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Teacher characteristics, school context, and school management as predictors of teacher professional learning in ICT-constrained rural middle schools: Evidence from Wenshan, China

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ABSTRACT

This cross-sectional study examined statistical associations of teacher characteristics, school context, and school management with teacher professional learning (TPL) in ICT-constrained rural middle schools in Wenshan, China. The sampling frame comprised 9,172 teachers and administrators across 99 schools; the analytical sample included 368 respondents. The questionnaire contained 63 questions in total: nine background questions and 54 five-point Likert-scale items (27 measuring TPL and 27 measuring school management). Overall Cronbach's alpha was .790 for TPL and .739 for school management; several nine-item subscales showed weaker reliability. Descriptive statistics, correlations, group comparisons, and two-block hierarchical multiple regression were used. In the first model, gender, teaching experience, and school resource disadvantage jointly accounted for 76.2% of observed TPL variance ($R^2 = .762$), with disadvantage showing the largest adjusted association. Adding ICT infrastructure, policy support, and management support explained a further 4.4 percentage points ($\Delta R^2 = .044$), yielding $R^2 = .806$. Among these management dimensions, policy support had the largest standardized coefficient. Findings support differentiated assistance for more disadvantaged schools and suggest areas for school-level improvement, but their cross-sectional design does not establish causal effects.

Keywords: Teacher professional learning; teacher characteristics; school context; school management; ICT-constrained schools; rural middle schools; hierarchical regression.

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INTRODUCTION

Teacher professional learning (TPL) is crucial for enhancing instructional quality and for instructors to respond effectively to changing educational needs. It incorporates continuous learning, reflective practice, professional cooperation, and instructional innovation built into teachers' daily work (Desimone, 2009; Opfer and Pedder, 2011). Furthermore, professional learning communities foster this process by providing opportunities for instructors to exchange knowledge, cooperatively solve instructional difficulties, and enhance instructional practices through ongoing collaboration (Stoll et al., 2006; Vescio et al., 2008). However, teachers do not experience professional learning in the same way. The extent of their participation may depend on individual qualities such as gender and teaching experience, as well as on the structural conditions of the schools in which they work.

School context and school administration are two different institutional influences on TPL. Wang et al. (2017) found that rural schools are more geographically isolated, have less instructional resources, limited professional networks, and less access to professional development than urban schools. Variations in resource capacity, geographic accessibility, staffing, and institutional strength result in different levels of school distress, which may impede possibilities for teachers to engage in professional growth. At the same time, in China school leadership,

organisational support, professional trust and access to learning opportunities have been connected with teacher learning (Huang et al., 2020; Liu et al., 2016a, 2016b). Effective professional learning in ICT-constrained schools is not only dependent on digital equipment and internet connectivity but also on policy support, management support, technical assistance, training and opportunities to apply digital resources in professional practice (Tondeur et al., 2017; UNESCO, 2018).

Previous studies have investigated teacher traits and organisational settings, but few studies have differentiated the relative and incremental contributions of individual, contextual, and management-level determinants of TPL in ICT-constrained rural Chinese schools. This distinction is important because each level implies a different response: individual differences may need differentiated professional development, school distress may need targeted resource allocation, and management conditions may be addressed through school-level policies and leadership practices. This study therefore aims to investigate the predictive contribution of gender and teaching experience, the additional contribution of school distress level and the incremental explanatory power of ICT infrastructure, policy support and management support in predicting TPL of rural middle school teachers in Wenshan, China.

Research problem

Rural teachers may face overlapping barriers involving professional experience, unequal school resources, digital access, and organizational support. It is not clear from this setting how much of the observed variation in teacher learning is aligned with structural school differences, or whether management conditions provide additional explanatory information once those differences are taken into account.

Significance of the study

Distinguishing school context from management practices matters for policy: resource disadvantage calls for targeted public support, whereas opportunities for professional learning may also be expanded through leadership, coherent policies, and usable ICT. This study offers descriptive and adjusted associations from one rural Chinese prefecture, with cautious implications for similarly resource-constrained education systems.

Research objectives

1. To describe differences in TPL and estimate associations with gender, teaching experience, and school resource disadvantage in ICT-constrained rural middle schools in Wenshan, China.
2. To determine how much additional variance in TPL is statistically associated with ICT infrastructure, policy support, and management support after adjusting for background and school resource disadvantage.
3. To compare the observed associations of school management dimensions with digital literacy, professional networking, and teacher innovation, and to formulate practical priorities.

Research questions or hypotheses

RQ1. How are teacher background and school resource disadvantage associated with TPL?
RQ2. What incremental TPL variance is associated with ICT infrastructure, policy support, and management support after adjustment for those baseline variables?
RQ3. How do the three school-management dimensions correlate with digital literacy, professional networking, and teacher innovation?

LITERATURE REVIEW

The study builds on perspectives in which professional learning depends on the interplay of teacher activity and organizational conditions (Opfer and Pedder, 2011). Research in China has linked school leadership, professional trust, and collaborative learning to teachers' development (Liu et al., 2016a, 2016b; Qian and Walker, 2021; Yin and Zheng, 2018). Studies of technology use further distinguish access to ICT from the pedagogical and organizational arrangements required to make it useful (Tondeur et al., 2017). Such evidence motivates examining management-related associations in a resource-constrained rural sample, while avoiding the assumption that cross-sectional regression establishes a causal hierarchy.

Conceptual framework

Figure 1 portrays teacher background, school context, and management as three conceptual groups. For statistical estimation, the first two groups were entered together as the baseline model and the management group was added in the second model. The original diagram is retained to show the conceptual groupings; its three boxes should not be interpreted as three separately estimated regression models.

METHODOLOGY

Research design

This study used a quantitative cross-sectional survey to

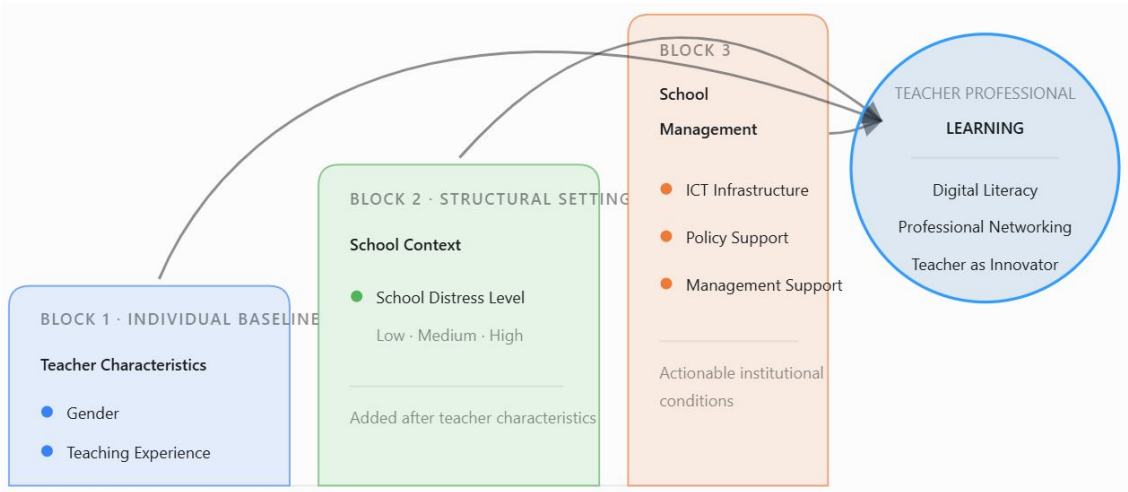


Figure 1. Conceptual framework.

examine statistical associations between teacher characteristics, school context, school management, and TPL. Hierarchical multiple regression compared two nested models. The baseline model included gender, teaching experience, and school resource disadvantage; the expanded model added ICT infrastructure, policy support, and management support. The term predictor is used in its statistical, noncausal sense.

Population and sample

The study population was reported as 9,172 teachers and administrators across 99 rural middle schools in Wenshan, China. A total of 368 respondents were included in the analysis. The sampling considered location and position. Among respondents, 89 were from low-disadvantage schools, 158 from medium-disadvantage schools, and 121 from high-disadvantage schools. School disadvantage (termed “distress level” in the original classification) reflected school resource capacity, geographical accessibility, and institutional conditions; it was coded ordinally from 1 (low) to 3 (high). The number of respondents per individual school and the eligible invitation denominator were not documented in the source manuscript.

Research instruments

The questionnaire had nine background questions and 54 Likert items, not 63 Likert items. TPL was measured by digital literacy, professional networking, and teacher innovation (nine items per dimension); school management comprised ICT infrastructure, policy support, and management support (nine items per dimension). Scale options ranged from 1 (strongly disagree) to 5 (strongly agree). The original study reported assessment by three experts and an item–objective congruence index (IOC) of 1.00. Composite alpha coefficients were .790 for TPL and .739 for school management. Subscale alphas were .582 (digital literacy), .540 (networking), .531 (innovation), .347 (ICT infrastructure), .505 (policy support), and .537 (management support); the comparatively weak subscale reliabilities limit the precision of dimension-specific interpretations.

Data collection

Permission was obtained from the participating schools before questionnaire distribution. Participants were informed of the study’s purpose, the voluntary nature of their participation, the confidentiality of their responses, and their right to withdraw at any time. The questionnaires were distributed to the selected participants and collected after completion. All returned questionnaires were examined for completeness and response quality before data entry. No personally identifying information was included in the dataset used for statistical analysis.

Data analysis

Descriptive statistics summarized the study variables and Pearson coefficients characterized bivariate associations. Two models were estimated: Model 1 included gender (female = 0, male = 1), teaching experience (coded in four increasing categories), and school resource disadvantage (low = 1, medium = 2, high = 3). Model 2 added mean scores for ICT infrastructure, policy support, and management support. Incremental fit was summarized using ΔR^2 and the F-change test. The latest analytical summary reports variance inflation factors of 1.002–3.968

and visual inspection of residual plots; the available documents do not include the underlying diagnostics. Statistical significance was assessed at .05. No multilevel or school-cluster-adjusted model was reported.

RESULTS

Results for research objective 1: Teacher background and school context

The first objective addressed differences in TPL associated with teacher characteristics and school context. The existing institutional classification of low-, medium-, and high-distress schools is described here as low, medium, and high school resource disadvantage.

As shown in Table 1, teachers in low-distress schools reported the highest level of teacher professional learning (M = 3.98, SD = 0.17), followed by teachers in medium-distress schools (M = 3.64, SD = 0.17). Teachers in high-distress schools reported the lowest level (M = 3.20, SD = 0.16). The differences among the three groups were statistically significant, F(2,365) = 594.12, p < .001.

Table 1. Teacher professional learning by school distress level.

School distress level	n	M	SD	Interpretation	Rank
Low-distress schools	89	3.98	0.17	High	1
Medium-distress schools	158	3.64	0.17	High	2
High-distress schools	121	3.20	0.16	Moderate	3
Overall	368	3.58	0.34	High	—

Note. TPL was rated on a five-point scale. “High” and “Moderate” are the authors’ original descriptive labels; cut-off criteria were not documented. The one-way ANOVA statistic shown in the source was F(2,365) = 594.12, p < .001; it has not been recalculated from raw observations.

The regression model was statistically significant, F(3,364)=388.23, p<.001. Gender, teaching experience, and school distress level collectively explained 76.2% of the variance in teacher professional learning (R^2 = .762, adjusted R^2 = .760).

Table 2. Model summary for teacher characteristics and school context predicting teacher professional learning.

Model	R	R^2	Adjusted R^2	Unexplained variance	F	df	p
Teacher characteristics and school context	.873	.762	.760	23.8%	388.23	3, 364	<.001

Note. Predictors included gender, teaching experience, and school distress level. Dependent variable: Overall Teacher Professional Learning Score.

As presented in Table 3, school distress level was the strongest predictor (β = −.870, p < .001). Teaching experience had a small negative effect (β = −.053, p = .037), while gender was not statistically significant (β = .033, p = .191).

Table 3. Regression coefficients for teacher characteristics and school context predicting teacher professional learning.

Predictor	B	SE	95% CI for B	β	t	p	Result
Gender	0.023	0.018	[−0.012, 0.058]	.033	1.31	.191	Not significant
Teaching Experience	−0.017	0.008	[−0.033, −0.001]	−.053	−2.09	.037*	Significant, weak
School Distress Level	−0.394	0.012	[−0.418, −0.370]	−.870	−34.00	<.001***	Significant, dominant

Note. B = unstandardized regression coefficient; SE = standard error; CI = confidence interval; β = standardized regression coefficient. Gender was dummy-coded. Teaching experience and school distress level were coded from lower to higher categories. *p<.05. ***p<.001.

School context was more influential than teacher characteristics in predicting teacher professional learning. Higher school distress was associated with lower teacher professional learning, whereas teaching experience made only a small contribution and gender was not statistically significant.

Results for research objective 2: School management increment

The second objective tested whether ICT infrastructure, policy support, and management support added statistical explanatory power beyond the baseline variables in Model 1.

The hierarchical regression results showed that teacher characteristics and school context initially explained 76.2% of the variance in teacher professional learning. After ICT infrastructure, policy support, and management support were entered, the explained variance increased to 80.6%. The 4.4-percentage-point increase was statistically significant, $\Delta F(3,361) = 27.22$, $p < .001$.

Table 4. Incremental contribution of school management to teacher professional learning.

Added predictor block	R^2 before entry	R^2 after entry	Adjusted R^2 after entry	ΔR^2	ΔF	df	p
School Management	.762	.806	.803	.044	27.22	3, 361	<.001

Note. The school management block included ICT infrastructure, policy support, and management support. Gender, teaching experience, and school distress level were statistically controlled.

All three school management dimensions were positively related to teacher professional learning. Policy support had the strongest bivariate relationship (r = .759), followed by management support (r = .709) and ICT infrastructure (r = .650). In the final hierarchical regression model, all three dimensions remained statistically significant after controlling for gender, teaching experience, and school distress level. Policy support remained the strongest management-level predictor ($\beta = .202$, $p < .001$), followed by management support ($\beta = .150$, $p < .001$) and ICT infrastructure ($\beta = .145$, $p < .001$).

Table 5. Bivariate and adjusted contributions of school management dimensions.

School management dimension	r with TPL	Bivariate r^2	Adjusted β	t	p	Adjusted rank
Policy Support	.759***	.576	.202	5.58	<.001	1
Management Support	.709***	.503	.150	4.40	<.001	2
ICT Infrastructure	.650***	.423	.145	4.79	<.001	3

Note. Bivariate r^2 represents shared variance before the other predictors were controlled and should not be interpreted as a unique contribution. Adjusted β values were obtained after controlling for gender, teaching experience, school distress level, and the other school management dimensions. ***p<.001.

Policy support demonstrated the largest unique contribution to teacher professional learning. A one-unit increase in policy support was associated with a 0.183-point increase in teacher professional learning when the other predictors were held constant. Management support and ICT infrastructure also made significant positive contributions.

Table 6. Regression estimates for school context and management dimensions.

School management dimension	B	SE	95% CI for B	β	Statistical result	Interpretation
School Distress Level	−0.233	0.021	—	−.515	p < .001	Strongest overall predictor
Policy Support	0.183	0.033	[0.118, 0.248]	.202	p < .001	Strongest management-level predictor
Management Support	0.139	0.032	[0.076, 0.202]	.150	p < .001	Leadership and organizational support contributed positively
ICT Infrastructure	0.128	0.027	[0.075, 0.181]	.145	p < .001	Digital access and technical conditions contributed positively

Note. The coefficients were obtained from the final hierarchical regression model after controlling for gender and teaching experience. All predictors shown in the table were statistically significant at p < .001. The final model explained 80.6% of the variance in teacher professional learning ($R^2 = .806$, adjusted $R^2 = .803$).

School management was associated with additional explained variance beyond teacher background and school context. In the adjusted model, school resource disadvantage retained the largest standardized coefficient (β = −.515, p < .001). The smaller magnitude relative to the baseline model (β = −.870) reflects shared statistical variation after adjustment; this change alone is not evidence of mediation. Among management variables, policy support showed the largest standardized association (β = .202), followed by management support (β = .150) and ICT infrastructure (β = .145), all p < .001.

Results for research objective 3: TPL dimensions and priorities

The third objective examined correlations between each school management dimension and the three TPL dimensions, followed by a synthesis of practical priorities.

The findings revealed different patterns across the three dimensions of teacher professional learning. Policy support had the strongest relationship with digital literacy, professional networking, and teacher innovation. Management support also demonstrated consistently positive relationships with all three dimensions. ICT infrastructure had stronger relationships with digital literacy and professional networking than with teacher innovation. (Table 7)

The three predictor levels performed different functions. Teacher characteristics provided information about individual differences but had limited explanatory importance after school-level variables were considered. School context captured structural disadvantage, while school management represented conditions that could be addressed through policy and leadership interventions. (Table 8)

Table 7. Relationships between school management and teacher professional learning dimensions.

School management dimension	Digital literacy	Professional networking	Teacher innovation	Strongest associated outcome
ICT infrastructure	.577***	.574***	.498***	Digital literacy
Policy support	.671***	.624***	.626***	Digital literacy
Management support	.643***	.589***	.563***	Digital literacy

Note. Values are Pearson correlation coefficients. ***p < .001.

Table 8. Synthesis of the roles of the three predictor levels.

Predictor level	Variables	Function in the framework	Main finding	Practical meaning
Teacher Characteristics	Gender; Teaching Experience	Represent individual differences among teachers	Limited contribution after school-level factors were considered	Professional-learning support should not be based primarily on demographic characteristics
School Context	School Distress Level	Represents structural resources, accessibility, and institutional capacity	Strongest source of variation in teacher professional learning	High-distress schools require differentiated structural assistance
School Management	ICT Infrastructure; Policy Support; Management Support	Represents actionable institutional conditions	Added significant explanatory power beyond teacher characteristics and context	Management improvement can strengthen professional learning within existing constraints

The findings indicate that the most effective improvement strategy should combine structural assistance with school-level management interventions. The priority assigned to each area was determined by its statistical contribution, current condition, and practical capacity for intervention. (Table 8)

The results further suggest that the management dimensions should not be implemented independently. ICT infrastructure provides access to digital resources, policy support establishes the institutional conditions for sustained learning, and management support converts resources and policies into practical professional-learning opportunities. (Table 9)

Table 9. Proposed evidence-based priorities for strengthening teacher professional learning.

Priority	Area	Supporting evidence	Main problem	Recommended action
1	High-distress schools	School context was the dominant source of variation in TPL	Resource shortages, isolation, and weak institutional capacity	Prioritize funding, staffing, connectivity, technical assistance, and professional-development access
2	Policy Support	Strongest management-level predictor and strongest relationship with all TPL dimensions	Gaps in funding, implementation guidance, protected time, and monitoring	Establish clear implementation procedures, protected learning time, funding guarantees, and accountability
3	ICT Infrastructure	Lowest school management mean and significant contribution to TPL	Inadequate equipment, unstable connectivity, limited maintenance, and insufficient technical support	Improve equipment, internet access, maintenance systems, and technical personnel
4	Teacher Innovation	Lowest dimension of teacher professional learning	Difficulty translating professional learning into new instructional practices	Support experimentation, lesson design, peer observation, feedback, and dissemination of innovative practices
5	Management Support	Significant relationship with all three TPL dimensions	Need for sustained leadership guidance and collaboration	Strengthen leadership feedback, professional learning communities, recognition, and inter-school networks

School distress level remained the principal contextual concern, while policy support was the most influential actionable management factor. Strengthening teacher professional learning therefore requires differentiated assistance for high-distress schools and coordinated improvements in policy implementation, ICT infrastructure, leadership support, professional collaboration, and teacher innovation. (Table 10)

Table 10. Proposed integrated mechanism for strengthening teacher professional learning.

Management condition	Immediate function	Professional-learning process supported	Expected TPL outcome
ICT Infrastructure	Provides equipment, connectivity, maintenance, and technical access	Digital resource use and online participation	Improved digital literacy and professional networking
Policy Support	Provides funding, protected time, guidance, recognition, and monitoring	Sustained and formally supported professional learning	Improvement across all TPL dimensions
Management Support	Provides leadership, feedback, coordination, and professional trust	Collaboration, experimentation, and knowledge exchange	Stronger networking and teacher innovation
Differentiated Contextual Support	Adjusts assistance according to school distress level	Reduces unequal professional-learning opportunities	More equitable TPL across rural schools

DISCUSSION

Regarding the first research objective, school distress level was the strongest predictor of teacher professional learning, while teaching experience had only a small negative effect and gender was not statistically significant. Teachers in high-distress schools reported lower professional learning than those in low- and medium-distress schools, indicating that structural conditions were more influential than individual characteristics. This finding

supports Opfer and Pedder's (2011) view that professional learning develops through interactions between individual engagement and the school environment and is consistent with Wang et al. (2017), who identified limited resources and instructional capacity as major challenges in rural Chinese schools.

Regarding the second research objective, ICT infrastructure, policy support, and management support significantly increased the explained variance in teacher professional learning after teacher characteristics and school context were controlled. Policy support was the strongest management-level predictor, followed by management support and ICT infrastructure. This finding supports previous evidence that organizational support, learning-centered leadership, professional trust, and access to learning opportunities promote teacher development (Huang et al., 2020; Liu et al., 2016a, 2016b; Qian and Walker, 2021). It also indicates that policy must be translated into funding, protected learning time, clear guidance, and meaningful collaboration to support teacher professional learning effectively.

Regarding the third research objective, school context and school management were more influential than teacher characteristics. Policy support was positively related to digital literacy, professional networking, and teacher innovation, while ICT infrastructure was more strongly related to digital literacy and networking than to innovation. This suggests that technology access alone is insufficient to produce innovative teaching practices; teachers also require pedagogical guidance, leadership support, opportunities for collaboration, and encouragement to experiment. Strengthening teacher professional learning therefore requires differentiated assistance for high-distress schools and coordinated improvements in policy implementation, ICT infrastructure, and school leadership.

Alternative explanations and limitations

Several explanations must be considered. Because measures were collected at one time and mostly from the same respondents, observed associations may reflect common-method variance, social desirability, or different perceptions of management quality among teachers with more active professional learning. Neither reverse causation nor mediation can be ruled in or out with these regressions. The unusually large baseline R^2 and large school-context coefficient may reflect pronounced group separation or overlapping constructs; they warrant replication with school-level data.

The study is confined to one prefecture. The low Cronbach alpha values for individual dimensions (.347–.582) require particular caution, notwithstanding acceptable composite reliabilities. Respondents were nested within schools, but the regression estimates were not adjusted for clustering and could therefore understate uncertainty. School-level response allocations, an invitation denominator, raw-item factor structure, and confirmatory validity statistics were not documented in the materials used for this revision. The original F statistic for group comparisons and corresponding confidence intervals should be verified against individual-level records before definitive statistical interpretation.

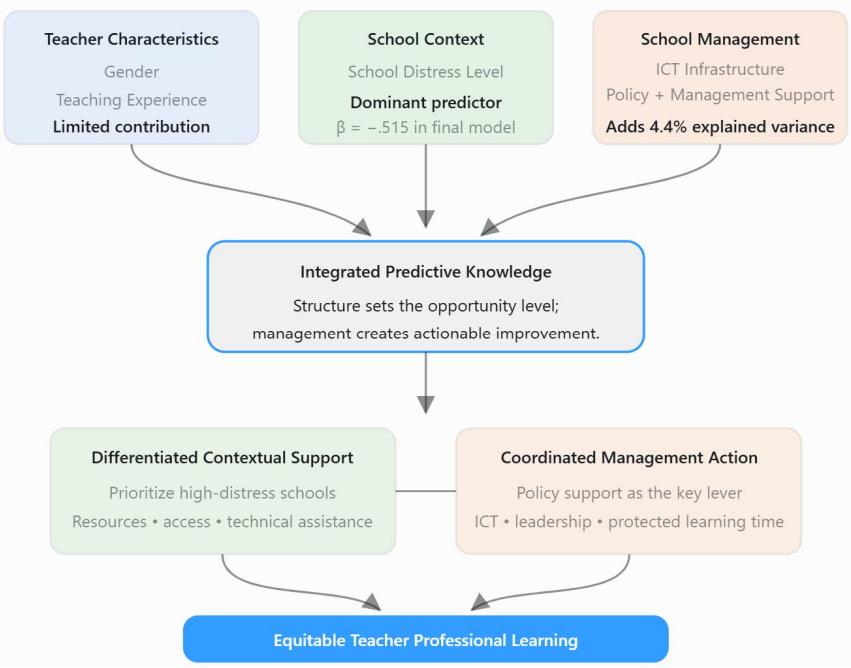


Figure 2. New knowledge generated by the study.

Implications

Figure 2 synthesizes the descriptive evidence into a framework for local action. Resource support for comparatively disadvantaged schools should be coupled with school-level policies providing protected learning time, sustained leadership support, and practical ICT assistance. These recommendations are applications suggested by observational associations rather than estimated intervention effects. Comparable rural and ICT-constrained settings, including education systems outside China, may consider the framework as a question for locally adapted evaluation rather than a proven universal solution.

Conclusion

Among 368 respondents from rural middle schools in Wenshan, school resource disadvantage showed the largest adjusted association with teacher professional learning. Gender and experience were comparatively minor predictors; ICT infrastructure, policy support, and management support jointly added 4.4 percentage points to the variance explained by the background-and-context model (R^2 = .762 to .806). The evidence supports the importance of examining structural and management conditions together, without establishing causality.

RECOMMENDATIONS

Educational authorities should prioritize schools with the most severe resource constraints for connectivity, equipment maintenance, technical assistance, and accessible professional learning opportunities. School leaders can strengthen protected learning time, practical feedback, leadership-supported peer collaboration, and transparent implementation of teacher-development policies. Investments in devices should be paired with instructional guidance rather than treated as a stand-alone intervention.

Future directions

Future research should use school identifiers to estimate cluster-robust or multilevel models, report school-specific response distributions and survey participation rates, and examine longitudinal change rather than only cross-sectional differences. Scale development should include item-level diagnostics, factor analysis, and improvements to weak subscales. Comparative studies spanning different Chinese provinces and rural school systems in Africa and other low-resource contexts could test transferability of the proposed practical framework.

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