various qualifications, may also relate to student outcomes. Wayne and Youngs (2003) found that school-level teacher qualifications showed significant associations with student achievement. Similarly, Darling-Hammond (2000) demonstrated that school-level teacher qualification measures were significant predictors of student achievement, even when controlling for student background characteristics.

In conclusion, research on teacher characteristics and their associations with adolescent reading achievement highlights the multifaceted nature of these relationships. While formal credentials may not consistently show direct relationships with student outcomes, factors such as teacher experience, content-specific knowledge, and targeted professional development demonstrate more consistent associations with student success. The present study extends this research by examining both teacher-level characteristics and school variables in relation to reading achievement among U.S. adolescents using PISA 2018 data.

3. Materials and Methods

3.1 Participants and Sampling Design

The PISA 2018 was administered by the National Center for Education Statistics in the United States following the OECD guidelines for sampling and administration using a stratified systematic sample, with sampling probabilities proportional to the estimated number of 15-year-old students in the school based on grade enrollments (National Center for Education Statistics [NCES], 2019). This study utilized two complementary datasets derived from the PISA implementation.

The first dataset focused on teacher data collected through surveys from 3,526 teachers across 164 schools participating in the 2018 PISA assessment. Per the PISA sampling protocol, up to ten English/language arts teachers and fifteen non-English/language arts teachers eligible to teach the model grade (10th grade in the United States) were sampled in each

school (NCES, 2019b). Average school reading scores were calculated using the data from 4,838 students who attended these same schools, though it's important to note that the students were not necessarily taught by all surveyed teachers. This dataset was primarily used to address the first research question.

The second dataset included data from the same 4,838 15-year-old US students attending these 164 schools, compiled with principals' responses to the school questionnaire, along with student performance test scores and student questionnaire data. The school-level sample consisted of 164 schools out of the 257 schools in the 257 schools in the U.S. PISA 2018 national school sample (NCES, 2019b). This complied dataset was used to address the second research question regarding school.

A critical limitation of the PISA data is that it does not allow for direct matching between teachers and the specific students that they taught. This structural constraint impacted our methodological approach, as explained in the data analysis section.

3.2 Instruments and Measures

3.2.1 Student Reading Assessment

Students completed a two-hour computer-based assessment that evaluated various aspects of reading literacy. The PISA 2018 reading framework focused on students' ability to read single and multiple texts and be able to answer correctly by accessing and retrieving information in a text, searching and selecting relevant text, representing literal meaning, integrating and generating inferences, assessing quality and credibility of a text, reflecting on content and form, and detecting and handling conflict in the text (NCES, 2019b).

Reading performance in PISA is reported through plausible values, which are multiple imputations drawn from a posterior distribution. As recommended in PISA technical documentation, all analyses using achievement data incorporated all ten plausible values using Rubin's (1987) rules for combining results from multiple imputed datasets based on Rubin's rule for multiple imputed variables (International Association for the Evaluation of Educational Achievement [IEA], 2023).

3.2.2 Teacher Questionnaire

Teachers completed a confidential 30-minute online questionnaire that collected information about their backgrounds, education, professional development opportunities, and teaching practices. The teacher questionnaire demonstrated adequate reliability across its scales (Cronbach's alpha ranging from .70 to .86), according to PISA technical documentation (IEA, 2023). Specific teacher variables used in this study included:

- Demographics: Gender, Age
- Employment Characteristics: Full-time versus part-time status, years of experience
- Educational Qualifications: Length of teacher education program (none, one year or less, more than one year), highest degree obtained
- Professional preparation: Initial qualification pathway (pre-service, in-service, work-based, another pedagogical profession, other)
- Professional development: Participation in professional development activities during the previous 12 months

3.2.3 School Questionnaire

School principals completed a 45-minute online questionnaire that gathered information about school background, management practices, teaching staff characteristics, assessment approaches, and evaluation methods. School variables extracted from this questionnaire included:

- Student-teacher ratio
- Proportion of teachers with various education levels (bachelor's, master's, doctoral degrees)
- Proportion of fully certified teachers

3.3 Data Analysis

3.3.1 Data Preparation and Missing Value Treatment

Data preparation included merging teacher, student, and school datasets using appropriate school identifiers. Missing data were addressed through multiple imputation using chained equations, following recommendations by Austin et al. (2021) for handling missing data in complex educational research. Five complete imputed datasets were generated using mice package (van Buuren & Groothuis-Oudshoorn, 2011) in R, with the imputation model incorporating all analysis variables and preserving their distributional properties.

The pooled regression considered all five data sets, an approach shown to increase power and reduce bias in statistical analysis (Collins et al., 2001; Enders, 2010).

3.3.2 Analytical Approach

Multiple regression analysis was conducted using R statistical software (R Core Team, 2025) to examine the relationships between the independent variables (teacher characteristics and school) and the dependent variable (average school reading score). Two separate analytical procedures were implemented to address each research question.

For the first research question, standardized regression coefficients were estimated to facilitate comparison of effect sizes across predictors. Given the nested structure of the data (teachers within schools), robust standard errors were calculated with school-level clustering to account for non-independence of observations within schools.

For second research question, regression models measuring the associations between school variables and reading scores were conducted using the lavaan package (Rosseel, 2012) in R, with results cross-checked using Linear Modeling (lm) functions from the base R package.

3.3.3 Sampling Weights and Variance Estimation

To ensure appropriate handling of the complex sampling design in PISA, all statistics were computed using sampling weights; standard errors based on balanced repeated replication weights were used for statistical significance and/or confidence intervals (IEA, 2023). These procedures were implemented using the EdSurvey package, a specialized R package designed for analyzing data from the National Center for Education Statistics that properly incorporates the complex sampling design (Bailey et al., 2022).

3.3.4 Multilevel Modeling Considerations

While multilevel modeling would typically be appropriate for nested data structures like those in PISA, this approach was not feasible in the current study due to critical limitation in the data. As noted earlier, there is no direct link between individual teachers and the specific students they taught in the PISA dataset. Teachers were sampled at the school, and students were independently sampled within the same schools.

Given this constraint, we aggregated student reading scores to the school level, creating an average score for each school. This approach enables us to explore the relationship between teacher characteristics and school-level reading achievement, but it limited our ability to assess the true teacher effects at the individual student level. This limitation is acknowledged as affecting the interpretation of our results.

4. Results

Table 1 presents descriptive statistics for the key variables in this study. The sample included 3,526 teachers from 164 schools, with data on reading scores from 4,838 students. Among teacher demographics, 50.6% were female, and the average was 42.87 years (SD = 11.13). Teachers reported an average of 14.95 years of teaching experience (SD = 9.47). Most teachers (78.64%) were employed full-time, with only 1.7% working part-time. Regarding educational qualifications, 57.35% of teachers completed a teacher education program lasting more than one year, 16.36% completed a program of one year or less, and 6.5% reported no formal teacher education. The majority of teachers (65.31%) received their initial qualification through a pre-service teacher training program.

Table 1. Descriptive Statistics of key Study Variables

	N	*%*	Mean	SD	Min	Max
Panel A: Teacher Characteristics						
Gender						
Female	1784	50.60	-	-	-	-
Male	1019	28.90	-	-	-	-
Age	-	-	42.87	11.13	20	70
Experience	-	-	14.95	9.47	0	50
Employment Status						
Full-time	2773	78.64	-	-	-	-
Part-time	60	1.70	-	-	-	-
Teacher Education						
None	229	6.50	-	-	-	-
1-Year or less	577	16.36	-	-	-	-
More than 1 Year	2022	57.35	-	-	-	-
Initial Qualification						
Pre-service	2303	65.31	-	-	-	-
In-Service	113	3.20	-	-	-	-
Work-based Teacher Training	241	6.83	-	-	-	-
Training in Another Pedagogical Profession	31	0.88	-	-	-	-
Other	142	4.03	-	-	-	-
In-Service Training						
Yes	429	12.17	-	-	-	-
No	1313	34.27	-	-	-	-
Teacher Workshop						
Yes	1637	46.43	-	-	-	-
No	128	3.63	-	-	-	-
Professional Development						
Yes	2753	70.08	-	-	-	-
No	51	1.45	-	-	-	-
Panel B: School Variables						
Student teacher ratio	-	-	16.99	9.91	1.67	100
Percentage of teachers fully certified	-	-	0.93	0.20	0	1.0
Percentage of teachers with bachelor's degree or above	-	-	0.81	0.25	0.01	1.0
Percentage of teachers with master's degree or above	-	-	0.49	0.27	0.02	1.0
Percentage of teachers with doctoral degree	-	-	0.02	0.03	0	0.22
Reading scores (school average)	-		505.35	107.91	260.3	608.1
Total Students	4838	-	-	-	-	-
Total Teachers	3526	-	-	-	-	-
Total Schools	164	-	-	-	-	-

Note. Missing data accounts for differences between total N and category sums. Percentages represent a proportion of the total sample (N = 3,526). Teacher characteristics data were collected from the PISA 2018 Teacher Questionnaire. School variables were obtained from the PISA 2018 School Questionnaire completed by principals. School variables (percentages) are represented as proportions where 0.93 indicates 93% of teachers. Reading scores represent the average of all 10 plausible values calculated at the school level using appropriate PISA sampling weights. SD = standard deviation.

School-level variables showed that the average student-teacher ratio was 16.99 (SD = 9.91). On average, schools reported that 93% of their teachers were fully certified, 81% held at least a bachelor's degree, 49% held at least a master's degree, and 2% held doctoral degrees. The mean reading scores across all schools was 505.35 (SD = 107.91).

4.1 Correlational Analysis

Table 2 displays the correlation matrix of teacher characteristics, school variables, and average school reading scores. Several teacher and school variables showed statistically significant correlations with average school reading scores. Teaching experience ($r = .10$, $p < .001$) and teacher age ($r = .05$, $p < .01$) showed weak positive correlations with average school reading scores. Interestingly, full-time employment status showed a negative correlation with average school reading scores ($r = -.11$, $p < .001$). Among school variables, the percentage of teachers with master's degrees showed the strongest positive correlation with average school reading scores ($r = .20$, $p < .001$), while the percentage of teachers with bachelor's degrees showed a negative correlation ($r = -.14$, $p < .001$). The student-teacher ratio was positively correlated with average school reading scores ($r = .12$, $p < .001$), while the percentage of fully certified teachers was negatively correlated ($r = .11$, $p < .001$).

Table 2. Correlation Matrix of Teacher Characteristics, School, and Reading Scores

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Reading Score	1.00												
2. Teacher Age	.05**	1.00											
3. Teaching Experience	.10***	.76***	1.00										
4. Teacher Gender[a]	-.01	-.06**	-.05**	1.00									
5. Employment Status[b]	-.11***	-.07**	-0.4*	-.02	1.00								
6. Teacher Education < 1 year[c]	.01	-.03	-.09***	-.04*	-.02	1.00							
7. Teacher Education > 1 year[d]	.04	.04*	.13***	.07**	.03	-.80***	1.00						
8. Initial Qualification[e]	.08***	.02	.21***	.06**	-.01	-.26***	.43**	1.00					
9. Professional Development[f]	-.05*	-.04*	-.05**	.04	.11***	.00	.00	-.04	1.00				
10. Student Teacher Ratio	.12***	-.01	-.02	-.02	-.01	.05*	-.05*	.00	-.02	1.00			
11. % of Fully Certified Teachers	-.11***	-.02	-.04	.01	.05*	.02	.04*	.08***	.05*	.04*	1.00		
12. % Teachers w/ Bachelor's	-.14***	-.06*	-.03	-.04*	.01	.03	-.02	-.01	-.03	.03	-.08***	1.00	
13. % Teachers w/ Master's	.20***	.07**	.10***	-.03	-.09***	-.03	.06**	.12***	-.05	-.12***	.12***	-.03	1.00
14. % Teachers w/ Doctorate	.08***	-.02	-.02	.02	-.02	.00	-.02	-.09***	-.01	.11***	.02	-.07***	.08**

Note. [a]Teacher Gender: 1 = Female, 0 = Male; [b]Employment Status: 1 = Full-Time, 0 = Part-Time; [c]Teacher Education 1 year or less, 0 = None; [d]Teacher Education more than 1 year, 0 = None; [e]Initial Qualification: 1 = Standard Teacher Preparation Program, 0 = Other; [f]Professional Development: 1 = Participated, 0 = Didn't Participate. The table presents Pearson correlation coefficients. *$p < .05$. **$p < .01$. ***$p < .001$. The correlation matrix also revealed significant relationships among teacher and school variables. Teacher age and teaching experience were strongly correlated ($r = .76$, $p < .001$), as expected. Teachers with longer education programs (more than 1 year) were more likely to have received their qualification through a standard program ($r = .43$, $p < .001$). The percentage of teachers with master's degrees was positively correlated with teaching experience ($r = .10$, $p < .001$) and negatively correlated with student-teacher ratio ($r = -.12$, $p < .001$).

4.2 Association of Teacher Characteristics with Average School Reading Scores

Table 3 presents the results of multiple regression analysis examining associations between teacher characteristics and average school reading scores. The model accounted for approximately 3.3% variance in average school reading scores.

Several teacher characteristics showed significant associations with average school reading scores.

Table 3. Regression Analysis Predicting Average School Reading Score from Teacher Characteristics

Predictor	Estimate (B)	Std. Err	z-value	$p(>|z|)$	Std. Estimate (β)
Intercept	507.62	8.82	57.58	<. 001***	10.66
Teaching Experience (TC_TEXP)	0.677	0.247	2.739	.006**	0.135
Age (TC_AGE)	-0.311	0.161	-1.930	.054	-0.072
Gender: Male vs. Female	1.694	2.499	0.678	.498	0.017
Employment: Part-time vs. Full-time	35.021	7.856	4.458	< .0001***	0.106
Teacher Education (*ref*.: None)					
Teacher Ed: ≤ 1 year	12.36	5.876	2.104	.035*	0.105
Teacher Ed: ≥ 1 year	10.781	5.383	2.003	0.045*	0.102
Initial Qualification (*ref*: preservice/standard teacher training)					
In-service	-10.816	5.972	-1.811	.070	-0.045
Work-based	-3.377	4.342	-0.778	.437	-0.020
Another Profession	-12.523	9.532	-1.314	.189	-0.026
Other	-0.034	5.429	0.006	.995	0.000
Professional Development (*ref*.: No)	-9.579	5.591	-1.714	.087	-0.034
Workshop (*ref*.: No)	-0.212	1.486	-0.143	.887	-0.002
Training (*ref*.: No)	-2.032	3.152	-0.645	.519	-0.015

Note. This table presents standardized (β) and unstandardized (B) regression coefficients from structural equation modeling using the lavaan package with robust maximum likelihood estimation (MLR) and school-level clustering (CNTSCHID). Analysis was conducted using EdSurvey with proper PISA sampling weights on data from 2,777 teachers in 158 schools. The model explained 3.3% of variance in average school reading scores. Reference categories are indicated in parentheses with "ref." As this was a saturated model (*df* = 0), the fit indices are not reported. For Initial Qualification, the reference category is "preservice/standard teacher training program". For categorical variables, the coefficient indicates the average difference in reading scores compared to the reference category. *p < .05. **p < .01. ***p < .001.

Teaching experience showed a positive association with average school reading scores (β = 0.135, p = .006), indicating that for each additional year of teaching experience, average school reading scores increased by 0.677 points, holding other factors constant. Employment status showed a significant relationship with average school reading scores, with part-time teachers associated with higher average school reading scores compared to full-time teachers (β = 0.106, p < .001). Specifically, schools with higher proportions of part-time teachers scored approximately 35.02 points higher on average.

Teacher education was also significantly associated with average school reading scores. Compared to teachers with no formal teacher education, those who completed programs of one year or less (β = 0.105, p = .035) and those who completed programs longer than one year (β = 0.102, p = .045) were associated with higher average school reading scores. Teacher age showed a negative association with average school reading scores that approached statistical significance (β = -0.072, p = .054). Gender, initial qualification pathway, and professional development participation did not show statistically significant associations with average school reading scores.
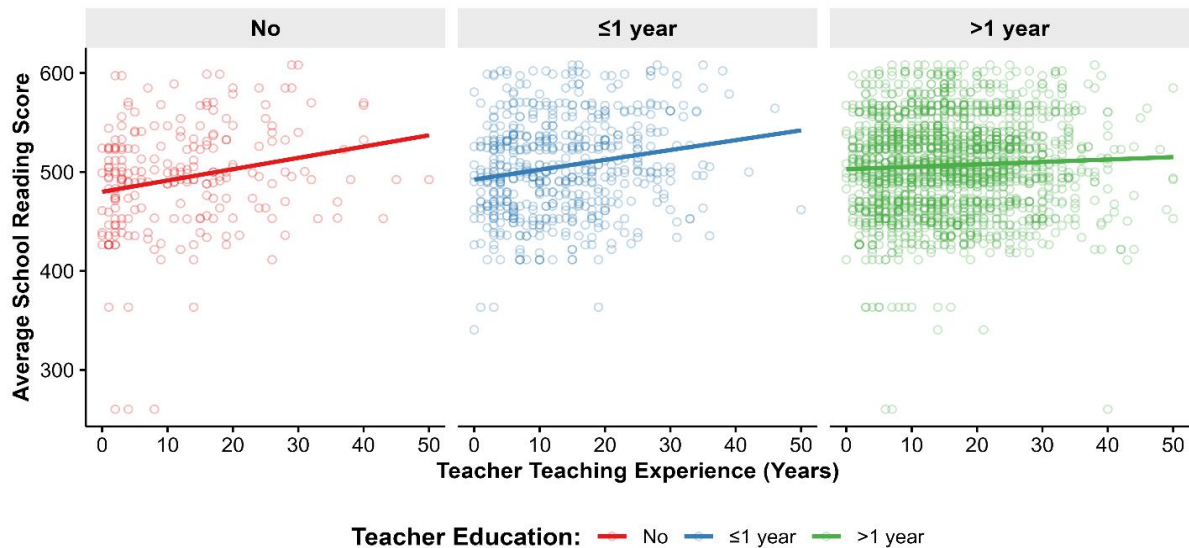
Figure 1. Relationship Between Average School Reading Score and Teachers' Teaching Experience by Participation in Teacher Education Program Length

Figure 1 illustrates the association between teaching experience (years) and average school reading scores. Data points represent individual teachers linked to school-level scores. Panels (facets) separate teachers based on the reported length of their completed teacher education program: none ("No"), one year or less ("≤ 1 year"), or more than one year ("> year"). Within each panel, the line represents the linear regression trend fitted to the data for that specific teacher education group. Notably, the steeper slope for teachers with no teacher education suggests that the positive association between experience and average school reading scores may be stronger for this group, while the relatively flatter slope for teachers with more than one year of education indicates a more modest relationship between experience and reading scores for these teachers.

4.3 Association of School Variables with Average School Reading Score

Table 4 summarizes the regression analysis examining associations between school variables and average school reading scores. This model explained approximately 13.1% of the variance in average school reading scores, suggesting that school variables collectively had stronger explanatory power than teacher characteristics alone.

Table 4. Standardized Regression Coefficient Predicting Average School Reading Score from School Variables

Predictor	Estimate (B)	Std. Err	z-value	$p(>|z|)$	Std. Estimate (β)
Intercept	520.24	26.02	19.995	$<. 001$***	11.42
SCHSIZE	0.008	0.005	1.498	.134	0.165
STRATIO	0.784	0.742	1.056	0.291	0.122
PROATCE	-43.65	24.834	-1.758	.079	-0.156
PROAT5AM	41.298	17.999	2.294	.022*	0.228
PROAT5AB	-23.281	15.145	-1.537	0.124	-0.142
PROAT6	-2.326	125.79	-0.018	.985	-0.002

Note. The table presents standardized (β) and unstandardized (B) regression coefficients from structural equation modeling using the lavaan package with robust maximum likelihood estimation (MLR) and school-level clustering (CNTSCHID). Analyses were conducted using EdSurvey with proper PISA sampling weights on data from 2,763 teachers in 124 schools. The model explained 13.1% of the variance in average school reading scores. As this was a saturated model ($df = 0$), the fit indices are not reported. PROTACE = proportion of fully certified teachers; PROAT5AM = proportion of teachers with master's degrees; PROAT5AB = proportion of teachers with bachelor's degrees; PROAT6 = proportion of teachers with doctoral degrees. *$p < .05$. **$p < .01$. ***$p < .001$.

The percentage of teachers with master's degrees showed a significant positive association with average school reading scores ($β = 0.228$, $p = .022$), indicating that schools with higher proportions of teachers holding master's degrees tended to have higher average school reading scores. Although not reaching conventional statistical significance threshold, several other school variables showed notable relationships, e.g., the percentage of fully certified teachers, and the percentage of teachers with bachelor's degrees etc.

4.4 Combined Model: Teacher and School Variables

Table 5 presents the results from the combined regression model that simultaneously examined teacher characteristics and school variables. This model explained approximately 15.9% of the variance in average school reading scores, representing an improvement over either the teacher only (3.3%) or school-only (13.1%) models.

Table 5. Combined Regression Analysis Predicting Average School Reading Scores from Teacher and School Characteristics

Predictor	Estimate (B)	Std. Err	z-value	$p(>|z|)$	Std. Estimate (β)
Intercept	521.31	25.44	20.49	< .001***	11.84
Teacher Variables					
Teaching Experience (TC_TEXP)	0.421	0.218	1.927	.054*	0.091
Age (TC_AGE)	-0.211	0.137	-1.535	.125	-0.053
Gender: Male vs. Female	1.199	2.073	0.578	.563	0.013
Employment: Part-time vs. Full-time	21.707	6.955	3.121	.002**	0.070
Teacher Education (*ref*.: None)					
Teacher Ed: ≤ 1 year	5.979	4.475	1.336	.182	0.054
Teacher Ed: ≥ 1 year	6.923	4.354	1.590	.112	0.071
Initial Qualification (*ref*: preservice/standard teacher training)					
In-service	-2.055	5.956	-0.345	.730	-0.009
Work-based	1.341	3.502	0.383	.702	0.008
Another Profession	-0.891	7.485	-0.119	.905	-0.002
Other	-4.651	5.194	-0.895	.371	-0.023
Professional Development (*ref*.: No)	-4.261	6.638	-0.642	.521	-0.016
Workshop (*ref*.: No)	0.724	1.453	0.498	.618	0.008
Training (*ref*.: No)	0.521	3.027	0.172	.863	0.004
School Variables					
SCHSIZE	0.011	0.005	2.050	.040*	0.235
STRATIO	0.447	0.696	0.643	.520	0.075
PROATCE	-42.709	23.456	-1.821	.069	-0.156
PROAT5AM	39.340	16.276	2.417	.016*	0.223
PROAT5AB	-22.157	13.540	-1.636	.102	-0.137
PROAT6	1.842	129.107	0.014	.989	.001

Note. The table presents standardized (β) and unstandardized (B) regression coefficients from structural equation modeling using the lavaan package with robust maximum likelihood estimation (MLR) and school-level clustering (CNTSCHID). Analyses were conducted using EdSurvey with proper PISA sampling weights on data from 2,200 teachers in 124 schools. The model explained approximately 15.9% of the variance in average school reading scores. As this was a saturated model (*df* = 0), the fit indices are not reported. Reference categories are indicated in parentheses. School-level variables include SCHSIZE (school size), STRATIO (student-teacher ratio), PROATCE (proportion of fully certified teachers), PROAT5AM (proportion of teachers with master's degrees), PROAT5AB (proportion of teachers with bachelor's degrees), and PROAT6 (proportion of teachers with doctoral degrees). *p < .05. **p < .01. ***p < .001.

In the combined model, three variables emerged as statistically significant predictors of average school reading scores. School size showed a significant positive association with average school reading scores (*β* = 0.235, *p* = .040), as did the percentage of teachers with master's degree (*β* = 0.223, *p* = .016). Part-time employment status remained significantly associated with higher average school reading scores (*β* = 0.070, *p* = .002). Teaching experience showed a positive association that approached significance (*β* = 0.091, *p* = .054).
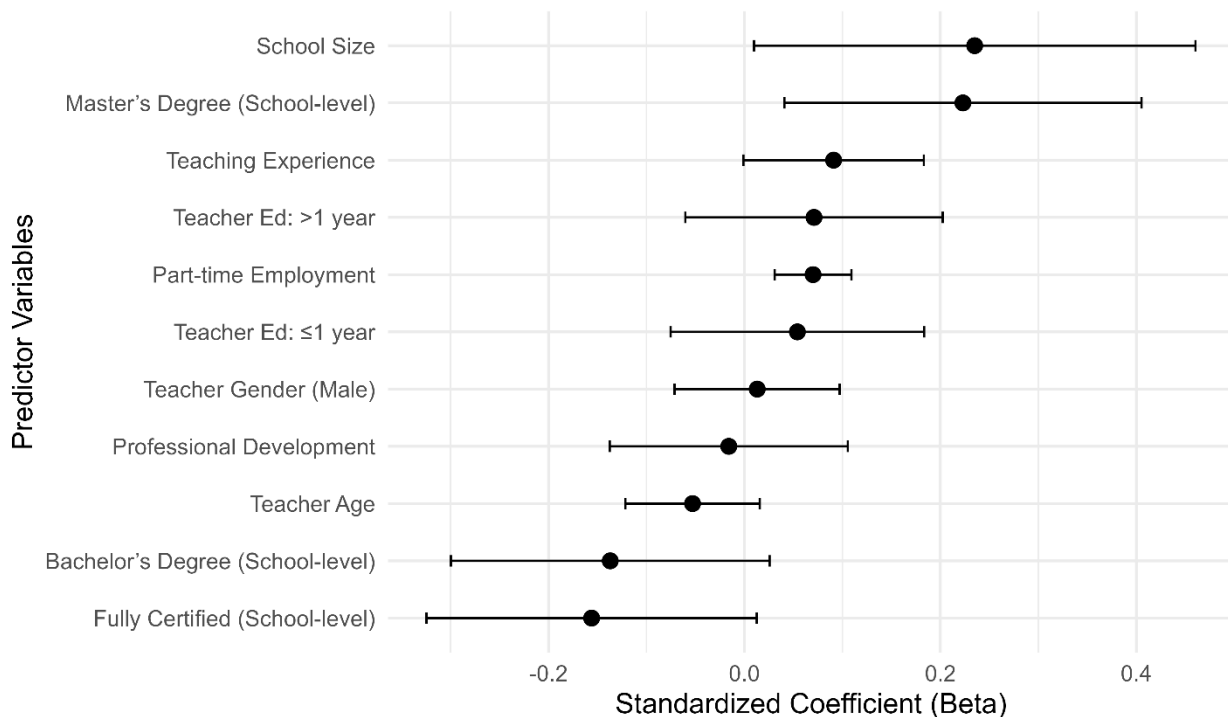
Figure 2. Standardized Regression Coefficients (Beta) and 95% Confidence Intervals for Predictors of Adolescent Reading Achievement from the Combined Model

Figure 2 displays the standardized regression coefficients (Beta values) for variables in the combined model, allowing for direct comparison of the relative strength of associations between different predictors and average school reading scores. As illustrated in Figure 2, school-level variables (school size, percentage of teachers with master's degrees) demonstrated the strongest associations with average school reading scores, followed by teacher-level variables such as part-time status and teaching experience. Compared to teacher-only model, the magnitude of coefficients for teaching experience and part-time status decreased in the combined model, suggesting that school variables may partially account for the relationships observed between teacher characteristics and reading achievement.

In summary, the results indicate that both teacher characteristics and school variables are associated with average school reading scores among 15-year-old students in the United States. Teaching experience, part-time employment status, teacher education, school size, and the percentage of teachers with master's degrees showed positive associations with average school reading scores. Unexpectedly, the percentage of fully certified teachers showed a negative association with average school reading scores. These findings highlight the complex nature of factors related to adolescent reading achievement and suggest that both teacher- and school-level variables merit consideration when examining educational outcomes.

5. Discussion

This study examined the relationships between teacher characteristics, school, and reading achievement among 15-year-old U.S. students using 2018 PISA data. The findings reveal complex patterns that both align with the diverge from previous literature.

5.1 Teacher Characteristics and Reading Achievement

Our findings highlight several teacher characteristics significantly associated with average school reading scores. Teaching experience showed a positive association with reading achievement ($\beta = 0.135$), aligning with previous research by Podolsky et al. (2019) and Goldhaber et al. (2019). This relationship likely reflects experienced teachers' deeper instructional repertoire, stronger classroom management, and enhanced content knowledge developed over time.

Teachers who completed formal teacher education programs, either one year or less ($\beta = 0.105$) or more than one year ($\beta = 0.102$), were associated with higher average school reading scores compared to teachers without formal preparation. This finding supports research by Darling-Hammond (2020) and Konig et al. (2020) regarding the value of pedagogical training and specialized knowledge for effective teaching.

Interestingly, part-time teaching status was significantly and positively associated with higher average school reading scores (β = 0.106). This counterintuitive finding may reflect several possibilities: part-time positions might attract specialists with specific expertise in literacy; experienced teachers might opt for reduced schedules while maintaining high effectiveness; or schools with higher achievement might employ different staffing strategies that include specialized part-time faculty. This resonates with research by Antony and Hayden (2011), who found that part-time faculty often report high commitment to their institutions despite reduced hours.

Teacher age showed a slight negative association with reading scores that approached significance (β = 0.072), creating an interesting contrast with the positive association of experience. This pattern could suggest that younger teachers, despite less experience, might employ more contemporary instructional methods or demonstrate greater adaptability to current educational contexts, as suggested by Cochran-Smith (2004).

Professional development participation showed no significant association with reading achievement, contemporary to some previous research (Darling-Hammond, 2008). This may reflect limitations in how professional development was measured (as binary participation rather than quality or relevance) or suggest that not all professional development effectively translates to improved student outcomes, echoing Harris and Sass's (2011) finding that only content-specific professional development showed clear benefits.

5.2 School and Reading Achievement

School variables demonstrated stronger collective associations with reading achievement than teacher characteristics alone, explaining 13.1% of variance compared to 3.3% for teacher variables. The percentage of teachers with master's degrees showed a robust positive association with average school reading scores (β = 0.228), supporting previous research on the value of advanced teacher education (Clotfelter et al., 2007; Wayne & Youngs, 2003).

Contrary to expectations, the percentage of fully certified teachers showed a negative association with reading scores that approached significance (β = 0.156). This finding diverges from studies by Darling-Hammond (2020) and Brew and Saunders (2020), which generally found positive relationships between teacher certification and student outcomes. This unexpected pattern may reflect limitations in certification measures, differential distribution of certified teachers across school contexts, or interaction with other qualification factors (Lankford et al., 2002).

School size showed a positive association with reading achievement in the combined model (β = 0.235), suggesting possible advantages of larger schools in providing diverse resources, specialized instruction, or broader curricular offerings. This finding aligns with research suggesting that larger schools may offer more comprehensive programming, though literature on school size effects remains mixed (Darling-Hammond, 2000).

The combined model, incorporating both teacher and school variables, explained approximately 15.9% of the variance in average school reading scores, representing a substantial improvement over either the teacher-only or school-only models. This highlights the importance of considering both individual teacher characteristics and broader school context when examining educational outcomes.

5.3 Implications for Educational Policy and Practice

The associations observed in this study offer considerations for educational research, though caution is warranted given our ecological, cross-sectional design. The positive association between teaching experience and school-level reading scores aligns with existing research but cannot establish causality. Similarly, the unexpected relationship between part-time teacher status and average school reading achievement raises questions about staffing configurations worthy of further investigation.

The association between advanced degrees and higher reading scores adds perspective to discussions about teacher qualifications, while the counterintuitive finding regarding certification percentages highlights the complexity of using certification as a quality indicator. The substantial difference in explanatory power between our models suggests value in research approaches considering both teacher characteristics and school context simultaneously.

These considerations should be interpreted within the context of this study's substantial limitations, particularly the inability to link teachers to their specific students and the cross-sectional nature of the data.

6. Conclusions

This study examined relationships between teacher characteristics, school, and adolescent reading achievement using 2018 PISA data from U.S. schools. Our findings revealed several notable associations: teaching experience and formal teacher education were positively associated with average school reading scores, while the percentage of teachers with master's degrees emerged as a particularly strong positive correlation at the school level. Unexpectedly, part-time teacher status was positively associated with reading scores, while the percentage of certified teachers exhibited a negative trend.

The school model demonstrated substantially higher explanatory power (13.1%) than the teacher characteristics (3.3%),

suggesting the importance of considering school-level factors when studying educational outcomes. However, the combined model (15.9%) indicated that both teacher and school variables contribute uniquely to understanding the patterns observed in reading achievement.

These findings should be interpreted with caution due to several notable methodological limitations, particularly the ecological nature of the analysis and cross-sectional design. This study does not establish cause relationships but rather identifies patterns of association that may inform future research employing more robust designs. Future studies should aim to better understand how teacher characteristics and school relate to student literacy development over time.

7. Limitation and Future Research

Limitations

Several important methodological limitations should be considered when interpretating the results:

Cross-sectional nature: The PISA 2018 data are cross-sectional, which limits our ability to make causal inferences about the relationship observed. All findings represent associations rather than cause-effect relationships.

Ecological relationships: Since teachers could not be directly linked to the students they taught; our analyses examine ecological relationships at the school rather than direct instructional effects. This limitation means that observed associations between teacher characteristics and student outcomes may be influenced by unmeasured school-level factors.

Aggregation bias: Aggregating individual student data to the school level can introduce aggregation bias, potentially inflating correlation coefficients.

Measurement limitations: While PISA instruments undergo rigorous development and validation, they remain proxy measures of complex educational constructs and may not capture all relevant aspects of teaching quality or student learning.

Sample representativeness: Although PISA employs probability sampling, non-response at both school and student levels can affect the representativeness of the sample. Our analytical sample includes only the schools where both teachers and student data were collected, which may differ systematically from the full PISA sample.

Measurement Considerations: Additionally, the reding scores used in this study represent average school scores based on the PISA assessment, which may not fully capture the complexity of reading achievement. The PISA reading assessment, while comprehensive, represents a specific conceptualization of reading literacy that may differ from other reading assessments or classroom-based evaluations.

The measurement of teacher characteristics also presents limitations. For example, professional development was assessed through a binary indicator of participation within the past 12 months, which does not capture the quality, duration, or content of these activities. Similarly, teacher education and qualification measures reflect formal credentials but may not adequately capture teachers' actual knowledge, skills, or instructional effectiveness.

Future Research Directions

Future research should address these limitations by employing longitudinal designs that can better establish temporal precedence necessary for causal inference. Studies that directly link teachers to the students they instruct would provide more precise estimates of teacher effects on student outcomes.

Additionally, mixed method approaches that complement quantitative analyses with qualitative investigations would help elucidate the mechanisms through which teacher characteristics and school relate to student achievement. Future research could also explore potential interaction effects between teacher characteristics and student demographics, examining whether certain teacher attributes show stronger associations with reading achievement for specific student populations.

Given the unexpected findings regarding negative associations between full-time teacher status and average school reading scores, as well as between the proportion of certified teachers and achievement, further investigation is needed to understand these counterintuitive relationships. Such research might consider more unnuanced measures of teacher quality beyond certification status and identify potential mediating variables.

Finally, as educational contexts continuously evolve, particularly following the COVID-19 pandemic, updated research using more recent data would be valuable to determine whether the relationships identified in this study persist in changed educational environments.

Acknowledgments

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