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RESEARCH ARTICLE

The impact of teacher-student power structure on classroom psychological environment an educational big data perspective

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ABSTRACT

This research aimed to investigate the effects of power arrangements on psychological environments in the classroom by analyzing big data in 156 classrooms and 4,680 students in 28 Malaysian secondary schools. Using K-means clustering, four typologies of power arrangements: Democratic-Supportive, Authoritarian-Directive, Moderate-Collaborative, and Laissez-faire, were found. MANOVA revealed significant typology effects across all psychological environment dimensions, with effect sizes ranging from small to large (η^2 = 0.07 to 0.54). Democratic-Supportive typologies demonstrated superior outcomes, particularly in student autonomy ($F = 58.35$, $p < 0.001$, $\eta^2 = 0.54$). Psychological adaptation acted as a significant mediator for power arrangements: $\beta = 0.35$ for Democratic-Supportive typologies and $\beta = 0.22$ for Moderate-Collaborative typologies but not for Authoritarian-Directive typologies. Behavioral measures accounted for 6% to 16% additional variance beyond self-reports, supporting multi-source approaches in education literature. This study makes three key contributions: it advances a novel empirically-derived typology of teacher-student power structures based on objective behavioral data, provides evidence linking specific power structure types to distinct classroom psychological outcomes, and demonstrates the incremental validity of big data analytics over traditional self-report measures in educational psychology research.

Keywords: Teacher-student power structure; Classroom psychological environment; Educational big data; Psychological adaptation; Behavioral data analytics

1. Introduction

Teacher-student power dynamics have emerged as a critical area in contemporary educational research. As education shifts from traditional authoritarian approaches to more democratic practices, understanding these power relationships becomes increasingly important. Research demonstrates that power dynamics significantly affect student engagement, performance, and psychological adaptation[1]. Specifically, how power is distributed in decision-making, communication, and evaluation processes influences students' sense of autonomy, relatedness, and security. Studies show that instructional behaviors supporting student competence and relatedness enhance classroom engagement[2]. Teacher care practices, which inherently involve power elements, reciprocally shape how students perceive their relationships with teachers[3].

The emergence of big data in education offers new opportunities to study power relationships with

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greater objectivity. Advanced algorithms can now process vast amounts of data from interactive educational technologies that traditional observation methods cannot capture[4]. Big data enables researchers to measure abstract relational concepts with empirical precision, including teaching practices, participation patterns, and evaluation processes[5]. Recent literature emphasizes that classroom psychological environments are profoundly shaped by authority structures, which manifest concretely in seating arrangements, discourse patterns, and instructional practices[6].

Despite these developments, much is still unknown about relationships involving power between a teacher and his or her students that affect classroom psychological environments. Existing research predominantly relies on self-report questionnaires and subjective perceptions, which are susceptible to social desirability bias and may not capture the nuanced reality of power interactions in authentic classroom settings[7]. This limitation is particularly pronounced in classroom power studies, where social desirability may lead to overreporting of positive interactions and underreporting of controlling behaviors. Although scholars have theorized various power structure models, including democratic, authoritarian, and laissez-faire styles, there remains a lack of empirically-derived typologies based on objective behavioral indicators[8]. Most studies examine power as a unidimensional construct rather than identifying distinct patterns that naturally occur in educational contexts, creating a significant typology gap for educators and researchers who lack clear, data-driven classification systems.

The mechanisms through which power structures influence classroom psychological environments also remain underexplored. The mediating role of students' psychological adaptation in this relationship has received limited attention[9], hindering our understanding of the underlying psychological processes through which power dynamics shape learning environments. Moreover, the potential of educational big data in illuminating classroom power dynamics has been largely untapped. While big data analytics has revolutionized other educational research domains such as learning outcomes prediction and student engagement analysis[4], its application to examining teacher-student power structures and psychological environments is still in its infancy. Recent methodological advances in big data analytics[10-12] have demonstrated the value of objective behavioral data in understanding complex social phenomena, yet remain underutilized in classroom power research.

To address these gaps, the current study adopts an integrated educational big data approach to examine teacher-student power structures and their effects on classroom psychological environments. We develop an empirically-grounded typology of power structures using objective behavioral indicators derived from multiple data sources, including learning management system logs, classroom observation records, and social network analysis. This data-driven approach moves beyond traditional self-report measures to capture actual patterns of power distribution in authentic classroom settings. We systematically examine how different power structure types differentially impact multiple dimensions of classroom psychological environment, including student autonomy, teacher support, academic press, and relationship quality. Additionally, we investigate the mediating role of students' psychological adaptation in this relationship, illuminating the psychological mechanisms through which classroom power dynamics shape student outcomes. Through this comprehensive approach combining typology development, outcome assessment, and mechanism investigation, the study bridges methodological, theoretical, and practical gaps in understanding classroom power dynamics, ultimately contributing to both educational psychology theory and evidence-based practice.

2. Literature review

2.1. Teacher-student power structure research

Researchers increasingly recognize power distribution as crucial for classroom interactions and learning. Studies on innovative learning environments reveal that educators face complex decisions about power distribution. Mixed-method studies verify that effective pedagogical practices require strategic, context-specific power sharing[8]. Research on classroom power transformation clarifies how educators and students negotiate authority. Qualitative findings suggest that power emerges through interpersonal interactions rather than structural imposition[13]. Power interactions operate at multiple levels, including decision-making in educational activities, communication patterns, and evaluation responsibilities. However, empirically-derived typologies based on behavioral indicators remain understudied. This gap limits our understanding of how specific power arrangements affect classroom outcomes.

2.2. Classroom psychological environment research

Research emphasizes how classroom psychological elements shape student affective, cognitive, and behavioral engagement. Studies reveal that quality relationships, teaching practices, and organizational culture interconnect to create classroom climate. These elements foster psychological safety essential for effective learning[14]. Supportive environments enhance student autonomy, competence, and relatedness, increasing intrinsic motivation and engagement[15]. Studies demonstrate that classroom psychological environments integrate interpersonal, spatial, and pedagogical dimensions. Understanding how power structures affect these environments requires innovative analytical approaches.

2.3. Educational big data in classroom research

Technological advancements enable unprecedented exploration of educational processes through big data analytics. Integrating big data with active learning enhances students' analytical and critical thinking skills while revealing behavioral patterns inaccessible through traditional assessments[16]. Learning analytics enables real-time performance tracking, early identification of struggling students, and evidence-based instructional adaptation[17]. Despite privacy and analytical challenges, big data offers substantial potential for evidence-based teaching decisions[18]. However, power structures remain unexplored in educational big data research.

2.4. Teacher-student relationship, psychological adaptation, and classroom environment connections

Longitudinal studies reveal the teacher-student relationship's lasting impact on students' social, academic, and behavioral adaptation[19]. Relationship quality serves as a process variable predicting future adaptation outcomes. Cross-cultural research shows that social integration and inclusiveness perceptions moderate students' psychological adaptation during educational transitions[20]. Adaptation depends critically on relationship quality between students and educators. Systemic analyses reveal how psychological and pedagogical factors interact to influence student adaptation in higher education[21]. These analyses highlight that teacher-student relationships extend beyond outcome correlations; they constitute developmental systems enabling students to navigate environments and build psychological resources. However, integrated models examining power structures, relationship quality, adaptation, and perception remain underdeveloped.

2.5. Research framework and hypotheses

This study proposes a framework examining power structures in classroom psychological environments. Power structures encompass decision-making authority, discourse control, and evaluation power, measured through big data indicators. Student psychological adaptation mediates the relationship between power

structures and psychological environments.The proposed research will test four hypotheses. First, there will be typologies of power structures discernible by cluster analyses on behavioral indicators. Second, there will be a link between democratic and more favorable psychological environments than in authoritarian power structures. Third, psychological adaptation will play a role in incorporating both kinds of power structures and psychological environments. Fourth, incremental validity for the prediction of psychological environment outcomes will be shown by behavioral indictors.

3. Methodology

3.1. Research design

The proposed work involves a quantitative design with a cross-sectional focus on combining big data analytics for education with survey research to examine how classroom power constellations affect classroom psychological contexts. Big data architecture is used to translate complex relational concepts into behaviorally manifested variables by using internet-based education platforms.

Data gathering was done across one semester. This design systematically incorporates and makes use of several data sources such as LMS logs, classroom interactions, and valid psychological instruments for triangulating the data and improving construct validity.

3.2. Research participants and sampling

The proposed research uses stratified cluster sampling with geographical stratification conducted on metropolitan, semi-urban, and rural areas, involving 28 secondary schools with 156 classrooms, 156 teachers, and 4,680 students in grades 7-12. School selection is made on a systematic utilization of digital platforms for education, thus involving teachers with varying levels of experience and students with different levels of prowess, all made possible through stratification on different school environments.

Criteria for inclusion include schools using learning management systems, educators consenting to data protocols, and students with guardians signed with informed consents. Criteria for exclusion include schools without technological infrastructure or participation commitment. The proposed research has been approved by Institutional Review Boards (2024-EDU-158) to meet all required criteria concerning minors for education research.

3.3. Educational big data collection

This particular study includes big data education information on multiple platforms. Courses delivered by learning management systems involve automated information on interactions between students and lecturers. Classroom platforms involve information on patterns for discourse practice, sequences for inquiries, and levels for participation with automated timestamping. Teaching management systems clearly illustrate levels for decision-making practices, distribution levels for assessment, and levels for allocation of authority in every classroom.

Supplementing these behavioral data is another source which includes valid psychological instruments for assessing classroom psychological environments, adaptations, and relationships for a one-point measure. These design architectures enable triangulations between objective behavior patterns and subjective experiences. Big data analytics provide insight on interaction behaviors on an unparalleled scale with emphasis on validity for psychological constructs.

3.4. Variables measurement

Core Independent Variable: Teacher-Student Power Structure: The core independent variable is captured by including variables related to authority in decision-making, which is identified by initiation

scores, control over discourses identified through turn-taking and talk ratios, control over evaluation, which is identified by involvement in grading and feedback, and control in interaction networks, which is identified by social networks. These variables are then used for clustering to identify typologies for power structures.

Outcome variables: Classroom Psychological Environment: assessed by means of the Classroom Environment Scale (CES) (Moos & Trickett, 1974, adapted) with five dimensions: psychological safety, Teacher Support, Autonomy, Peer Cohesion, and Academic Press (α = 0.87-0.91); Teach-Student Relationship Quality: evaluated by means of the Student-Teacher Relationship Scale (Pianta, 2001) with closeness and conflict dimensions (α = 0.89).

Mediating Variable—Student Psychological Adaptation: Adaptation was assessed with the Student Adaptation to College Questionnaire (adapted for secondary education; Baker & Siryk, 1984), which tested all four dimensions (academic, social, personal and emotional, and institutional association; Cronbach's alpha = 0.88). Control variables: demographic and achievement variables, teacher experience, and class size.

3.5. Data analysis

Data processing included standardization for behavioral indicators and missing data treatment by means of multiple imputations. Typologies for power structures have been found by hierarchical clustering with Ward's linkage, relying on the four standard indicators, with determination by means of silhouette coefficients.

The typology effects investigated through these analyses are those on dimensions of classroom psychological environment (N = 156 classrooms), with individual student data used to provide reliability estimates for each classroom. Mediation by bootstrapping tested whether psychological adaptation mediated between power structures and environments. Hierarchical regression evaluated big data indicators' incremental validity for dimensions of psychological environments.

Analyses employed SPSS 27.0 for descriptive statistics and clustering, Mplus 8.6 for multilevel modeling and mediation analysis, and R 4.3.0 for hierarchical regression. Statistical significance was established at α = 0.05.

3.6. Validity and reliability

The reliability for each instrument was achieved by conducting internal consistency analyses, which revealed Cronbach Alpha values ranging between 0.87 and 0.91 for all psychological questionnaires. Construct validity for this research was confirmed by demonstrating alignment with theoretical constructs and by using multiple data sources. System errors in the behavior variables were tested for by automated validation. Care was taken to check for indications of inattention on questionnaires, with multiple imputations used to compensate for missing data. The behavioral variables for power structures aligned with perceptions.

4. Results

4.1. Descriptive statistics

Table 1 depicts the demographics. The final pool represented 28 secondary schools located in both urban (35.7%), suburban (39.3%), and rural (25.0%) areas, including a total of 156 classrooms with 4,680 students. Teacher qualifications varied across levels (M = 12.45 years, SD = 7.82), including both young and veteran staff. Also represented were a nearly even split (51.5% male, 48.5% female) with differing levels of academic achievement (GPA M = 3.26, SD = 0.68). Psychological environment and adaptation measures

were aggregated to the classroom level by calculating means across students within each classroom (average within-classroom ICC = 0.24, range: 0.18-0.31), justifying classroom-level analyses.

Table 2 presents descriptive statistics and intercorrelations among study variables. Power structure indicators were standardized ($M \approx 0$, $SD \approx 1$) to facilitate comparability. Psychological environment dimensions exhibited moderate to moderately high ratings ($M = 3.54$ to 3.89), with academic press receiving highest scores. Power indicators demonstrated significant positive intercorrelations ($r = 0.45$ to 0.61, $p < 0.001$). Most power indicators correlated positively with psychological environment dimensions, though academic press showed weaker associations with some power indicators ($r = 0.09$ to 0.18, ns or $p < 0.05$). All scales demonstrated good to excellent internal consistency ($\alpha = 0.87$ to 0.91).

Table 1. Sample characteristics and demographic information.

	Characteristic	N	%	M (SD)
Geographic Distribution	Urban schools	10	35.7	
	Suburban schools	11	39.3	
	Rural schools	7	25.0	
	Total schools	28	100.0	
Participating Units	Classrooms	156		
	Teachers	156		
	Students	4,680		
Grade Distribution (Students)	Grade 7	823	17.6	
	Grade 8	796	17.0	
	Grade 9	761	16.3	
	Grade 10	812	17.3	
	Grade 11	728	15.6	
	Grade 12	760	16.2	
Teacher Characteristics	Teaching experience (years)			12.45 (7.82)
	Novice (< 5 years)	38	24.4	
	Experienced (5-15 years)	72	46.2	
	Veteran (> 15 years)	46	29.5	
Highest degree	Bachelor's	89	57.1	
	Master's	61	39.1	
	Doctoral	6	3.8	
Gender	Male	2,412	51.5	
	Female	2,268	48.5	
	Prior achievement (GPA)			3.26 (0.68)
	Socioeconomic status (proxy)[a]			2.84 (0.92)
Class Size	Students per classroom			30.00 (4.23)
	Range	22-38		

Note: *N = total sample size; % = percentage; M = mean; SD = standard deviation.* [a] *Socioeconomic status proxy measured on 5-point scale (1 = low to 5 = high) based on parental education and school lunch eligibility.*

Table 2. Descriptive statistics and correlations among study variables.

Variable	M	SD	1	2	3	4	5	6	7	8	9	10
Power Structure Indicators												
1. Decision-making authority	0.00	1.00	—									
2. Discourse control	0.02	0.98	0.52***	—								
3. Evaluative power	-0.01	1.01	0.48***	0.45***	—							
4. Network centrality	0.01	0.99	0.58***	0.61***	0.53***	—						
Psychological Environment												
5. Psychological safety	3.68	0.74	0.42***	0.38***	0.35***	0.47***	(0.91)					
6. Teacher support	3.82	0.68	0.39***	0.44***	0.38***	0.45***	0.64***	(0.87)				
7. Student autonomy	3.54	0.79	0.51***	0.46***	0.44***	0.52***	0.58***	0.61***	(0.90)			
8. Peer cohesion	3.71	0.72	0.35***	0.31**	0.29**	0.38***	0.68***	0.72***	0.59***	(0.90)		
9. Academic press	3.89	0.66	0.09	0.15*	0.12	0.18*	0.26**	0.33***	0.24**	0.37***	(0.88)	
Exploratory Variables												
10. Psychological adaptation	3.76	0.71	0.44***	0.41***	0.38***	0.49***	0.67***	0.69***	0.72***	0.65***	0.44***	(0.91)
11. Relationship quality	3.85	0.69	0.37***	0.42***	0.36***	0.43***	0.61***	0.75***	0.63***	0.68***	0.47***	0.71***

Note: *N = 4,680 students nested in 156 classrooms. M = mean; SD = standard deviation. Power structure indicators are standardized (M = 0, SD = 1). Psychological environment, psychological adaptation, and relationship quality measured on 5-point Likert scales (1 = strongly disagree to 5 = strongly agree). Values in parentheses on the diagonal represent Cronbach's alpha coefficients. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.*

4.2. Power structure type identification

K-means cluster analysis identified four distinct power structure types based on the four behavioral indicators. **Table 3** presents the characteristics of each type. One-way ANOVA revealed significant differences among types across all power dimensions ($F = 52.18$, $p < 0.001$). Bonferroni post-hoc tests confirmed distinct profiles for each type.

Table 3. Power structure types and their characteristics.

Type	N	%	Decision-making Authority M (SD)	Discourse Control M (SD)	Evaluative Power M (SD)	Network Centrality M (SD)	F
Type 1: Democratic-Supportive	42	26.9	0.68 (0.71)[a]	0.54 (0.68)[a]	-0.31 (0.63)[b]	0.42 (0.69)[a]	52.18***
Type 2: Authoritarian-Directive	38	24.4	-0.74 (0.66)[c]	-0.59 (0.72)[c]	0.71 (0.64)[a]	0.38 (0.71)[ab]	
Type 3: Moderate-Collaborative	48	30.8	0.35 (0.58)[b]	0.48 (0.61)[ab]	0.22 (0.59)[b]	0.29 (0.65)[ab]	

Type	N	%	Decision-making Authority M (SD)	Discourse Control M (SD)	Evaluative Power M (SD)	Network Centrality M (SD)	F
Type 4: Laissez-faire	28	17.9	-0.42 (0.64)^{bc}	-0.51 (0.69)^{c}	-0.58 (0.61)^{c}	-0.89 (0.67)^{c}	
Total	156	100.0	0.00 (1.00)	0.02 (0.98)	-0.01 (1.01)	0.01 (0.99)	

Note: *N = number of classrooms; % = percentage; M = mean; SD = standard deviation. All power structure indicators are standardized (M = 0, SD = 1). F-values are from one-way ANOVA comparing the four types. Superscripts denote significant differences based on Bonferroni post-hoc tests: means with different superscripts differ significantly at p < 0.05.*** p < 0.001.*

Type 1 (Democratic-Supportive, 26.9%) showed high levels of decision-making authority and control of discourse, moderate levels of network centrality, but lower levels of evaluative power. Type 2 (Authoritarian-Directive, 24.4%) had high levels of evaluative power, moderate levels of network centrality, but lower levels of decision-making authority/discourse control. Type 3 (Moderate-Collaborative, 30.8%), with the largest percentage, had overall moderate-positive levels on each measure, suggesting balanced power distribution. Type 4 (Laissez-faire, 17.9%) had overall negative levels, especially concerning network centrality, suggesting little involvement by the teachers in power matters. The subsequent analyses, exploring type differences on outcome variables, held constant demographics (gender, grade, socioeconomic status) of students, prior academic achievement, teacher experience, and class size.

Figure 1 visualizes these distinct type profiles across the four power dimensions, illustrating clear differentiation patterns while acknowledging within-type variability.

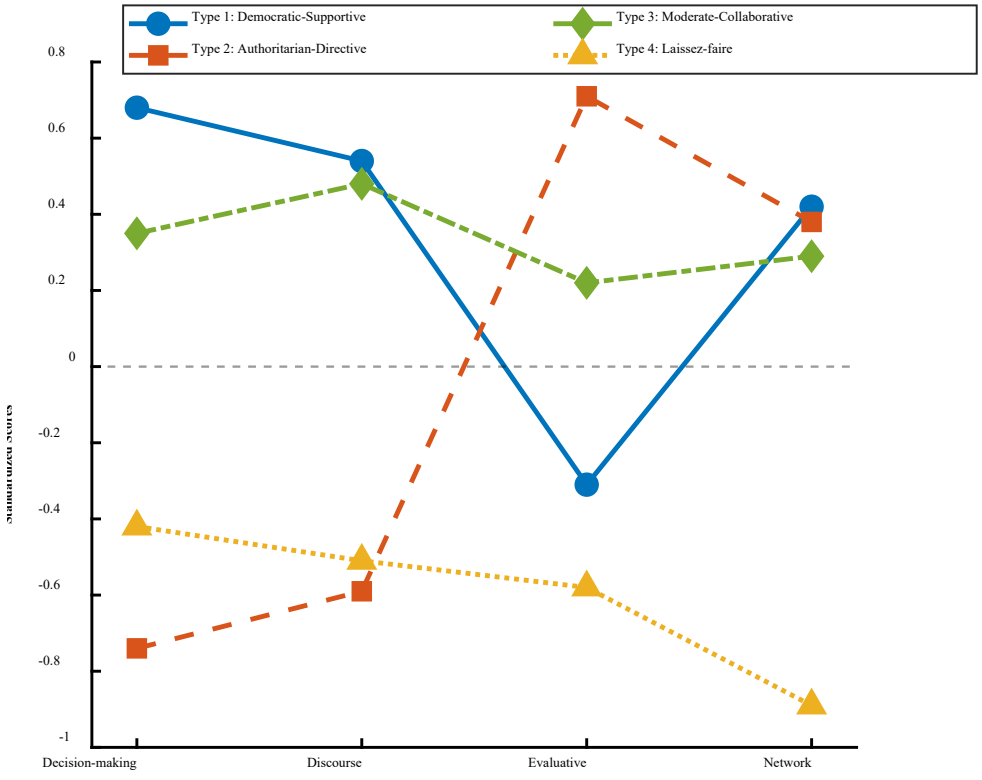

Figure 1. Power structure type profiles across four dimensions.

4.3. Effects of power structure types on psychological environment

Table 4 presents MANOVA results examining power structure type effects on psychological environment dimensions, controlling for student demographics, prior achievement, teacher experience, and class size. Multivariate tests revealed significant overall effects (Wilks' Lambda = 0.468, F = 8.92, p < 0.001,

η^2 = 0.21). Univariate analyses showed significant type effects across all dimensions, though effect sizes varied considerably.

Table 4. Effects of power structure types on psychological environment dimensions.

Dimension	Type 1 M (SD)	Type 2 M (SD)	Type 3 M (SD)	Type 4 M (SD)	F	η^2	Post-hoc
Psychological safety	4.12 (0.58)^{a}	3.28 (0.71)^{c}	3.85 (0.64)^{b}	3.35 (0.68)^{c}	38.62***	0.43	1>3>2,4
Teacher support	4.25 (0.55)^{a}	3.42 (0.68)^{c}	3.98 (0.61)^{b}	3.48 (0.72)^{c}	44.18***	0.47	1>3>2,4
Student autonomy	4.18 (0.62)^{a}	2.89 (0.76)^{c}	3.72 (0.69)^{b}	3.28 (0.71)^{bc}	58.35***	0.54	1>3>4>2
Peer cohesion	3.95 (0.68)^{a}	3.52 (0.74)^{b}	3.88 (0.66)^{ab}	3.42 (0.79)^{b}	12.47***	0.20	1,3>2,4
Academic press	3.82 (0.71)^{ab}	4.08 (0.58)^{a}	3.91 (0.64)^{ab}	3.78 (0.68)^{b}	3.84*	0.07	2>4

Note: *N = 156 classrooms (Type 1: n = 42, Type 2: n = 38, Type 3: n = 48, Type 4: n = 28). M = mean; SD = standard deviation measured on 5-point Likert scales (1 = strongly disagree to 5 = strongly agree). F-values are from one-way ANOVA. η^2 = partial eta squared (effect size). Superscripts (a, b, c) denote significant differences based on Bonferroni post-hoc tests (p < 0.05): means sharing the same superscript do not differ significantly, while means with different superscripts differ significantly at p < 0.05. Post-hoc column uses simplified notation: "1>3>2,4" means Type 1 > Type 3 > Type 2 and Type 4 (where Type 2 and Type 4 do not differ significantly from each other). * p < 0.05. *** p < 0.001.*

Student autonomy demonstrated the strongest differentiation (F = 58.35, p < 0.001, η^2 = 0.54), with Democratic-Supportive classrooms (M = 4.18) significantly exceeding all other types. Teacher support (F = 44.18, p < 0.001, η^2 = 0.47) and psychological safety (F = 38.62, p < 0.001, η^2 = 0.43) also showed substantial type effects, with Democratic-Supportive and Moderate-Collaborative classrooms outperforming Authoritarian-Directive and Laissez-faire types. Peer cohesion exhibited moderate differentiation (F = 12.47, p < 0.001, η^2 = 0.20), while academic press showed the weakest type effects (F = 3.84, p < 0.05, η^2 = 0.07), with only Authoritarian-Directive classrooms significantly exceeding Laissez-faire types.

Figure 2 visualizes these patterns, illustrating consistent superiority of Democratic-Supportive classrooms across most dimensions, contrasted with Authoritarian-Directive classrooms' lower scores in autonomy-related dimensions but comparable performance in academic press.

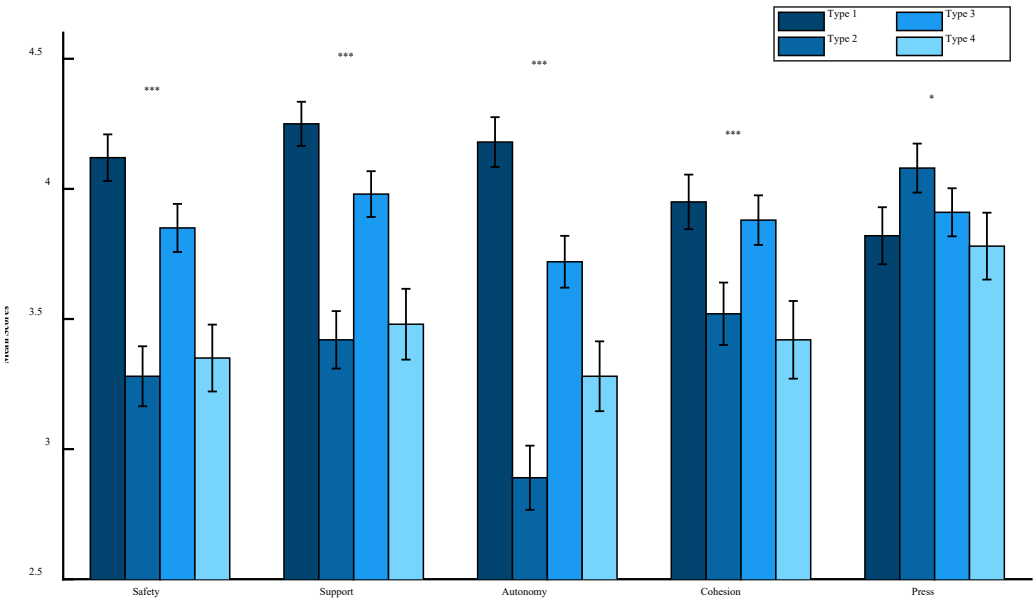

Figure 2. Psychological environment dimensions across power structure types.

4.4. Mediation effects of psychological adaptation

Mediation analyses examined whether psychological adaptation mediated the relationship between power structure types and relationship quality, using Type 4 (Laissez-faire) as the reference group, with models controlling for demographic and classroom covariate. Bootstrap analyses (5,000 samples) revealed differential mediation patterns across type contrasts (**Table 5**).

Table 5. Mediation effects of psychological adaptation on the relationship between power structure types and relationship quality.

Contrast	Path a (Type → Adaptation)β (SE)	Path b (Adaptation → Quality)β (SE)	Path c (Total Effect)β (SE)	Path c' (Direct Effect)β (SE)	Indirect Effecta×b (SE)	Bootstrap 95% CI [LL, UL]	Mediation Type
Type 1 vs. Type 4	0.68 (0.09)***	0.52 (0.06)***	0.71 (0.10)***	0.36(0.09)***	0.35 (0.06)***	[0.24, 0.48]	Partial
Type 2 vs. Type 4	0.14 (0.09)	0.52 (0.06)***	0.18 (0.10)	0.11 (0.09)	0.07 (0.05)	[-0.02, 0.18]	No mediation
Type 3 vs. Type 4	0.42 (0.09)***	0.52 (0.06)***	0.48 (0.10)***	0.26 (0.09)**	0.22 (0.05)***	[0.12, 0.33]	Partial

Note: *N = 156 classrooms. Type 4 (Laissez-faire) serves as the reference group. All models control for student demographics (gender, grade level, socioeconomic status), prior academic achievement, teacher experience, and class size. β = standardized regression coefficient; SE = standard error. Path a represents the effect of power structure type on psychological adaptation. Path b represents the effect of psychological adaptation on relationship quality, controlling for power type. Path c represents the total effect of power type on relationship quality. Path c' represents the direct effect after controlling for psychological adaptation. Indirect effect = a×b. Bootstrap confidence intervals (CI) based on 5,000 bootstrap samples. LL = lower limit; UL = upper limit. Mediation is supported when the 95% CI for the indirect effect does not include zero. ** p < 0.01. *** p < 0.001.*

For Type 1 (Democratic-Supportive) versus Type 4, psychological adaptation exhibited significant partial mediation. The indirect effect was substantial (β = 0.35, 95% CI [0.24, 0.48]), with the total effect (β = 0.71, $p < 0.001$) reduced but remaining significant after controlling for adaptation (direct effect: β = 0.36, $p < 0.001$). Similarly, Type 3 (Moderate-Collaborative) versus Type 4 demonstrated significant partial mediation (indirect effect: β = 0.22, 95% CI [0.12, 0.33]), with the direct effect remaining significant (β = 0.26, $p < 0.01$).

However, Type 2 (Authoritarian-Directive) versus Type 4 showed no significant mediation, as evidenced by a non-significant indirect effect (β = 0.07, 95% CI [-0.02, 0.18]) and weak path from type to adaptation (β = 0.14, ns). The mediator explained substantial variance in relationship quality ($R^2 = 0.64$), representing a 0.22 increase over the model without adaptation ($R^2 = 0.42$).

4.5. Incremental validity of behavioral data

Hierarchical regression analyses assessed whether objective behavioral indicators provided incremental validity beyond self-report measures in predicting psychological environment dimensions. **Table 6** presents results for three key outcomes: psychological safety, student autonomy, and relationship quality.

Table 6. Incremental validity of behavioral data indicators beyond self-report measures.

	Predictor	Psychological Safety		Student Autonomy		Relationship Quality	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Step 1: Self-report measures	Perceived power structure (questionnaire)	0.57 (0.05)***	0.41 (0.06)***	0.62 (0.05)***	0.43 (0.06)***	0.73 (0.04)***	0.61 (0.05)***
Step 2: Behavioral data indicators	Objective power behaviors (platform data)	-	0.36 (0.06)***	-	0.42 (0.06)***	-	0.26 (0.07)***

	Predictor	Psychological Safety		Student Autonomy		Relationship Quality	
Model fit	R^2	0.32***	0.43***	0.38***	0.54***	0.54***	0.60***
	Adjusted R^2	0.31	0.42	0.37	0.53	0.53	0.59
	ΔR^2	-	0.11***	-	0.16***	-	0.06**
	F change	-	28.47***	-	47.82***	-	13.25**

Table 6. (*Continued*)

Note: *N = 156 classrooms. Values are standardized regression coefficients β with standard errors in parentheses. Model 1 includes only self-report questionnaire measures of perceived power structure. Model 2 adds objective behavioral data indicators derived from digital platform interactions (decision-making frequency, discourse contributions, evaluation patterns, network centrality indices). All models control for demographic variables (school type, class size, teacher experience). ΔR^2 represents the incremental variance explained by behavioral data beyond self-report measures. F change tests the significance of ΔR^2. ** p < 0.01. *** p < 0.001.*

Behavioral data demonstrated significant incremental validity across all outcomes, though effect sizes varied. Student autonomy showed the strongest incremental effect ($\Delta R^2 = 0.16$, $F = 47.82$, $p < 0.001$), followed by psychological safety ($\Delta R^2 = 0.11$, $F = 28.47$, $p < 0.001$) and relationship quality ($\Delta R^2 = 0.06$, $F = 13.25$, $p < 0.01$). Notably, self-report measures remained significant predictors after controlling for behavioral data ($\beta = 0.41$ to 0.61, all $p < 0.001$), indicating that both measurement approaches capture unique variance. Behavioral indicators explained an additional 6% to 16% of variance beyond questionnaire measures, supporting the complementary value of multi-source assessment in educational contexts.

5. Discussion

This study explored links between power structures and classroom psychological environments using educational big data. It identified four typologies (Democratic-Supportive, Authoritarian-Directive, Moderate-Collaborative, and Laissez-faire) building on previous research[22,23] through objective behavioral criteria. Democratic-Supportive structures demonstrated superior psychological environment outcomes, consistent with meta-analyses showing that participant-centered relationships enhance educational outcomes[22]. This research specifies mechanisms through which power relationships operate, particularly through psychological adaptation as a mediating pathway. The mediation patterns between power structures warrant attention.

Notably, Authoritarian-Directive classrooms showed non-significant mediation. This finding challenges assumptions about universal psychological processes. It aligns with evidence that teacher-student interaction patterns vary across pedagogical contexts[24]. The non-significant mediation in Authoritarian-Directive settings suggests that power structures may bypass psychological adaptation pathways. Instead, they may operate through alternative mechanisms not captured by this model. Students in highly controlled environments may adapt through different routes[25].

Methodologically, this study demonstrates incremental validity for behavioral data. Objectively gathered indicators explained 6-16% additional variance beyond self-reports, addressing concerns regarding social desirability bias and common method variance[26,27]. This multi-source approach using digital platform interactions provides greater ecological validity than traditional assessments relying on teacher or student perceptions[28]. These findings have implications for educational organizations seeking evidence-based assessment tools for technology-enhanced learning environments[29,30].

Several limitations exist regarding generalizability. The cross-sectional design limits causal interpretations, though prior longitudinal research[31] supports the proposed causal directions. Cultural factors

may moderate observed effects, limiting external validity. The emphasis on quantitative behavioral measures may overlook qualitative aspects of teacher-student interactions. Future research should employ longitudinal designs to examine temporal dynamics and power structure stability across academic years. Cross-cultural comparative studies would identify boundary conditions. Intervention studies could investigate strategies for enhancing psychological environments[29]. Research examining additional mediators, including academic motivation or social-emotional competencies, would advance theoretical understanding.

6. Conclusion

This work moved the literature on power structures in teacher-student relationships one step forward by combining big data analytics in education with psychological variables in 156 classrooms with 4,680 students. Four typologies of empirically-supported power structures were revealed, with Democratic-Supportive styles outperforming on all dimensions of psychological environment ($F = 3.84$-58.35, $p < 0.05$ to $p < 0.001$). Psychological adaptation was found to play a significant role in mediating both Democratic-Supportive (indirect effect $\beta = 0.35$) and Moderate-Collaborative ($\beta = 0.22$) power structures, with no mediation found for Authoritarian-Directive environments. From a methodological perspective, objective behavioral variables accounted for an additional 6% to 16% variance than self-reported psychology variables, which supports multiple source approaches to assessment. These results can thus inform practice in education by providing empirical models to improve power structures in the classroom, while providing sound methodological design for exploring big trace data with traditional psychological variables.

This study focused on developing an empirically-grounded typology of power structures, examining their impacts on psychological environment dimensions, and investigating psychological adaptation as a mediating mechanism. Future research should pursue longitudinal designs to examine long-term effects, cross-cultural studies to test generalizability, and intervention research to establish causal relationships. Integration of artificial intelligence could enable real-time feedback systems, while investigation of interactions with curriculum and peer factors would provide comprehensive understanding of classroom ecosystems.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. G. Di Lisio, A. Milá Roa, A. Halty, A. Berástegui, A. Couso Losada, and C. Pitillas, "Nurturing bonds that empower learning: a systematic review of the significance of teacher-student relationship in education," in *Frontiers in Education*, 2025, vol. 10, p. 1522997: Frontiers Media SA.
2. Y. Shao, Y. Feng, X. Zhao, G. Liu, and L. Zhang, "Teacher support and secondary school students' learning engagement: A moderated mediation model," *Scientific Reports,* vol. 15, no. 1, p. 2974, 2025.
3. Z. Zhang, Y. Wang, W. Deng, X. Ma, and C. Qi, "The impact of teacher care on teacher-student relationship: evidence from cross-sectional and longitudinal data," *Frontiers in Psychology,* vol. 16, p. 1551081, 2025.
4. B. Alshemaimri, A. Badshah, A. Daud, A. Bukhari, R. Alsini, and O. Alghushairy, "Regional computing approach for educational big data," *Scientific Reports,* vol. 15, no. 1, p. 7619, 2025.
5. A. Tawalbeh, M. Allaymoun, E. Alnawafa, and J. Aldoseri, "Harnessing Big Data Analytics: A Comprehensive Approach to Enhancing Student Performance and Curriculum Effectiveness," in *Business Sustainability with Artificial Intelligence (AI): Challenges and Opportunities: Volume 2*: Springer, 2024, pp. 467-477.
6. R. Khany and P. Barzan, "The influence of classroom environment on cognitive and emotional engagement," *Contemporary Educational Journal,* vol. 14, no. 1, pp. 88-105, 2025.
7. M. P. Franco, J. H. Bottiani, and C. P. Bradshaw, "Assessing teachers' culturally responsive classroom practice in PK–12 schools: A systematic review of teacher-, student-, and observer-report measures," *Review of Educational Research,* vol. 94, no. 5, pp. 743-798, 2024.

8. P. Bergström, A. Wiklund Engblom, and M. Lindfors, "Sharing teacher power: exploring teaching practices in innovative learning environments through mixed methods analysis," *Teachers and Teaching,* pp. 1-23, 2025.
9. X. Liu, "Effect of teacher–student relationship on academic engagement: the mediating roles of perceived social support and academic pressure," *Frontiers in Psychology,* vol. 15, p. 1331667, 2024.
10. Z. Fang and S. Wang, "Boosting Financial Market Prediction Accuracy With Deep Learning and Big Data: Introducing the CCL Model," *Journal of Organizational and End User Computing (JOEUC),* vol. 36, no. 1, pp. 1-25, 2024.
11. A. Lawson-Body, A. Illia, L. Lawson-Body, K. Rouibah, G. Akalin, and E. M. Tamandja, "Big Data Analytics and Culture: Newly Validated Measurement Instruments for Developing Countries' Value Proposition," *Journal of Organizational and End User Computing (JOEUC),* vol. 36, no. 1, pp. 1-30, 2024.
12. F. Meng, S. Jiang, K. Moses, and J. Wei, "Propaganda information of internet celebrity influence: Young adult purchase intention by big data analysis," *Journal of Organizational and End User Computing (JOEUC),* vol. 35, no. 1, pp. 1-18, 2023.
13. K. Carlson and D. Blanchard, "Restructuring Power Dynamics within a Classroom: A Phenomenological Qualitative Study," *The Interactive Journal of Global Leadership and Learning,* vol. 3, no. 2, p. 2, 2024.
14. S. A. Rusticus, T. Pashootan, and A. Mah, "What are the key elements of a positive learning environment? Perspectives from students and faculty," *Learning environments research,* vol. 26, no. 1, pp. 161-175, 2023.
15. H. A. Dalimunthe, I. K. Dewi, Y. Yunita, F. Faadhil, and D. M. G. S. Lubis, "Building a Supportive Learning Environment: The Role of Psychology in Increasing Student Motivation and Engagement," *OPSearch: American Journal of Open Research,* vol. 3, no. 4, pp. 934-939, 2024.
16. Y.-C. Tsai, "Empowering students through active learning in educational big data analytics," *Smart Learning Environments,* vol. 11, no. 1, p. 14, 2024.
17. S. Caspari-Sadeghi, "Learning assessment in the age of big data: Learning analytics in higher education," *Cogent Education,* vol. 10, no. 1, p. 2162697, 2023.
18. M. I. Baig, L. Shuib, and E. Yadegaridehkordi, "Big data in education: a state of the art, limitations, and future research directions," *International Journal of Educational Technology in Higher Education,* vol. 17, no. 1, p. 44, 2020.
19. S. W. Magro, D. Berry, A. R. Palmer, and G. I. Roisman, "Teacher–student relationship quality and social, academic, and behavioral adjustment are associated within and between persons from kindergarten to grade 6," *Developmental psychology,* 2025.
20. A. Bethel, C. Ward, and V. H. Fetvadjiev, "Cross-cultural transition and psychological adaptation of international students: The mediating role of host national connectedness," in *Frontiers in Education*, 2020, vol. 5, p. 539950: Frontiers Media SA.
21. L. Iliichuk and O. Vorobets, "Psychological and pedagogical features of students' adaptation to studying at higher education institutions," *Journal of Vasyl Stefanyk Precarpathian National University,* vol. 7, no. 1, pp. 184-191, 2020.
22. J. Cornelius-White, "Learner-centered teacher-student relationships are effective: A meta-analysis," *Review of educational research,* vol. 77, no. 1, pp. 113-143, 2007.
23. L. Kincade, C. Cook, and A. Goerdt, "Meta-analysis and common practice elements of universal approaches to improving student-teacher relationships," *Review of educational research,* vol. 90, no. 5, pp. 710-748, 2020.
24. D. Zhou, S. Liu, H. Zhou, J. Liu, and Y. Ma, "The association among teacher-student relationship, subjective well-being, and academic achievement: Evidence from Chinese fourth graders and eighth graders," *Frontiers in Psychology,* vol. 14, p. 1097094, 2023.
25. P. Shi and W. Liu, "Adaptive learning oriented higher educational classroom teaching strategies," *Scientific Reports,* vol. 15, no. 1, p. 15661, 2025.
26. J. C. Chow *et al.*, "A systematic meta-review of measures of classroom management in school settings," *Assessment for Effective Intervention,* vol. 49, no. 2, pp. 60-74, 2024.
27. R. Korest and J. S. Carlson, "A meta-analysis of the current state of evidence of the Incredible Years Teacher-Classroom Management program," *Children,* vol. 9, no. 1, p. 24, 2021.
28. N. A. Gage and A. S. MacSuga-Gage, "Salient classroom management skills: Finding the most effective skills to increase student engagement and decrease disruptions," *Report on emotional & behavioral disorders in youth,* vol. 17, no. 1, p. 13, 2017.
29. D. R. Giri, B. P. Neupane, N. Dahal, and D. Subedi, "Enhancing school performance through whole school intervention: a case study," in *Frontiers in Education*, 2025, vol. 10, p. 1533586: Frontiers Media SA.
30. N. J. Wilkins, J. M. Verlenden, L. E. Szucs, and M. M. Johns, "Classroom management and facilitation approaches that promote school connectedness," *Journal of School Health,* vol. 93, no. 7, pp. 582-593, 2023.
31. D. V. Poling, C. L. Van Loan, J. D. Garwood, S. Zhang, and D. Riddle, "Enhancing teacher-student relationship quality: A narrative review of school-based interventions," *Educational Research Review,* vol. 37, p. 100459, 2022.