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Artificial intelligence integration in instructional leadership: Impact on teacher innovation and job satisfaction

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Abstract

This study explores the impact of AI-integrated instructional leadership on teacher innovation and job satisfaction in underdeveloped regions of China. Based on the Job Demands-Resources (JD-R) model, AI-integrated leadership is conceptualized as a job resource that offers timely feedback, reduces workload, and supports innovation. Data were collected from 366 junior high school teachers and analyzed using partial least squares structural equation modeling (PLS-SEM). The results show that AI-integrated leadership significantly enhances both teacher innovation and job satisfaction, with teacher innovation partially mediating this relationship. These findings extend the JD-R framework by positioning AI-supported leadership as a technology-mediated resource that promotes professional growth and psychological well-being. The study provides practical insights for school leaders and policymakers in resource-constrained settings, suggesting that the strategic application of AI can alleviate teacher burden, foster innovative practices, and improve overall job satisfaction.

Keywords: AI-Integrated leadership, Artificial intelligence, Instructional leadership, Principal leadership, Secondary school, Structural Equation Modeling, Teacher innovation, Teacher job satisfaction.

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1. Introduction

In recent years, the global shift toward digitalization has accelerated the integration of artificial intelligence (AI) technologies into both school management and classroom teaching. AI applications, including data-driven decision-making platforms, intelligent tutoring systems, and automated teaching support tools, are increasingly leveraged to improve teaching efficiency, personalize learning, and enhance administrative effectiveness [1, 2]. Within this transformation, school leaders, particularly principals in their instructional leadership roles, play a pivotal part in the adoption and institutionalization of AI tools [3]. However, despite substantial research on AI's impact on student outcomes and instructional strategies, relatively little is known about how principals integrate AI into their instructional leadership and how this process shapes teachers' work experiences and professional attitudes.

In China, the central government's "Education Informatization 2.0" initiative underscores the strategic importance of leveraging smart technologies to modernize schools and reduce regional disparities [4]. Against this policy backdrop, a number of underdeveloped regions in inland and western China have become pilot sites for the "Internet + Education" program. Underdeveloped regions typically refer to areas with relatively low levels of economic development, limited educational resources, and weaker digital infrastructure compared to more developed eastern provinces. Despite economic constraints, many of these regions have made substantial investments in digital infrastructure and educational technologies, particularly in the integration of AI-driven platforms and intelligent teaching systems in junior high schools [5]. Nevertheless, the effective implementation of these technologies hinges not only on infrastructure but crucially on the capacity of school leaders especially principals to effectively integrate such innovations into teaching and learning processes.

Instructional leadership, a central concept in educational administration, encompasses the principal's role in setting school goals, managing instructional programs, and fostering a positive learning climate [6]. While traditionally focused on curriculum and pedagogy, instructional leadership in the digital era increasingly requires the capacity to select, implement, and support technology-enhanced practices, making digital and AI literacy essential for effective school leadership [3, 7]. Recent frameworks suggest that principals who leverage AI tools such as learning analytics dashboards, adaptive learning technologies, and intelligent tutoring platforms can improve teachers' instructional practices by providing data-driven insights and automating routine administrative tasks [8, 9]. These advances are expected to empower teachers, alleviate administrative burdens, and foster instructional innovation. Nevertheless, the impact of AI-integrated instructional leadership on teacher behaviors and attitudes, particularly in under-resourced contexts such as underdeveloped areas in China, remains insufficiently explored in empirical research.

Teacher innovation and job satisfaction are widely recognized as critical outcomes influenced by school leadership. Teacher innovation, reflected in the implementation of novel teaching strategies and the creative application of new tools, is essential for educational quality and adaptability in the 21st century [10]. Its development is strongly influenced by teachers' perceptions of their work environment, opportunities for professional growth, and the degree of leadership support they receive [11]. Likewise, teacher job satisfaction is a key determinant of individual performance, teacher retention, and overall school effectiveness [12]. While existing research suggests that strong instructional leadership promotes both innovation and satisfaction, it remains unclear whether these positive effects are further enhanced when leadership is mediated by the use of emerging AI technologies [13-15]. This question is particularly salient in underdeveloped areas and ethnic minority regions, where school leaders face the dual challenge of implementing national digital education initiatives while retaining qualified and motivated teachers.

While existing studies have established the positive association between teacher innovation and job satisfaction, these findings are largely grounded in conventional leadership contexts. With the growing integration of AI in school leadership practices, it is essential to revisit and empirically validate whether this established mechanism still holds under digitally enhanced leadership environments. AI-integrated instructional leadership may alter the ways in which teachers innovate and derive satisfaction from their work by changing the availability of resources, support mechanisms, and collaborative opportunities. Therefore, this study seeks not only to test new relationships introduced by AI adoption but also to re-examine well-established pathways, such as the link between teacher innovation and job satisfaction, in the context of AI-enabled leadership.

To guide this study, we examine the following questions:

1. Does AI-integrated instructional leadership positively influence teachers' class-room innovation?
2. Does AI-integrated instructional leadership enhance teacher job satisfaction?
3. Does teacher innovation mediate the relationship between AI-integrated instructional leadership and job satisfaction?

Data collected from teachers in underdeveloped areas of China are analyzed using structural equation modeling (SEM) to test these hypotheses. This approach aims to deepen the theoretical understanding of digital instructional leadership and to inform practical strategies for leveraging AI to foster innovation and job satisfaction among teachers.

2. Literature Review

The integration of AI into education is fundamentally transforming the demands and practices of school leadership. AI technologies empower principals to utilize data-driven decision-making, provide targeted instructional support, and automate routine administrative tasks, thereby enabling more strategic and innovative school management [2, 16-18] However, realizing the full potential of AI requires school leaders not only to possess advanced digital literacy but also to demonstrate strong ethical awareness, particularly in areas such as data privacy and equitable access [19-21].

Principal instructional leadership is defined as the proactive role of school principals in shaping and supporting teaching and learning. This includes setting a clear educational vision, managing instructional programs, and fostering a positive, innovative school climate especially through the integration of AI and digital technologies [3, 6, 22]. AI-integrated instructional leadership in this study refers to the systematic use of AI technology (such as data analysis dashboards, intelligent feedback systems, etc.) by principals in the process of clarifying school goals, managing teaching projects, and creating a positive learning environment to improve management accuracy and teaching support effectiveness.

Policy initiatives around the world and especially in China, where the "New Generation AI Development Plan" has accelerated educational technology reform have spurred widespread adoption of AI in schools [23, 24]. Yet, persistent challenges such as infrastructure gaps, ambiguous curricular guidance, and insufficient preparation for principals have led to uneven implementation and outcomes [25, 26]. Ultimately, the effectiveness of AI in schools depends on the capacity and readiness of principals to lead meaningful instructional change.

Recent research has identified teacher innovation and teacher job satisfaction as key outcomes influenced by instructional leadership, particularly in technology-rich environments [27, 28]. Teacher innovation refers to teachers' capacity and willingness to proactively integrate AI technologies into their instructional practices, encompassing innovation in teaching cognition, content, methods, resources, and evaluation [29]. Teacher job satisfaction is defined as teachers' overall sense of fulfillment and positive affect toward their work, influenced by aspects such as the nature of their tasks, working environment, compensation, professional relationships, and opportunities for career advancement [28].

Although previous research has consistently demonstrated a positive relationship between teacher innovation and job satisfaction [28, 29] most of these studies were conducted in traditional school settings where AI technologies were not yet prevalent. The integration of AI in instructional leadership introduces new dynamics such as automation of tasks, personalized data feedback, and novel collaboration channels that may reshape how innovation affects teacher well-being. Therefore, it is theoretically and practically necessary to revisit this established relationship under the influence of AI-enabled leadership practices, particularly in developing contexts where technological transformation is accelerating.

Empirical studies demonstrate that principals who cultivate supportive school climates, promote autonomy, and invest in professional development significantly enhance both teacher innovation and job satisfaction [22, 30, 31]. Moreover, a reciprocal relationship exists: satisfied teachers are more receptive to change and more likely to implement innovative instructional strategies, which can further reinforce their job satisfaction [29]. Despite these insights, the interplay between principal instructional leadership, teacher innovation, and job satisfaction particularly in the context of AI integration remains underexplored, especially in developing and under-resourced regions. Addressing this gap, the present study investigates how AI-integrated instructional leadership shapes teacher innovation and satisfaction, offering new evidence to inform both theory and practice in the digital era.

The integration of AI into schools adds complexity to the interplay between instructional leadership, teacher innovation, and job satisfaction. While AI-powered tools can facilitate personalized teaching and foster professional growth, inadequate support or insufficient training may result in technical stress, role ambiguity, or diminished well-being among teachers [2, 32]. In such contexts, principal leadership becomes essential for building a supportive climate that maximizes the benefits of AI while mitigating its challenges.

Emerging evidence further suggests that teacher innovation serves as a key mediating mechanism linking instructional leadership to job satisfaction, particularly in technologically enhanced educational environments [33, 34]. However, empirical studies examining this mediation effect especially in resource-constrained settings such as northwest China remain limited, with most existing research being conceptual or descriptive [35, 36].

Addressing these gaps, the present study investigates how principals in the Ningxia Hui Autonomous Region an under-resourced but technologically progressive area navigate the integration of AI to support both teacher innovation and job satisfaction. As illustrated in Figure 1, the conceptual framework positions principal instructional leadership as a multidimensional construct directly influencing both teacher innovation and job satisfaction, with teacher innovation hypothesized as a mediating variable. This research aims to provide empirical insights into the dynamics of instructional leadership, teacher innovation, and well-being in AI-enhanced, developing educational contexts.

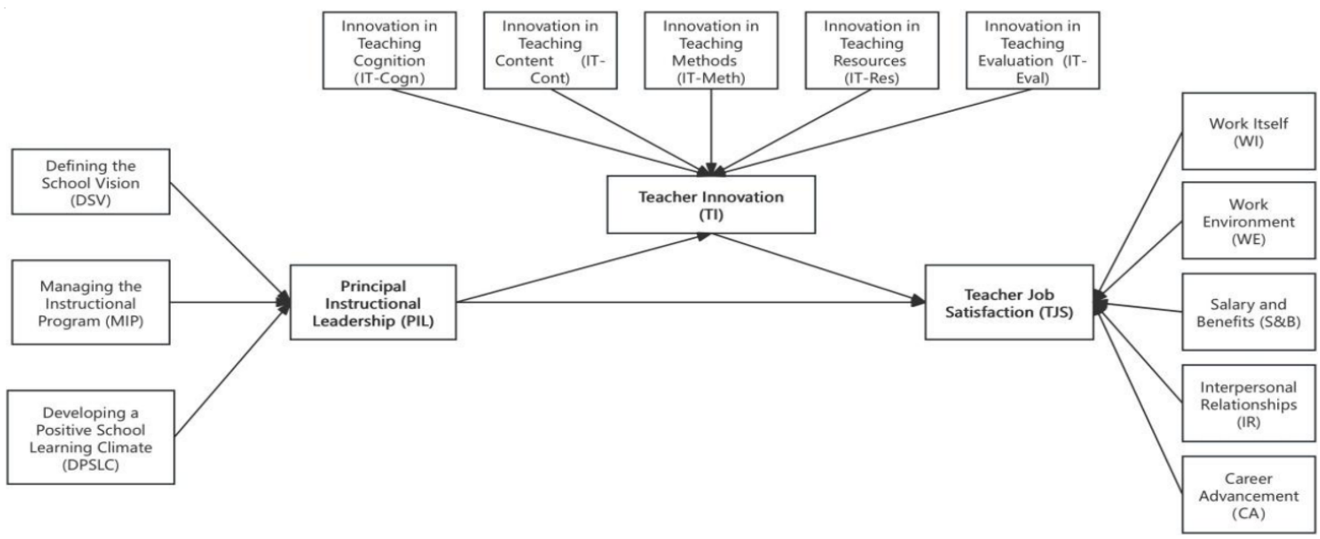

Figure 1.
Conceptual Framework.

This study adopts the Job Demands-Resources (JD-R) model as its primary theoretical lens to explain the relationships among principal instructional leadership, teacher innovation, and teacher job satisfaction. The JD-R model posits that job resources such as effective leadership, access to digital technologies, and opportunities for professional development play a central role in fostering positive work outcomes by promoting proactive and innovative behaviors among employees [37, 38]. Within the context of this research, principal instructional leadership functions as a critical job resource, providing guidance, support, and the necessary infrastructure for teachers to experiment with and implement innovative instructional practices, particularly those involving AI technologies. Teacher innovation, conceptualized as the active and creative integration of new tools and approaches into teaching, acts as a key mechanism through which job resources exert their influence on job satisfaction [39]. Accordingly, the JD-R model supports the hypothesized mediating role of teacher innovation: principals' provision of resources and supportive environments encourage teacher innovation, which in turn enhances teachers' sense of professional fulfillment and job satisfaction. This theoretical approach is supported by prior studies showing that leadership-driven resources can stimulate innovation and improve overall well-being among teachers [37, 38, 40].

3. Methodology

3.1. Research Design

This study employs a quantitative, cross-sectional correlational research design, which is suitable for exploring relationships between instructional leadership, teacher innovation, and teacher job satisfaction. The decision to use this design is guided by the research purpose to examine the influence of principals' AI-integrated instructional leadership on teaching innovation and job satisfaction among junior high school teachers. A cross-sectional survey method was utilized to systematically collect empirical data at a single point in time, facilitating robust statistical analyses and generalization of findings [41].

3.2. Population and Sample

The target population for this study comprised junior high school teachers working in the Ningxia Hui Autonomous Region of Northwest China. To ensure representation across diverse school contexts, a stratified random sampling technique was used. In the first step, the overall population of teachers was divided into distinct strata based on relevant characteristics such as school location (urban or rural) and school type. The sample size for each stratum was then determined according to its proportion in the total population. Finally, simple random sampling was conducted within each stratum, so that teachers were randomly selected from each group. This approach ensured that the final sample of approximately 363 teachers accurately reflected the diversity of the population and provided sufficient statistical power for Structural Equation Modeling (SEM) and regression analyses [42].

According to Table 1, the gender distribution of the sampled junior high school teachers is relatively balanced, with females accounting for 52.62% (n = 191) and males for 47.38% (n = 172). In terms of educational qualifications, 209 teachers hold a bachelor's degree, 119 have a master's degree, and 35 possess a PhD. Regarding age, most participants are under 40 years old, with 30.58% below 30 and 50.69% between 30 and 39, while only a small proportion are aged 40 or above. For teaching experience, over half of the teachers (50.96%) have 0–5 years of experience, 34.71% have 6–10 years, with smaller groups reporting 11–15 years (7.16%), 16–20 years (5.51%), or over 20 years (1.65%) of teaching.

Table 1.
Demographic Information of respondent.

		Teacher sample (N = 366)	
Characteristic	**Measure**	**Frequency**	**%**
Gender	Male	172	47.38
	Female	191	52.62
Qualification	Bachelor	209	57.58
	Master	119	32.78
	PhD	35	9.64
Age	below 30	149	30.58
	30-39	142	50.69
	40-49	75	13.77
	50 and above	18	4.96
Teaching Experience	0-5 years	185	50.96
	6-10 years	126	34.71
	11-15 years	26	7.16
	16-20 years	20	5.51
	Over 20 years	6	1.65

3.3. Instruments

Data collection involved three five Likert questionnaires. Principal instructional management was assessed using Hallinger et al. [6] Principal Instructional Management Rating Scale (PIMRS), adapted specifically for this study to emphasize AI integration within its established dimensions: Defining the School Vision (6 items), Managing the

Instructional Program (6 items), and Developing a Positive School Learning Climate (7 items). To accurately reflect the AI elements central to this research, the original PIMRS items were modified accordingly. For instance, the item "My principal draws upon the results of school-wide testing when making curricular decisions" was adapted to "My principal observes and evaluates classroom instruction using AI-generated insights (such as analytics on student engagement or assessment results) to provide data-informed feedback to teachers." Teacher innovation was measured with Cui [43] questionnaire, covering cognition (6 items), content (8 items), methods (5 items), resources (4 items), and evaluation (6 items) related to teaching. Finally, Jia [44] instrument gauged teacher job satisfaction across dimensions including the work itself (5 items), working environment (5 items), salary and benefits (4 items), colleague relationships (4 items), and career development opportunities (4 items).

The measurement model was evaluated to ensure construct reliability and validity. Table 2 presents the Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) for each construct. All constructs exhibit Cronbach's α and CR values well above the recommended 0.70 threshold [42] demonstrating excellent internal consistency. Cronbach's α ranged from 0.97 (Principal instructional leadership) to 0.98 (Teacher innovation), and CR values ranged from 0.97 to 0.98, indicating that the indicators for principals' AI-integrated leadership, teacher innovation, and teacher job satisfaction are highly reliable. Similarly, the average variance extracted (AVE) for each construct was very high (AVE_ Principal instructional leadership = 0.937, AVE_ Teacher innovation = 0.924, AVE_ Teacher job satisfaction = 0.895), exceeding the 0.50 benchmark for convergent validity [45]. These AVE values (see Table 2) mean that each construct explains well over 89% of the variance in its indicators, which confirms strong convergent validity.

Table 2.
Construct reliability and convergent validity indicators.

Construct	Cronbach's α	CR	AVE
Principal instructional leadership	0.97	0.97	0.94
Teacher innovation	0.98	0.98	0.92
Teacher job satisfaction	0.97	0.97	0.9

Discriminant validity was supported by multiple criteria. Table 3 shows the inter-construct correlation matrix with the square root of each construct's AVE on the di-agonal [45]. Each construct's diagonal value (in bold) is greater than its correlations with any other construct, indicating that each latent variable shares more variance with its own indicators than with other variables. For example, the square root of AVE for principal instructional leadership is 0.968, which is higher than its correlations with teacher innovation (0.472) and teacher job satisfaction (0.461). Similarly, teacher innovation's square root AVE (0.961) exceeds its correlations with principal instructional leadership (0.472) and teacher job satisfaction (0.560).

Table 3.
Discriminant validity.

Construct	Principal instructional leadership	Teacher innovation	Teacher job satisfaction
Principal instructional leadership	**0.968**		
Teacher innovation	0.472	**0.961**	
Teacher job satisfaction	0.461	0.56	**0.946**

Note: Diagonal elements in bold are the square roots of AVE. Off-diagonal values are the correlations between constructs.

In addition, the Heterotrait–Monotrait (HTMT) ratios between constructs were all well below the conservative threshold of 0.85 [46] the highest HTMT value was 0.57 (for the Teacher innovation–Teacher job satisfaction pair), confirming clear discriminant validity shown in Table 4. Finally, a confirmatory factor analysis indicated an excellent fit for the three-factor measurement model (χ^2/df = 1.06, RMSEA = 0.013, CFI = 0.999), whereas alternative models that combined the constructs yielded very poor fit (e.g., χ^2/df > 30, RMSEA > 0.28 when teacher innovation and teacher job satisfaction were merged into a single factor). This evidence further reinforces that principal instruction leadership, teacher innovation, and teacher job satisfaction are distinct constructs in the context of our study.

Table 4.
Heterotrait–Monotrait (HTMT) Ratios for Discriminant Validity.

Constructs	Principal instructional leadership	Teacher innovation	Teacher job satisfaction
Principal instructional leadership	—	0.485	0.475
Teacher innovation	0.485	—	0.573
Teacher job satisfaction	0.475	0.573	—

3.4. Data Analysis

Measurement Model Validation: The Confirmatory Factor Analysis helped to test construct validity, reliability (Cronbach's alpha), convergent validity (Average Variance Extracted - AVE), and discriminant validity. Model Fitness Assessment: Model fitness was determined through several indices such as the Comparative Fit Index (CFI), Tucker-Lewis

Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Residual (SRMR), indicating that the model performs adequately under observed data [42].

Structural Equation Modeling (SEM): We employed SEM through the use of software (e.g., SmartPLS 4.0) to test hypothesized relationships among constructs. The overall analysis involved examining direct effects (AI-integrated instructional leadership → Teacher Innovation; Teacher Innovation → Teacher Job Satisfaction) and the indirect mediating impact (AI-integrated instructional leadership → Teacher Innovation → Teacher Job Satisfaction).

4. Results

After establishing measurement validity, we examined the structural model to address the research questions. The structural relationships among AI-integration in principle instructional leadership, teacher innovation, and teacher job satisfaction were tested. Path analysis results demonstrated that principal instructional leadership significantly influences teacher innovation, and both principal instructional and teacher innovation significantly impact teacher job satisfaction, confirming the hypotheses of the study.

Analysis of the structural model indicates that principal instructional leadership has a strong positive and statistically significant influence on teacher innovation as shown in Table 5. The path coefficient from principal instructional leadership to teacher innovation was $\beta = 0.525$, with a t-value of 11.409 and $p < .001$. Substantively, the standardized coefficient of 0.525 suggests a sizable effect: principals' instructional leadership practices are associated with substantially higher levels of teacher innovation. Therefore, RQ1 can be answered in the affirmative greater principal instructional leadership does lead to higher teacher innovation, and this relationship is both strong and highly significant.

Table 5.
Structural model results for direct effects.

Path (Relationship)	Coefficient (β)	T-value	p-value
Principal instructional leadership → Teacher innovation	0.525	11.409	< 0.001
Principal instructional leadership → Teacher job satisfaction	0.266	5.363	< 0.001

The Table 5 show that principal instructional leadership also has a positive and significant direct effect on teacher job satisfaction, though the effect size is more modest than for teacher innovation. The path coefficient from principal instructional leadership to TJS was $\beta = 0.266$ ($t = 5.363$, $p < .001$), indicating a statistically significant influence of principal instructional leadership on teachers' job satisfaction. This coefficient (~0.27) suggests that the direct impact of principal instructional leadership on teacher job satisfaction, while meaningful, is of moderate magnitude. In practical terms, higher principal instructional leadership is associated with higher teacher job satisfaction, but the strength of this direct relationship is not as pronounced as principal instructional leadership's effect on teacher innovation. Nonetheless, the finding confirms that RQ2 is supported: principals who exhibit strong instructional leadership tend to foster greater job satisfaction among teachers (e.g., through setting clear goals, supporting teacher needs, and creating a positive instructional environment), with the effect being statistically significant ($p < .001$).

To address RQ3, a mediation analysis was conducted with teacher innovation as the mediating variable between principal instructional leadership and teacher job satisfaction in Table 6. The analysis revealed a significant indirect effect of principal instructional leadership on teacher job satisfaction through teacher innovation, as well as a remaining direct effect, indicating a partial mediation. First, even in the presence of the mediator, the direct path from principal instructional leadership to teacher job satisfaction remained positive and significant ($\beta = 0.266$, $t = 5.363$, $p < .001$). Importantly, principal instructional leadership also exerted a significant indirect influence on teacher job satisfaction via its effect on teacher innovation: the indirect path (principal instructional leadership → teacher innovation → teacher job satisfaction) had $\beta = 0.218$, with $t = 7.426$, $p < .001$. The product of coefficients (0.525×0.415) accounted for this indirect effect magnitude. By summing the direct and indirect pathways, the total effect of principal instructional leadership on teacher job satisfaction was approximately $\beta = 0.484$ ($p < .001$), indicating a substantial overall impact of principal leadership on job satisfaction. All effects (direct, indirect, and total) were statistically significant at the $p < .001$ level.

Table 6.
Mediation effect of teacher innovation on the relationship between principal instructional leadership and teacher job satisfaction.

Indirect Path	Indirect β	T-value	p-value
Principal instructional leadership → Teacher innovation → Teacher job satisfaction	0.218	7.426	< 0.001

The above results support a mediated model: principal instructional leadership influences teacher job satisfaction both directly and indirectly through teacher innovation. In other words, teacher innovation partially mediates the relationship between principal instructional leadership and teacher job satisfaction. The fact that both the direct and indirect effects are significant implies partial (rather than full) mediation principal instructional leadership still has its own direct effect on teacher job satisfaction even as it also works through teacher innovation. Notably, the mediated indirect effect ($\beta = 0.218$) is nearly as large as the direct effect ($\beta = 0.266$), suggesting that a considerable portion of principal instructional leadership's impact on teacher satisfaction is channeled through fostering teacher innovation.

5. Discussion

This study's findings indicate that principal AI-integrated instructional leadership has a significant positive effect on both teacher innovation and teacher job satisfaction. Moreover, teacher innovation partially mediates this relationship, suggesting that when school leaders strategically incorporate AI into their instructional practices, teachers are more likely to engage in innovative behaviors, which in turn enhance their job satisfaction. These results underscore a powerful synergy between AI integration and instructional leadership, highlighting that technology-enhanced leadership not only modernizes administrative and pedagogical processes but also empowers teachers by expanding their capacity for innovation and fulfillment.

Importantly, this study also reaffirms the well-established link between teacher innovation and job satisfaction, now within the context of AI-enhanced leadership. The persistence of this relationship suggests that innovation continues to serve as a meaningful pathway to teacher well-being, even as traditional support structures are transformed by digital tools. By validating this mechanism under new technological conditions, our findings extend prior work and confirm that teacher innovation retains its psychological and motivational value in digitally mediated educational environments. Specifically, AI technologies, such as real-time data feedback and personalized recommendations for instructional resources, help teachers more accurately identify instructional challenges and encourage innovative approaches. Such technological support effectively reduces the barriers and psychological burdens associated with instructional innovation, thereby enhancing teachers' professional satisfaction and motivation to innovate.

The significant positive effect of principals' instructional leadership on teachers' innovation reinforces the critical role of school leadership in technology integration and instructional transformation. While traditional instructional leadership often faces limitations in scalability and personalization [31]. AI integration expands leaders' capacity to foster innovation. Principals utilizing AI and digital tools can cultivate a data-driven culture conducive to pedagogical experimentation and instructional innovation [2, 30, 32]. Although previous research lacks consistency regarding specific variables, studies involving related constructs, such as digital leadership, confirm that AI positively influences teachers' innovative behaviors [33, 47]. The alignment between instructional leadership and teacher innovation is strengthened by leaders' strategic deployment of AI, suggesting that technology-enhanced leadership practices fundamentally reshape how teachers approach their pedagogical roles [1].

From the Job Demands-Resources (JD-R) model perspective, AI-integrated leadership provides crucial job resources, including autonomy, technological support, and a supportive environment, while concurrently reducing administrative burdens [48]. Abundant job resources buffer against demands, enhancing motivation and fostering innovative behaviors [49, 50]. By leveraging AI tools, principals effectively manage both tangible and intangible resources, thereby creating a balanced work environment that maximizes teachers' creative capacities and innovation potential [51].

Additionally, AI supports the development of adaptive professional learning communities by streamlining teacher collaboration and knowledge sharing. Predictive analytics and intelligent networking tools connect educators to expertise and resources, cultivating an environment that encourages innovation, autonomy, and professional fulfillment [30, 33, 52]. This adaptive and supportive network significantly contributes to teachers' professional identity and collective efficacy, further amplifying their willingness to engage in innovative practices [53]. Consequently, teachers benefit from ongoing professional growth opportunities and a reinforced sense of belonging and community [54].

The positive impact of instructional leadership on teacher satisfaction is enhanced by AI integration. Principals who employ AI effectively streamline administrative tasks and reduce workloads, enabling teachers to focus more on meaningful activities, thus increasing job satisfaction [1, 55]. Moreover, personalized support through AI strengthens teachers' sense of professional value and fulfillment, underscoring AI's role in fostering a supportive work environment [18, 28, 52, 56]. Therefore, the strategic use of AI not only reduces routine job demands but also promotes intrinsic motivation by enhancing teachers' sense of efficacy and professional recognition.

Applying the JD-R model, AI-integrated leadership effectively decreases teachers' job demands and increases job resources, thereby enhancing psychological well-being and job satisfaction [38, 48]. Empirical JD-R research consistently shows that adequate resources and manageable demands significantly improve employee satisfaction and engagement [57]. The integration of AI acts as a mechanism to balance teachers' workload while simultaneously enriching the professional environment, demonstrating a nuanced interplay between organizational resources and employee well-being.

The observed partial mediation indicates that teacher innovation represents a critical pathway linking instructional leadership to job satisfaction, although it is not exclusive. Principals also directly enhance job satisfaction through effective management, fair decision-making, and supportive climates, leading teachers to experience greater professional pride and security [18, 52, 58]. This direct influence underscores that teachers' perceptions of leadership fairness, transparency, and vision play essential roles independent of their engagement in innovative activities [28]. Thus, instructional leadership enriched by AI tools simultaneously fosters innovation and directly contributes to improved teacher satisfaction and organizational commitment.

From a JD-R perspective, engaging in innovative practices serves as job crafting, building teachers' personal resources such as self-efficacy and intrinsic motivation [29, 38, 48]. Innovation thus generates psychological resources, directly contributing to job satisfaction. This interplay establishes a positive feedback loop wherein resource-rich environments reinforce innovation and satisfaction [39, 59]. Teachers engaged in innovation not only experience immediate psychological benefits but also reinforce an organizational culture that consistently sustains resource growth and professional fulfillment.

6. Conclusion

This study provides empirical evidence that AI-integrated instructional leadership by principals can significantly enhance both teacher innovation and job satisfaction in under-resourced educational settings, based on survey data from junior high school teachers in Ningxia, China. Notably, our findings reveal that teacher innovation serves as a partial mediator, suggesting that AI-augmented leadership improves teacher well-being both directly and by fostering innovative practices. These results confirm and extend prior research, demonstrating the pivotal role of leadership in leveraging technology for positive school outcomes.

Building on these findings, our research advances the theoretical understanding of instructional leadership in the digital era. The study shows that AI tools can effectively extend traditional leadership functions, such as feedback, monitoring, and vision-sharing, enabling principals to drive instructional change more efficiently. By drawing on the Job Demands-Resources (JD-R) theory, this research demonstrates that AI-integrated leadership enhances teachers' job resources such as autonomy, support, and access to professional tools while also reducing job demands through process automation and targeted support. The identification of both direct and mediated effects enriches existing models of teacher well-being, clarifying how technology-integrated leadership supports not only innovative practice but also the broader professional and psychological needs of teachers through the strategic balancing of resources and demands.

Translating theory into practice, our results emphasize several actionable strategies for school leaders. Principals are encouraged to integrate AI tools and data-driven approaches as core elements of instructional leadership, actively modeling effective technology use. By fostering a culture of innovation and collaboration, and by relieving teachers of administrative burdens, school leaders can enhance job satisfaction and support sustained instructional improvement. At the policy level, these practical insights highlight the need for comprehensive support structures. We recommend strengthening professional development for AI literacy and digital leadership, ensuring robust technological infrastructure especially in less-developed regions establishing clear ethical guidelines for AI adoption, and providing incentives to recognize exemplary leadership in this domain. Implementing such measures will enable schools to realize the full potential of AI-driven instructional leadership and promote scalable educational innovation.

Despite these contributions, several limitations should be acknowledged. The use of cross-sectional, self-reported data limits our ability to draw causal conclusions, and the study's focus on a single region may affect generalizability. Additionally, the lack of objective performance and student outcome measures points to the need for more comprehensive data in future research. To address these limitations and extend our understanding, future research should employ longitudinal or experimental designs and investigate AI-integrated leadership across diverse contexts and school levels. It will be important to examine additional mediators and outcomes, including the broader impact on student learning and school performance. Such work will further refine our understanding of how AI-driven leadership shapes both educational practice and teacher well-being

In summary, this study offers cautious optimism regarding the role of AI in instructional leadership, underscoring its potential to foster teacher innovation and job satisfaction. As schools continue to embrace AI-enhanced management, ongoing research will be essential to ensure these technological advances genuinely benefit educators and the broader educational environment.

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