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Student-perceived teacher-related classroom ecology and reading achievement in Türkiye: A multilevel analysis of PISA 2018 data

Türkiye'de öğrenci algılarına göre öğretmenle ilişkili sınıf ekolojisi ve okuma başarısı: PISA 2018 verilerine dayalı çok düzeyli bir analiz

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Abstract

This study examined the associations between student-perceived teacher-related classroom ecology variables and reading achievement among 15-year-old students in Türkiye using PISA 2018 data. Grounded in a school ecology perspective, it focused on six student-perceived variables: adaptive instruction, teacher-directed instruction, teacher feedback, teacher support, teacher enthusiasm, and teacher stimulation of reading engagement. The analytic sample included 6,890 students nested within schools. Missing responses to teacher-related questionnaire items were handled through multiple imputation, and reading achievement was modeled using all ten plausible values. Two-level random-intercept hierarchical linear models were estimated with students at Level 1 and schools at Level 2. Adaptive instruction, teacher support, and teacher stimulation of reading engagement were positively associated with reading achievement. In contrast, teacher-directed instruction and teacher feedback were negatively associated with reading achievement, whereas teacher enthusiasm was not statistically significant. By linking PISA 2018 reading achievement data with student-perceived teacher-related classroom ecology variables, this study contributes to understanding how perceived instructional environments are associated with reading performance in Türkiye. The findings suggest that teacher-related classroom ecology is not uniformly associated with reading performance; rather, different teaching dimensions relate to reading achievement in distinct ways.

Keywords: *Reading literacy, PISA 2018, classroom environment, student perceptions, multilevel analysis, Türkiye.*

Öz

Bu araştırmada PISA 2018 verileri kullanılarak Türkiye'deki 15 yaş grubu öğrencilerin okuma başarısı ile öğrencilerin algılarına dayalı öğretmenle ilişkili sınıf ekolojisi değişkenleri arasındaki ilişkiler incelenmiştir. Okul ekolojisi bakış açısına dayanan çalışmada öğrencilerin algılarına dayalı altı öğretmenle ilişkili değişkene odaklanılmıştır: uyarlanabilir öğretim, öğretmen yönlendirmeli öğretim, öğretmen geri bildirimi, öğretmen desteği, öğretmen coşkusu ve öğretmenin okumaya katılımı teşvik etmesi. Araştırma örneklemi 6.890 öğrenciden oluşmuştur. Öğretmenle ilişkili maddelerdeki eksik veriler çoklu atama metoduyla ele alınmış, okuma başarısı ise on makul değer kullanılarak modellenmiştir. Öğrencilerin birinci seviyeyi, okulların ise ikinci seviyeyi oluşturduğu iki seviyeli hiyerarşik lineer modeller kurulmuştur. Bulgular uyarlanabilir öğretim, öğretmen desteği ve öğretmenin okumaya katılımı teşvik etmesinin okuma başarısıyla pozitif yönde ilişkili olduğunu göstermiştir. Buna karşılık öğretmen yönlendirmeli öğretim ve öğretmen geri bildirimi okuma başarısıyla negatif yönde ilişkili bulunmuş; öğretmen coşkusu ise istatistiki olarak anlamlı bulunmamıştır. PISA 2018 okuma başarısı verilerini öğrencilerin algılarına dayalı öğretmenle ilişkili sınıf ekolojisi değişkenleriyle birlikte ele alan bu çalışma, Türkiye bağlamında algılanan öğretim ortamlarının okuma performansıyla ilişkisini anlamaya katkı sunmaktadır. Sonuçlar öğrencilerin algılarına dayalı öğretmenle ilişkili sınıf ekolojisinin okuma performansıyla tek yönlü bir ilişki göstermediğini; farklı öğretim boyutlarının okuma başarısıyla farklı biçimlerde ilişkili olduğunu ortaya koymaktadır.

Anahtar Kelimeler: *Okuma okuryazarlığı, PISA 2018, sınıf ortamı, öğrenci algıları, çok düzeyli analiz, Türkiye.*

Introduction

Reading literacy is a key indicator of students' academic development and their capacity to participate in social, economic, and civic life. It also functions as a gateway skill that supports learning across disciplines and enables students to access, evaluate, and use information in increasingly complex textual environments (OECD, 2023; UNESCO, 2025). International large-scale assessments such as PISA provide an important framework for examining reading achievement because they combine cognitive measures with questionnaire-based contextual data, allowing researchers to investigate how features of educational environments are associated with student performance (OECD, 2018b, 2019b).

Within Türkiye, understanding how educational environments shape learning outcomes is especially important given the reform trajectory of the last two decades (MEB, 2006, 2024). Following the 2006 curriculum reforms and later revisions, the Turkish education system formally adopted a constructivist orientation emphasizing student-centered instruction, meaning-making, active learning, and higher-order thinking (Yazar, 2019). In principle, this orientation requires learning environments that support engagement, inquiry, and strategic learning (Precellas & Napil, 2024). However, the implementation of student-centered reforms often reveals a persistent tension: even when curricula foreground learner agency, teachers remain decisive in shaping classroom practices (Sakata et al., 2022). Teachers structure learning opportunities, guide engagement, establish expectations, and mediate instructional interactions—processes that may either enable or constrain the intended outcomes of constructivist and active-learning approaches (Cahyono & Rusiadi, 2025; Gautam & Agarwal, 2024). These considerations point to a need to clarify how student-perceived teacher-mediated classroom conditions are associated with reading achievement in Türkiye.

Within this broader school ecology perspective, this study focuses specifically on teacher-related classroom ecology as perceived by students. The term "teacher-related classroom ecology" emphasizes that classroom academic environments are multidimensional (Konrad et al., 2024; Wang & Degol, 2016) and shaped by both instructional supports and relational processes (Luo & Derakhshan, 2024). In PISA, student-perceived teacher-related classroom ecology variables reflect students' perceptions of instructional guidance, classroom practices, and broader teacher-mediated features of the learning setting (OECD, 2019b). These perceived conditions constitute an ecology because they operate together: guidance may be more effective in an orderly and supportive climate (Doyle, 2013; Pianta et al., 2012), instructional clarity may depend on classroom interaction patterns (Pianta et al., 2012), and engagement with reading tasks may be shaped by how teachers structure participation and feedback (Reeve, 2012).

Despite the policy prominence of student-centered reforms (MEB, 2006), research in Türkiye has often prioritized macro-level trends across assessment cycles (Sarıer, 2021) or student background characteristics in explaining achievement differences (Uysal & Eren, 2021). Although valuable, such work leaves student-perceived teacher-related classroom ecology variables comparatively underexamined, especially through internationally comparable and nationally representative data (OECD, 2019b). The central problem addressed in this study is the limited evidence on how student-perceived teacher-related classroom ecology variables are associated with reading achievement in Türkiye within a nationally representative and multilevel framework. Although Türkiye's curriculum reforms emphasize student-centered and active learning, it remains unclear which teacher-mediated classroom conditions, as perceived by students, are more strongly linked to reading performance. To support interpretation and policy relevance, these relationships should also be examined with modeling strategies that reflect PISA's measurement design and outcome structure (OECD, 2018b; Rutkowski et al., 2010).

PISA 2018 provides an appropriate empirical context for this purpose because it includes rich

reading-related data for 15-year-olds and questionnaire information suitable for operationalizing student-perceived teacher-related classroom ecology variables from the student perspective (OECD, 2019a, 2019b). It also represents the most recent cycle in which reading is a major assessment domain with extensive reading context, making it especially relevant for examining reading achievement and its instructional correlates (Shiel et al., 2022). Accordingly, PISA 2018 was selected because it combines reading-focused achievement measures with student-reported teacher-related indicators, allowing the relationships targeted in this study to be investigated at scale.

The present study therefore examines how student-perceived teacher-related classroom ecology variables derived from the PISA 2018 student questionnaire are associated with reading achievement among Türkiye's 15-year-old students. By focusing on teacher-related classroom ecology, the study contributes to three intersecting discussions: the empirical evaluation of constructivist-era curriculum implementation in Türkiye, the identification of classroom environment factors associated with stronger reading outcomes, and the development of nationally representative evidence to inform teacher development and instructional improvement. In line with this purpose, the study addresses the following research questions:

1. Which student-perceived teacher-related classroom ecology variables are significantly associated with students' reading achievement in Türkiye's PISA 2018 sample?
2. Which student-perceived teacher-related classroom ecology variables have the strongest association with students' reading achievement?
3. How much does the teacher-related classroom ecology variable block contribute to the model's overall ability to explain differences in reading achievement?

Teacher Related Classroom Ecology and Reading Achievement

Constructivist and active-learning principles entered Türkiye's Turkish curriculum through the Turkish Language Course Curriculum (Grades 6, 7, and 8) (MEB, 2006). The curriculum is student-centered and participation-oriented, while also assigning teachers active responsibility for transforming participation into learning (Aksit, 2007). It emphasizes sensitivity to individual differences, independent and collaborative learning, and activities beyond school (MEB, 2006). At the same time, it frames the teacher as a guide who directs and assists students (Bayburtlu, 2015), supports them in moments of difficulty (Göçer, 2014), attends to student products (Tabak & Göçer, 2013), monitors progress, encourages self-evaluation (Öz, 2011) and cooperates with families to support language development outside school.

In this study, teacher-related classroom ecology is operationalized by matching these curriculum-relevant teacher responsibilities with six teacher-related indicators available in PISA 2018: adaptive instruction, teacher-directed instruction, teacher feedback, teacher support, teacher enthusiasm, and teacher stimulation of reading engagement (OECD, 2019c). These indicators are treated as student-reported proxies for a coordinated instructional environment, consistent with the curriculum's emphasis on guidance, monitoring, and motivational structuring as conditions for meaningful participation and literacy development (OECD, 2019a).

Adaptive instruction corresponds to the curriculum's emphasis on individual differences, students' developmental characteristics, and learning environments responsive to students' levels and interests (Bach et al., 2024). In reading, such responsiveness is important because students differ in strategy repertoires, vocabulary resources, and stamina with complex texts (OECD, 2021). Adaptive instruction may therefore support achievement by maintaining appropriate challenge, enabling access to tasks, and reducing disengagement

among diverse learners. Classroom-process research similarly treats instructional adaptivity as a mechanism through which participation-oriented instruction becomes attainable for diverse learners (Bach et al., 2024; Hardy et al., 2022; Parsons et al., 2018).

Teacher-directed instruction reflects the teacher's role in providing purposeful structure, clear expectations, and strategic guidance for cognitively productive participation (Praetorius et al., 2018; Chi & Wylie, 2014). This is compatible with the curriculum's pairing of active student participation with teacher guidance (Cahyono & Rusiadi, 2025; MEB, 2006). In reading instruction, such guidance may include modeling text approaches, supporting comprehension monitoring and inference-making, and clarifying success criteria (Duke et al., 2021; Hattie, 2023). Large-scale findings also associate instructional clarity and structured teaching with achievement after accounting for background characteristics (OECD, 2019c).

Teacher feedback aligns with the curriculum's expectation that teachers monitor students' development and encourage self-evaluation (MEB, 2006). It also corresponds to formative assessment perspectives that emphasize feedback for self-regulated learning (Panadero et al., 2017; Wiliam, 2017). In reading, feedback may support comprehension and interpretation when it directs students to textual evidence, revision, and quality criteria (Duke et al., 2021). However, feedback effects vary by type and quality, with improvement-oriented feedback generally producing stronger achievement benefits than purely evaluative forms (Wisniewski et al., 2020).

Teacher support represents the relational dimension of teacher-related classroom ecology. Although the curriculum does not define support explicitly in relational terms, its emphasis on guidance and active participation implies assisting students during difficulties and providing constructive direction throughout learning (MEB, 2006). This aligns with research conceptualizing teacher support as responsiveness to students' needs and assistance that sustains engagement (Roorda et al., 2011; Ryan & Deci, 2020). For reading development, perceived support may help students persist with challenging texts and remain engaged when difficulties arise (Li et al., 2025; Lyu & Hu, 2025). Large-scale findings similarly link perceived instructional support to engagement and achievement (OECD, 2019c).

Teacher enthusiasm can be understood as a motivational signal within the classroom. Although the curriculum does not frame motivation as a separate construct, its emphasis on guided participation implies that teachers should sustain students' engagement in learning processes (MEB, 2006). Empirical studies associate expressed teacher enthusiasm with students' interest, motivation, and engagement (Keller et al., 2014; Lazarides et al., 2019). In reading, motivational conditions matter because achievement is shaped by persistence, time-on-task, and willingness to engage with demanding texts (OECD, 2021; Schiefele et al., 2012). International research also links enthusiasm to engagement and indirectly to achievement outcomes (Keller et al., 2014; Kunter et al., 2011).

The curriculum also provides guidance on cultivating reading habits and encouraging reading engagement (MEB, 2006). These statements correspond to teacher *stimulation of reading engagement* as a teacher-related indicator, representing teacher-mediated efforts to promote meaningful engagement with texts (Guthrie & Klauda, 2014), conditions linked to reading development through more frequent reading practices (OECD, 2021) and stronger reading motivation and competence (Schiefele et al., 2012). International and Türkiye-focused studies report positive associations between reading engagement and reading achievement (OECD, 2019c; Yıldız & Akyol, 2011).

In sum, these six variables provide curriculum-aligned and literature-supported indicators for examining student-perceived teacher-related classroom ecology. The literature suggests that teacher-related classroom conditions may be associated with reading achievement, although the strength and direction of these associations may vary by context, implementation, and model specification. Therefore, rather than assuming a uniform

effect of teacher-related classroom ecology, this study examines the direction and relative strength of the associations for each variable, as well as the explanatory contribution of the teacher-related classroom ecology variable block within a multilevel framework.

Method

This study employed a quantitative, correlational secondary-data design based on the PISA 2018 Türkiye student dataset. The design was appropriate because the study aimed to examine associations between student-perceived teacher-related classroom ecology variables and reading achievement rather than to make causal claims. Since students in PISA are nested within schools, a two-level random-intercept multilevel modeling approach was adopted to account for the clustered data structure and to estimate student-level associations while controlling for between-school variation.

Data and Sample

The analytic sample consisted of 6,890 students from Türkiye's nationally representative PISA 2018 sample. The school identifier (CNTSCHID) was used as the clustering variable. Reading achievement was measured through PV1READ–PV10READ, which represent multiple plausible estimates of students' latent reading proficiency and allow measurement uncertainty to be incorporated into the analysis (OECD, 2018b).

Measures

Reading achievement

Reading achievement was operationalized using the PISA 2018 reading plausible values. Because PISA reports proficiency through plausible values rather than a single observed score, all ten reading plausible values were used: PV1READ- PV10READ. Models were estimated separately for each plausible value and then pooled to incorporate measurement uncertainty in reading achievement into the final estimates (Aparicio et al., 2021, 2022).

Student-perceived teacher-related classroom ecology variables

Student-perceived teacher-related classroom ecology variables were selected from the PISA 2018 student questionnaire in line with the study's focus on teacher-related classroom ecology. Six student-reported teacher-related classroom ecology variables were included: adaptive instruction, teacher-directed instruction, teacher feedback, teacher support, teacher enthusiasm, and teacher stimulation of reading engagement. All constructs were operationalized as multi-item composites. Items were inspected for coding direction and missingness; when necessary, items were reverse-coded before imputation so that higher scores consistently represented higher levels of the intended construct. Composite scores were calculated within each imputed dataset by averaging relevant item responses. Reliability was assessed after imputation using Cronbach's alpha across the 20 imputed datasets (Demir, 2020).

Table 1. Summary of Study Variables, PISA 2018 Sources, and Model Roles

Variable	PISA source	Measurement source	Scoring / model role
Reading achievement	PV1READ–PV10READ	Cognitive test	Ten PVs pooled; DV
Adaptive instruction	ST212Q01HA–ST212Q03HA	Student questionnaire	Composite; α = .755; IV
Teacher-directed instruction	ST102Q01TA–ST102Q04TA	Student questionnaire	Reverse-coded composite; α = .795; IV
Teacher feedback	ST104Q02NA–ST104Q04NA	Student questionnaire	Composite; α = .853; IV
Teacher support	ST100Q01TA–ST100Q04TA	Student questionnaire	Reverse-coded composite; α = .853; IV
Teacher enthusiasm	ST213Q01HA–ST213Q04HA	Student questionnaire	Composite; α = .913; IV
Teacher stimulation of reading engagement	ST152Q05IA–ST152Q08IA	Student questionnaire	Composite; α = .858; IV

Note. PV = plausible value; DV = dependent variable; IV = independent variable. All teacher-related classroom ecology variables were derived from the PISA 2018 student questionnaire and represent student-perceived indicators. Reliability coefficients represent mean Cronbach's alpha values across the 20 imputed datasets.

Table 1 summarizes the outcome variable and the student-perceived teacher-related classroom ecology variables, including their PISA 2018 sources, measurement sources, scoring procedures, reliability estimates, and roles in the multilevel model.

For all teacher-related classroom ecology variables, composite scores were calculated by averaging the relevant item responses within each imputed dataset. Reverse coding was applied before imputation where necessary so that higher scores consistently represented higher levels of the intended construct.

Data Analysis

All analyses were conducted in R using the *haven* (Chang, 2018), *dplyr* (Chang, 2018), *mice* (Buuren & Groothuis-Oudshoorn, 2011), *psych* (Revelle, 2015), *lme4* (De Boeck et al., 2011), and *MuMIn* (Barton & Barton, 2015) packages. The analytic workflow included data preparation, missing-data diagnostics, reverse coding, multiple imputation, reliability estimation, assumption checks, multilevel hierarchical linear modeling, model comparison, and pattern-mixture sensitivity analysis (Hox et al., 2017; Snijders & Bosker, 2012). Because PISA uses plausible values to represent student proficiency, all models were estimated separately for PV1READ–PV10READ and then pooled (Aparicio et al., 2021).

Data preparation

The original PISA 2018 Türkiye dataset was inspected to verify the availability of the variables required for analysis: the student identifier (CNTSTUID), school identifier (CNTSCHID), ten reading plausible values (PV1READ–PV10READ), and teacher-related questionnaire items used to construct the six independent variables. The final analytic sample included 6,890 students. Since the study focused on associations between teacher-related classroom ecology variables and reading achievement in Türkiye, only variables directly relevant to the research questions were retained.

Missing-data diagnostics

Before imputation, missingness was examined at the item, construct, and case levels (Little, 2024). Item-level diagnostics assessed missing responses for each teacher-related item; construct-level diagnostics identified partial or complete nonresponse within each item block; and case-level diagnostics examined broader missing-data patterns across teacher-related variables. These diagnostics indicated modest item-level missingness and some complete item-block nonresponse, supporting the use of multiple imputation.

Multiple imputation

Missing responses to teacher-related questionnaire items were handled through multiple imputation by chained equations with predictive mean matching (Chen & Xu, 2024). Predictive mean matching was selected because it preserves observed response distributions and reduces the risk of implausible values for ordinal-type questionnaire items (Austin & van Buuren, 2025). Twenty imputed datasets were generated. The imputation model included teacher-related item variables and auxiliary information derived from reading achievement. After imputation, all required variables were retained, including CNTSTUID, CNTSCHID, the ten reading plausible values, and all teacher-related items. Post-imputation diagnostics confirmed zero missingness in the required variables and the six composite variables.

Reliability

Internal consistency was assessed after imputation by computing Cronbach's alpha for each teacher-related composite across the 20 imputed datasets and summarizing the mean estimates (Demir, 2020). Mean alpha values indicated acceptable to excellent reliability: adaptive instruction (.755), teacher-directed instruction (.795), teacher feedback (.853), teacher support (.853), teacher enthusiasm (.913), and teacher stimulation of reading engagement (.858).

Assumption checks

Assumption checks were conducted before interpreting the multilevel models. Multicollinearity was examined using variance inflation factors (VIF), with values ranging from 1.52 to 1.80, indicating no problematic multicollinearity (Hox et al., 2017). Model convergence was achieved for all imputed datasets, and no singular fit issues were detected (Bates et al., 2015). Linearity was assessed through scatterplots with linear and LOESS smoothing lines, which indicated approximately linear relationships between predictors and reading achievement (Hair et al., 2019). Residual diagnostics included Q–Q plots, histograms, and residuals-versus-fitted plots. Although Shapiro–Wilk tests were significant in some imputations, graphical inspections were prioritized because formal normality tests are highly sensitive in large samples (Field, 2009; Fox, 2016). Breusch–Pagan tests indicated heteroscedasticity; however, given the large sample size and multilevel framework, this was not considered to substantially bias fixed-effect estimates (Hox et al., 2017; Snijders & Bosker, 2012). The null model ICC was .571, indicating that 57.1% of the variance in reading achievement was attributable to between-school differences and supporting the use of two-level hierarchical linear modeling (Dong et al., 2016; Hox et al., 2017).

Multilevel hierarchical linear modeling

Because students were nested within schools, two-level random-intercept hierarchical linear models were estimated, with students at Level 1 and schools at Level 2. CNTSCHID was used as the clustering variable. The null model included only the random intercept to partition reading achievement variance into within-school and between-school components (Hox et al., 2017; OECD, 2018a). The full model included all six teacher-related classroom ecology variables simultaneously: adaptive instruction, teacher-directed instruction, teacher feedback, teacher support, teacher enthusiasm, and teacher stimulation of reading engagement. This allowed estimation of each variable's unique association while controlling for shared variance (Hair et al., 2019). A standardized version of the full model was also estimated to compare effect sizes across predictors.

Model comparison, plausible values, imputation, and weights

Model comparison was based on AIC, BIC, log-likelihood, ICC, marginal R^2, and conditional R^2. The null and full models were compared to determine whether teacher-related classroom ecology variables improved model fit. Marginal R^2 represented variance explained by fixed effects, whereas conditional R^2 represented variance explained by both fixed and random effects (Nakagawa & Schielzeth, 2013).

All models were estimated across the ten reading plausible values. For each plausible value, models were estimated separately across the 20 imputed datasets. Estimates were first pooled across imputations and then combined across plausible values to account for both missing-data and measurement uncertainty (OECD, 2018a; Rubin, 2018). The final student sampling weight (W_FSTUWT) was applied to account for unequal selection probabilities and improve representativeness for the Turkish PISA 2018 student population (OECD, 2018a).

Pattern-mixture sensitivity analysis

A pattern-mixture sensitivity analysis examined whether the main findings were robust to complete item-block nonresponse (Rubin, 2018). For each teacher-related construct, a binary missingness-pattern indicator was created from the original pre-imputation data. These indicators were included in an extended multilevel model with interaction terms between each teacher-related predictor and its corresponding pattern indicator.

This specification tested whether associations between teacher-related classroom ecology variables and reading achievement differed by missing-data patterns. Pattern-mixture modeling is commonly used for sensitivity analysis under potential

violations of the missing at random assumption (Little & Rubin, 2002). The analysis was estimated across the ten plausible values and 20 imputed datasets using the same pooling procedures as the primary model. Since it served as a robustness check, interpretation focused on whether the substantive conclusions remained stable after accounting for missing-data patterns.

Results

The findings are presented in four main steps. First, descriptive statistics are reported to summarize the study variables. Second, the null model is presented to justify the use of multilevel modeling by estimating between-school variance. Third, the full model is used to examine which student-perceived teacher-related classroom ecology variables are significantly associated with reading achievement and to compare the relative strength of these associations. Finally, model comparison and sensitivity analyses are reported to evaluate the explanatory contribution and robustness of the teacher-related classroom ecology variable block.

Descriptive Statistics

Table 2 presents the pooled descriptive statistics for the study variables. The analytic sample included 6,890 students.

Table 2. Descriptive statistics for the study variables

Variable	N	Mean	SD	Range
Reading achievement (PV1READ)	6890	464.00	87.80	175.61–771.51
Adaptive instruction	6890	2.59	0.78	1.00–4.00
Teacher-directed instruction	6890	3.07	0.71	1.00–4.00
Teacher feedback	6890	2.35	0.85	1.00–4.00
Teacher support	6890	3.22	0.76	1.00–4.00
Teacher enthusiasm	6890	2.74	0.81	1.00–4.00
Teacher stimulation of reading engagement	6890	2.59	0.78	1.00–4.00

Note. Descriptive statistics were pooled across 20 imputed datasets. Reading achievement is represented by PV1READ for descriptive purposes.

For descriptive purposes, reading achievement was represented by PV1READ, with a pooled mean of 464.00 (SD = 87.80). Among teacher-related classroom ecology variables, teacher support had the highest mean (M = 3.22, SD = 0.76), whereas teacher feedback had the lowest mean (M = 2.35, SD = 0.85). Overall, the variables showed sufficient variability for multilevel modeling.

Multilevel Modeling Overview

A series of two-level random-intercept hierarchical linear models was estimated with students nested within schools (CNTSCHID). The null model partitioned reading achievement variance into within- and between-school components, while the full model included adaptive instruction, teacher-directed instruction, teacher feedback, teacher support, teacher enthusiasm, and teacher stimulation of reading engagement simultaneously. A pattern-mixture sensitivity model was then estimated to assess robustness to complete item-block nonresponse. All models were estimated across the 10 reading plausible values (PV1READ–PV10READ), pooled across 20 imputed datasets within each plausible value, and combined across plausible values. In the final model, both unstandardized coefficients (B) and fully standardized coefficients (β) are reported.

Null model and between-school variance

The null model was estimated to determine how much variation in reading achievement was located between schools. The pooled ICC was .571, indicating that 57.1% of the variance was attributable to between-school differences and supporting the use of multilevel modeling. The null model yielded AIC = 76240.0, BIC = 76261.0, and logLik = -38117.0.

Associations between teacher-related classroom ecology variables and reading achievement

To address the first research question, the full multilevel model included all six teacher-related classroom ecology variables simultaneously. The model showed that five of the six variables were signifi-

cantly associated with reading achievement. Adaptive instruction, teacher support, and teacher stimulation of reading engagement were positively associated with reading achievement, whereas teacher-directed instruction and teacher feedback showed negative associations. Teacher enthusiasm was not statistically significant in the full model. Adaptive instruction was significantly and positively associated with reading achievement (B = 6.12, SE = 1.33, z = 4.60, p < .001, β = .055). Teacher-directed instruction showed a significant negative association (B = -5.31, SE = 1.42, z = -3.73, p < .001, β = -.043). Teacher feedback was also significantly and negatively associated with reading achievement (B = -3.64, SE = 1.19, z = -3.06, p = .002, β = -.036). Teacher support showed a significant positive association (B = 3.29, SE = 1.37, z = 2.40, p = .016, β = .029). Teacher enthusiasm was not significant (B = 0.79, SE = 1.16, z = 0.68, p = .496, β = .007). Teacher stimulation of reading engagement was significantly and positively associated with reading achievement (B = 4.07, SE = 1.37, z = 2.97, p = .003, β = .036).

Relative strength of associations

To address the second research question, standardized coefficients were compared to evaluate the relative strength of the associations. Among positively associated variables, adaptive instruction had the largest standardized coefficient, followed by teacher stimulation of reading engagement and teacher support. Among negatively associated variables, teacher-directed instruction had the largest absolute standardized coefficient, followed by teacher feedback. Overall, the findings show that teacher-related classroom ecology variables were differentially associated with reading achievement within a single multilevel framework. Table 3 presents the pooled fixed-effect estimates for the full multilevel model.

Table 3. Multilevel hierarchical linear model results for teacher-related classroom ecology variables and reading achievement

Predictor	B	SE	z	p	95% CI	β
Adaptive instruction	6.12	1.33	4.60	< .001	[3.52, 8.73]	.055
Teacher-directed instruction	-5.31	1.42	-3.73	< .001	[-8.10, -2.52]	-.043
Teacher feedback	-3.64	1.19	-3.06	.002	[-5.98, -1.31]	-.036
Teacher support	3.29	1.37	2.40	.016	[0.61, 5.97]	.029
Teacher enthusiasm	0.79	1.16	0.68	.496	[-1.48, 3.06]	.007
Teacher stimulation of reading engagement	4.07	1.37	2.97	.003	[1.38, 6.76]	.036

Note. B = pooled unstandardized fixed-effect coefficient; SE = standard error; β = pooled fully standardized coefficient. All six variables were entered simultaneously in the same two-level random-intercept model.

Model fit and explanatory contribution

To address the third research question, model comparison results are presented in Table 4. Compared with the null model, the full model showed improved fit, with lower AIC (ΔAIC = -63.30) and BIC (ΔBIC = -22.30) values and a higher log-likelihood (ΔlogLik = 37.70). The marginal R^2 increased by .005, indicating that the teacher-related classroom ecology variable block improved overall model fit, although the added fixed-effect variance remained limited.

Table 4. Model comparison statistics

Comparison	ΔAIC	ΔBIC	Δlog-Lik	ΔR^2 (marginal)	ΔR^2 (conditional)
Full model vs. null model	-63.30	-22.30	37.70	.00520	.00322
Pattern-mixture full model vs. full model	-9.63	72.40	16.80	.00236	.00037

Note. Negative ΔAIC and ΔBIC values indicate better fit for the more complex model when compared with the reference model.

The pattern-mixture full model showed a lower AIC than the main full model (ΔAIC = -9.63) and a higher log-likelihood (ΔlogLik = 16.80), but a higher BIC (ΔBIC = 72.40), reflecting the added complexity of the pattern indicators and interaction terms. Marginal R^2 increased by .002, while conditional R^2 changed only minimally. Overall, the sensitivity

specification did not materially alter the general pattern of findings.

Sensitivity analysis for missing-data patterns

A pattern-mixture sensitivity analysis evaluated whether the main full-model findings were robust to complete item-block nonresponse patterns. None of the interaction terms between teacher-related classroom ecology variables and their corresponding missing-data indicators reached statistical significance. The interactions for adaptive instruction, teacher-directed instruction, teacher enthusiasm, teacher feedback, teacher support, and teacher stimulation of reading engagement were all non-significant (all ps ≥ .669). Thus, predictor slopes did not differ meaningfully by modeled missing-data patterns, indicating that the primary full-model results were robust to this sensitivity analysis.

Table 5. Pattern-mixture interaction effects

Interaction term	B	SE	z	p	95% CI
AI × AI_PM	-2.31	18.80	-0.12	.902	[-39.2, 34.6]
TDI × TDI_PM	0.70	19.40	0.04	.971	[-37.2, 38.7]
TE × TE_PM	2.89	17.10	0.17	.866	[-30.6, 36.4]
TF × TF_PM	6.18	15.20	0.41	.684	[-23.6, 35.9]
TS × TS_PM	-0.29	17.70	-0.02	.987	[-35.1, 34.5]
TSoRE × TSoRE_PM	-7.77	18.20	-0.43	.669	[-43.4, 27.8]

Note. PM = complete item-block nonresponse indicator for the corresponding construct. None of the interaction terms were statistically significant.

Overall, the results indicate a modest but stable pattern of differentiated associations between student-perceived teacher-related classroom conditions and reading achievement. These associations are interpreted in the following section.

Discussion

The findings reveal a differentiated pattern of associations between student-perceived teacher-related classroom ecology variables and reading achievement. Adaptive instruction, teacher support, and teacher stimulation of reading engagement were positively related to achievement, whereas teacher-directed instruction and teacher feedback were negatively related; teacher enthusiasm showed no significant unique association. This pattern suggests that teacher-related classroom ecology should not be interpreted as a uniform instructional factor. Rather, its relevance for reading achievement depends on the specific instructional, relational, and motivational dimension considered. This interpretation is consistent with the PISA 2018 reading framework, which emphasizes understanding, evaluating, reflecting on, and engaging with texts across diverse contexts (Mo, 2019; OECD, 2019a).

A first important finding was the positive association between adaptive instruction and reading achievement. This result is theoretically coherent because adaptive teaching responds to variation in students' readiness, needs, and learning profiles rather than relying on a uniform instructional model (Langelaan et al., 2024; Smale-Jacobse et al., 2019). However, this association should be interpreted cautiously. Prior research suggests that differentiated instruction can have positive effects, but its effectiveness depends on implementation quality, teacher expertise, and meaningful alignment with students' learning needs (Langelaan et al., 2024; Smale-Jacobse et al., 2019). Therefore, the positive coefficient should not be read as evidence of a direct causal effect. A plausible interpretation is that students who experience instruction as responsive to learner differences tend to show higher reading achievement because such instruction may better support reading tasks requiring interpretation, integration, and evaluation across texts (Hu & Wang, 2022; OECD, 2019a).

Teacher support was also positively associated with reading achievement. This finding is consistent with research showing that supportive teacher–student relationships are linked to academic outcomes through motivational and affective processes. Meta-analytic evidence indicates that teacher support is associated with student engagement and achievement (Tao et al., 2022), and

reading-specific research suggests links with reading enjoyment, reading self-concept, and reading literacy (Ma et al., 2021). Supportive teachers may help students feel more secure, confident, and willing to persist when reading tasks are cognitively demanding. However, this relationship should not be understood as purely direct; teacher support may operate through engagement, enjoyment, and self-concept rather than through a simple linear pathway to achievement (Ma et al., 2021; Tao et al., 2022).

Teacher stimulation of reading engagement was also positively associated with reading achievement. Students who perceived their teachers as encouraging interest, participation, and engagement in reading-related activities tended to achieve higher reading scores. This result is consistent with recent PISA 2018-based evidence showing that teacher stimulation for reading engagement can function as an autonomy-supportive practice and may be positively linked to reading performance (Author, 2026). From a self-determination perspective, such stimulation may support autonomy and relevance by encouraging interpretation, discussion, and personal connection with texts (Ryan & Deci, 2020). Thus, reading achievement appears more favorably associated with classroom practices that invite meaningful engagement with texts rather than treating reading only as a performance task.

By contrast, teacher-directed instruction was negatively associated with reading achievement. One possible explanation is that highly teacher-controlled environments may be less compatible with the reading processes emphasized in PISA, especially when students are expected to compare sources, generate inferences, evaluate credibility, and construct meaning with autonomy (Mo, 2019; OECD, 2019a). This interpretation is consistent with PISA-based evidence showing that perceived teacher-directed instruction may be negatively associated with digital reading performance when modeled alongside other instructional dimensions (Hu & Wang, 2022). However, this result should not be simplified as evidence that teacher direction is inherently ineffective. Directive teaching may be used more often in classrooms serving lower-performing students, meaning that the negative coefficient may partly reflect a compensatory instructional response rather than the effect of teacher direction itself.

The negative coefficient for teacher feedback also requires careful interpretation. The broader feedback literature does not suggest that feedback is generally harmful. Meta-analytic evidence shows that feedback can positively affect learning, although its effectiveness depends on content, specificity, timing, and informational value (Wisniewski et al., 2020). However, reading-focused large-scale assessment studies present a more complex picture, reporting weak, heterogeneous, or negative associations between feedback and reading achievement depending on modeling strategy, level of analysis, and educational context (Hu & Wang, 2022; Munk et al., 2024). In addition, feedback may influence achievement indirectly through reading self-concept, enjoyment, or engagement rather than only through a direct pathway (Ma et al., 2022, 2024). Therefore, the negative association observed here should not be read as evidence against feedback itself. It may indicate that feedback is more common among struggling students, is experienced as corrective or controlling, or operates through motivational processes not fully captured by direct regression coefficients.

Teacher enthusiasm was the only teacher-related classroom ecology variable that was not significantly associated with reading achievement in the full model. This does not mean that enthusiasm is educationally unimportant. Rather, it suggests that enthusiasm may not make a unique direct contribution to standardized reading achievement once other teacher-related variables are considered. Prior work describes teacher enthusiasm as a complex construct whose relation to student outcomes may depend on how it is perceived, whether it is connected to meaningful instructional design, and whether it translates into student engagement (Keller et al., 2016). In this model, enthusiasm may overlap with teacher stimulation of

reading engagement and teacher support, reducing its unique association with reading achievement.

Taken together, the findings distinguish responsive, supportive, engagement-oriented, directive, and evaluative dimensions of teaching. Positive associations for adaptive instruction, teacher support, and teacher stimulation of reading engagement suggest that reading achievement is more favorably linked to classrooms perceived as responsive, relationally supportive, and motivationally engaging. Negative associations for teacher-directed instruction and teacher feedback suggest that directive or corrective experiences may relate to reading achievement in conditional and context-dependent ways. Therefore, the findings do not justify causal claims or simplistic conclusions that teacher direction is ineffective or feedback is harmful. A more defensible interpretation is that PISA reading achievement in Türkiye appears more closely aligned with teaching perceived as adaptive, supportive, and engagement-oriented, whereas the roles of teacher direction and feedback depend on context, implementation, and mediating student processes.

Conclusion

This study examined the associations between six student-perceived teacher-related classroom ecology variables and reading achievement among 15-year-old students in Türkiye using PISA 2018 data. In relation to the first research question, the findings showed that five of the six variables were significantly associated with reading achievement. Adaptive instruction, teacher support, and teacher stimulation of reading engagement were positively associated with reading achievement, whereas teacher-directed instruction and teacher feedback showed negative associations. Teacher enthusiasm was not statistically significant when the other variables were considered.

Regarding the relative strength of these associations, adaptive instruction had the strongest positive association, followed by teacher stimulation of reading engagement and teacher support. Among the negatively associated variables, teacher-directed instruction had the largest absolute standardized coefficient, followed by teacher feedback. This pattern indicates that reading achievement in Türkiye's PISA 2018 context is more closely aligned with classroom conditions perceived as adaptive, supportive, and engagement-oriented, while directive and feedback-oriented practices require careful contextual interpretation.

Model comparison results showed that the teacher-related classroom ecology variable block improved overall model fit; however, the increase in marginal R^2 was modest. Thus, these variables contribute to explaining reading achievement, but they do not account for the substantial between-school variation observed in the data. The pattern-mixture sensitivity analysis further indicated that the main findings were robust to modeled missing-data patterns.

Overall, the results should be interpreted as conditional associations rather than causal effects. Since the study is based on cross-sectional PISA data, it cannot determine whether teacher-related classroom ecology variables affect reading achievement, whether achievement shapes students' perceptions of teaching, or whether these relationships are reciprocal. Nevertheless, the study contributes to the literature by showing that student-perceived teacher-related classroom ecology variables have differentiated associations with reading achievement in the Türkiye PISA 2018 context.

Limitations

Several limitations should be considered when interpreting the findings. First, the study is based on cross-sectional PISA data; therefore, the reported relationships should be interpreted as associational rather than causal (Fraenkel et al., 2012). Although several teacher-related variables were significantly associated with reading achievement, the direction of these relationships cannot be determined.

Second, the teacher-related variables are based on students' perceptions of classroom experiences. These measures are valuable because they reflect learners' experiences, yet they may not fully correspond to teachers' actual classroom practices. Students may interpret the same instructional behavior differently depending on their motivation, prior achievement, classroom climate, or expectations about teaching.

Third, some constructs included in the analysis are broad and may represent heterogeneous classroom practices (OECD, 2019a). This is particularly relevant for teacher feedback and teacher-directed instruction. The findings capture overall patterns through large-scale survey indicators but do not distinguish between different forms, purposes, or qualities of these practices. Therefore, the negative coefficients for these variables should be interpreted with caution.

Finally, teacher enthusiasm was not significantly associated with reading achievement in the full model. This finding should not be taken as evidence that enthusiasm is unimportant. Its effects may be indirect, context-dependent, or more closely related to motivational and affective outcomes than to standardized reading achievement.

Future Research

Future research should examine these relationships through longitudinal designs to clarify temporal ordering and directionality (Caruana et al., 2015). Such designs would help determine whether teacher-related variables shape reading achievement over time, whether achievement influences students' perceptions of instruction, or whether these relationships are reciprocal.

Further studies should also investigate the mechanisms linking teacher-related classroom experiences to reading achievement. Future models could include mediating variables such as reading motivation, reading enjoyment, reading self-concept, engagement, and self-efficacy (Li et al., 2025; Ma et al., 2021). This would provide a more detailed explanation of how classroom experiences may translate into reading outcomes.

Another important direction is to examine variation within broad instructional constructs. Teacher feedback could be differentiated by quality, specificity, timing, emotional tone, and purpose (Wisniewski et al., 2020). Similarly, teacher-directed instruction could be examined in terms of when it provides helpful structure and when it may limit student autonomy and deeper engagement with texts (Cheon et al., 2020). Such distinctions would support a more precise interpretation of the negative associations observed in this study.

Future studies may also explore whether these relationships vary across student and school contexts, including gender, socioeconomic status, migration background, school climate, classroom disciplinary conditions, and regional educational contexts (OECD, 2019a). Finally, research could broaden the range of outcomes examined by investigating whether some teacher-related variables are more strongly associated with reading enjoyment, attitudes, engagement, and academic confidence than with achievement scores alone.

Implications

The findings carry several implications for educational practice. Most importantly, reading achievement appears to be more favorably associated with instruction that is responsive to student differences, supportive of learning, and capable of stimulating engagement with reading (Author, 2026). This highlights the importance of instructional flexibility, supportive teacher–student relationships, and engagement-oriented reading practices.

For teacher education and professional development, the findings suggest a stronger emphasis on helping teachers adapt instruction to diverse learner needs. This includes recognizing differences in students' readiness, providing appropriate challenge, and creating opportunities for text engagement aligned with learners' profiles (Langelaan et al., 2024; Smale-Jacobse et al., 2019). Teacher education programs may also benefit from developing candidates' self-efficacy in using

informational reading strategies, given the growing importance of complex informational texts in academic and digital environments (Author, 2025).

The results also suggest that teacher support should not be viewed only as a relational or emotional classroom feature. Supportive teacher behavior may help create academic conditions in which students are more willing to persist, seek help, and remain engaged in reading tasks (Ma et al., 2021). Therefore, supportive interaction should be considered an important component of effective reading instruction.

At the same time, the negative associations found for teacher-directed instruction and teacher feedback should not be interpreted as evidence that guidance or feedback should be reduced. Rather, these practices should be reconsidered in terms of how they are enacted and experienced (Wisniewski et al., 2020). Teachers may need to balance structure with student autonomy and focus on the quality and function of feedback rather than its frequency alone (Cheon et al., 2020).

More broadly, efforts to improve reading achievement should move beyond general calls for better teaching and focus on specific dimensions of instructional practice. The findings indicate that teacher-related classroom ecology variables do not operate uniformly and that some aspects of teaching may be more closely aligned with reading performance than others. This points to the value of a differentiated approach to instructional improvement in both policy and practice.

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Ethical Approval: Ethical committee approval was not required for this study because This study is based on secondary analysis of the anonymized PISA 2018 Türkiye dataset. No primary data were collected, no intervention was conducted, and there was no direct interaction with participants. Therefore, ethics committee approval was not required..

Data Availability: The data that support the findings of this study are openly available in PISA 2018 Database at https://www.oecd.org/en/data/datasets/pisa-2018-database.html#data.

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