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The Impact of Digital Leadership on Employee Performance in Guangdong Civil Engineering Construction Enterprises: The Mediating Role of Psychological Safety

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ABSTRACT

Digital transformation in civil engineering depends on technology adoption, leadership, and interpersonal conditions that allow employees to learn, speak up, and experiment. This study examines relationships among digital leadership, psychological safety, and employee performance in privately owned civil engineering construction enterprises in Guangdong Province, China. Drawing on Job Demands-Resources theory, it tests whether digital leadership is associated with performance directly and indirectly through psychological safety. A quantitative cross-sectional survey produced 484 valid responses. SPSS 29.0 supported preliminary screening and descriptive analysis, while SmartPLS 4.1 assessed the measurement and structural models using 5,000 bootstrap resamples. The measures demonstrated strong reliability and convergent validity: Cronbach's alpha ranged from 0.926 to 0.933, composite reliability from 0.940 to 0.945, and average variance extracted from 0.612 to 0.694. Digital leadership was positively associated with psychological safety (beta = 0.276, p < .001) and employee performance (beta = 0.215, p < .001), while psychological safety was positively associated with employee performance (beta = 0.236, p < .001). The indirect effect through psychological safety was significant (beta = 0.065, p < .001), indicating partial mediation. Construction enterprises can improve digital-transformation outcomes by developing leaders who combine digital competence with empowerment, feedback, and non-punitive communication.

Keywords: civil engineering construction, digital leadership, employee performance, Guangdong, psychological safety

1. INTRODUCTION

1.1 Background and Research Context

The construction industry is being reshaped by Building Information Modeling, artificial intelligence, cloud collaboration, digital twins, smart-site systems, and data-driven project controls. In Guangdong, these developments are reinforced by provincial and national intelligent-construction strategies. Yet the organizational value of technology depends on employees' willingness and ability to use new systems, exchange knowledge, report problems, and adapt established work routines. Studies of Construction 4.0 therefore increasingly describe transformation as a leadership-led and human-centered process rather than a purely technical upgrade (Gledson et al., 2024; Nazzal, 2025; Wang et al., 2024).

Digital leadership refers to the leader behaviors that give direction to digital change, support digital learning, provide useful feedback, involve employees in decisions, and create the conditions for technology-enabled work. Such leadership is especially important in civil engineering, where temporary project teams, dispersed sites, safety-critical operations, tight schedules, and complex stakeholder arrangements can make digital adoption difficult. Existing research identifies leadership support, organizational coordination, resource constraints, and risk perceptions as major barriers to transformation in construction (Zulu et al., 2024). Evidence outside construction also links digital leadership to engagement and digitally enabled task and innovative performance (Li et al., 2024; Shao et al., 2022).

At project level, digitalization changes both the content and coordination of work. BIM platforms, mobile reporting tools, cloud repositories, and data dashboards make information more visible, but they also redistribute decision rights and require employees to collaborate across professional boundaries. Leaders therefore influence whether technology becomes an accessible work resource or an additional demand. Clear priorities, timely explanations, and opportunities to participate in workflow design can reduce ambiguity, while inconsistent instructions or weak support may intensify resistance. This distinction is especially relevant in project-based construction, where teams are temporary and digital routines must be integrated with existing safety, quality, and schedule controls (Gledson et al., 2024; Wang et al., 2024).

Psychological safety is the shared belief that a team is safe for interpersonal risk-taking (Edmondson, 1999). It allows employees to ask questions, admit mistakes, challenge assumptions, request help, and offer new ideas without expecting humiliation or punishment. These behaviors matter in digital transformation because unfamiliar tools inevitably produce uncertainty and learning errors. They are equally important in civil engineering because silence about design, quality, or safety concerns can carry serious consequences. Contemporary reviews position psychological safety as a well-established organizational resource that supports learning, voice, resilience, and performance (Edmondson & Bransby, 2023), while construction research continues to show that leadership and psychosocial conditions are important antecedents of safe and effective behavior (Tariq et al., 2024; Xia et al., 2023).

1.2 Problem Statement

A practical gap persists between substantial investment in construction digitalization and the employee-level performance gains expected from that investment. Enterprises may install advanced systems yet still experience limited use, fragmented information, resistance to revised workflows, and reluctance to disclose errors. The literature explains many technical and organizational barriers but gives less attention to the psychological mechanism through which digital leader behavior becomes employee performance. This omission is important because digital change requires experimentation, while traditional construction hierarchies and zero-defect expectations may discourage precisely the questions and disclosures needed for successful learning.

The empirical gap is therefore threefold. First, digital leadership research is concentrated in manufacturing, services, information technology, or general organizational settings, with civil engineering construction underrepresented. Second, leadership research in construction has often emphasized safety compliance rather than broader task, adaptive, and innovative performance. Third, psychological safety has been established as an outcome of supportive leadership and an antecedent of performance, but its mediating role between digital leadership and employee performance in Guangdong's privately owned civil engineering enterprises has not been directly tested. The present study addresses this mechanism-focused gap.

The research problem is also contextual. Privately owned civil engineering enterprises often face stronger resource constraints than large state-owned contractors, while still being expected to comply with increasingly sophisticated digital and regulatory requirements. Their leaders may need to introduce new systems without extensive specialist support, formal training units, or long implementation periods. Under these conditions, employees' willingness to ask for clarification, report implementation problems, and share emerging knowledge becomes central to performance. Examining psychological safety as a mediating mechanism therefore addresses not only whether digital leadership matters, but also how everyday leader behavior can convert limited organizational resources into effective employee action.

1.3 Research Objectives and Questions

The study pursues four aligned objectives:

1. To determine whether digital leadership is positively associated with psychological safety.
2. To determine whether digital leadership is positively associated with employee performance.
3. To determine whether psychological safety is positively associated with employee performance.
4. To test whether psychological safety mediates the relationship between digital leadership and employee performance.

Accordingly, the research asks whether each of the three direct relationships is significant and whether digital leadership also affects employee performance indirectly through psychological safety.

1.4 Significance, Scope, and Limitations

Theoretically, the study opens the 'black box' between digital leadership and performance by testing psychological safety as a specific explanatory pathway. It also extends Job Demands-Resources theory to digitally transforming, project-based, and safety-critical work. Practically, the model identifies two manageable intervention points: leaders' digital-support behaviors and the team's climate for speaking up, asking for assistance, and learning from mistakes. The study is geographically limited to Guangdong Province and industrially limited to privately owned civil engineering construction enterprises. Its cross-sectional and self-report design supports conclusions about statistically significant associations, not definitive causation; generalization beyond the sampled setting should therefore be cautious.

The study also has methodological significance because it evaluates the measurement and structural components of the proposed model within one PLS-SEM analysis. This makes it possible to distinguish measurement quality from the substantive relationships among the constructs. The resulting evidence is useful for researchers seeking parsimonious explanations of employee performance during construction digitalization and for managers who require intervention points that can be translated into leader-development, communication, and learning practices. At the same time, the stated boundaries of the design prevent the statistical associations from being interpreted as universal causal effects.

2. LITERATURE REVIEW

2.1 Digital Leadership

Digital leadership is distinct from simply managing remote communication. It concerns the strategic and behavioral capacity to guide organizational transformation through digital technologies. At the employee level, it is visible when leaders involve staff in decisions that affect the digital work environment, encourage digital literacy, answer questions about digitalization, provide timely information and feedback, and support the use of digital applications. Claassen et al. (2021) operationalized these behaviors as a coherent employee-rated construct. From a resource perspective, digital leadership supplies autonomy, information, feedback, learning support, and access to tools; these resources reduce uncertainty and enable employees to perform in changing technological environments.

Empirical research generally indicates a positive relationship between digital leadership and employee or organizational outcomes. Middle managers' digital leadership has been associated with stronger work engagement (Li et al., 2024), while leadership support and supervisory transformation influence digitally enabled task and innovative performance through different organizational and psychological pathways (Shao et al., 2022). Within construction, digital leadership frameworks emphasize vision, resource alignment, collaboration, and capability development as conditions for firm-level transformation (Gledson et al., 2024; Nazzal, 2025). These findings support testing both the direct performance effect and the possibility that some of the effect operates through employees' psychological experience of the work environment.

Digital leadership is therefore best understood as a pattern of enabling behaviors rather than as personal familiarity with software. A technically knowledgeable manager may still provide weak digital leadership if employees are excluded from decisions, receive delayed feedback, or cannot obtain the resources needed to apply a system. Conversely, leaders can strengthen implementation by connecting digital objectives with project tasks, recognizing different levels of digital literacy, and establishing credible channels for assistance. This behavioral interpretation is consistent with evidence that leader support and participation are associated with stronger engagement and digitally enabled performance (Claassen et al., 2021; Li et al., 2024).

2.2 Psychological Safety

Psychological safety captures whether employees expect interpersonal consequences when they speak candidly, admit uncertainty, ask for help, or test an unfamiliar approach. It is not the absence of accountability, nor does it imply tolerance of poor performance. Instead, it makes accurate reporting, learning, and constructive disagreement possible. Edmondson and Bransby (2023) describe psychological safety as a mature research domain with consistent links to learning and performance-related behaviors. It can also function as an enduring social resource when employees face operational pressure and resource constraints (Bahadurzada et al., 2024).

Digital leaders may cultivate this resource by responding constructively to questions, making learning expectations explicit, and involving employees in workflow decisions. In civil engineering, those signals are especially consequential because authority gradients, schedule pressure, and safety-critical tasks may otherwise encourage silence. Once psychological safety is present, employees can direct attention toward task execution and improvement rather than self-protection. This reasoning predicts a positive path from digital leadership to psychological safety and another from psychological safety to performance.

Psychological safety should not be confused with low performance standards or the absence of control. In safety-critical work, its value lies in allowing concerns to surface early enough for corrective action. Employees can remain accountable for procedures while also being encouraged to question incomplete information, disclose uncertainty, or report an error without disproportionate interpersonal consequences. This combination of voice and accountability is particularly important when teams are learning unfamiliar digital systems, because hidden problems can quickly affect design coordination, quality, cost, and site safety. Construction research similarly shows that workplace and leadership conditions shape whether employees communicate and behave safely (Tariq et al., 2024; Xia et al., 2023).

2.3 Employee Performance

Employee performance in a digitally transforming construction enterprise extends beyond completing assigned duties. It includes accurate and timely task performance, problem identification and solution, effective coordination with managers and colleagues, adaptation to new procedures or technologies, and willingness to undertake useful extra-role activities. Research on construction performance similarly emphasizes productivity, capability, quality, and adaptive work behavior rather than a single output measure (Manoharan et al., 2023). In this study, performance is treated as an individual-level outcome measured through ten self-report items covering task execution, problem-solving, efficiency, quality, and discretionary contribution.

The present study treats employee performance as a multidimensional individual-level outcome. Routine task completion remains important, but digitally transforming work also requires responsiveness, problem solving, coordination, and the ability to apply new information. These behaviors are interdependent: an employee may use a digital platform accurately yet perform poorly if information is not communicated in time, while proactive reporting can prevent rework and improve collective execution. A broad performance measure is therefore more appropriate than a single productivity indicator for evaluating how leadership and psychological safety operate in contemporary civil engineering enterprises (Manoharan et al., 2023).

2.4 Job Demands-Resources Theory

Job Demands-Resources (JD-R) theory classifies work characteristics as demands that require sustained effort or resources that help employees achieve goals, reduce the costs of demands, and stimulate learning and development (Demerouti et al., 2001). Leadership can operate as a job resource by providing direction, autonomy, support, information, and feedback (Tummers & Bakker, 2021). The theory also recognizes personal and social resources that shape whether employees invest effort confidently or protect themselves from possible loss (Bakker & de Vries, 2021).

Applied here, digital leadership is a distal job-resource bundle. Psychological safety is a proximal interpersonal resource and motivational condition. Employee performance is the outcome of the resource-driven process. A digitally competent and supportive leader reduces ambiguity surrounding technological change and signals that responsible experimentation is acceptable. Employees who feel psychologically safe can then invest more attention and energy in problem-solving, adaptation, and innovation. The framework therefore predicts both a direct enabling effect of leadership and an indirect effect transmitted through psychological safety.

JD-R theory also clarifies why the proposed direct and indirect effects can coexist. Leadership resources may influence performance directly by improving access to information, autonomy, feedback, and learning opportunities. The same resources may also improve psychological safety by signaling that questions and responsible experimentation are legitimate. Psychological safety then helps employees invest attention in task execution rather than self-protection. The model consequently represents a resource pathway in which distal organizational support is translated into a more immediate interpersonal condition and, ultimately, into employee performance (Demerouti et al., 2001; Tummers & Bakker, 2021).

2.5 Research Gap and Hypotheses

The integrated evidence leads to four hypotheses:

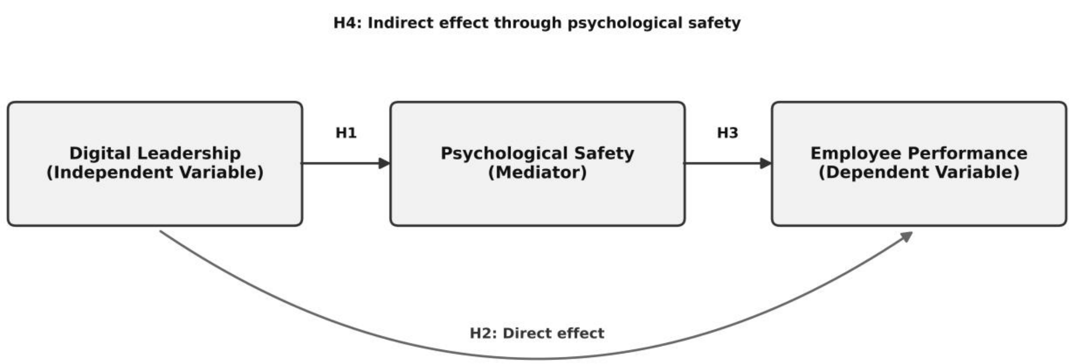
H1: Digital leadership has a significant positive effect on psychological safety.

H2: Digital leadership has a significant positive effect on employee performance.

H3: Psychological safety has a significant positive effect on employee performance.

H4: Psychological safety mediates the relationship between digital leadership and employee performance.

Figure 1. Conceptual framework and hypothesized relationships



Source: Developed for this study from the JD-R theoretical framework.

3. MATERIAL AND METHODS

3.1 Research Design, Population, and Sampling

The study used a quantitative, cross-sectional survey design and PLS-SEM to test a predictive mediation model. The target population comprised full-time employees of privately owned civil engineering construction enterprises operating in Guangdong Province. Eligible respondents had at least one year of organizational tenure, direct exposure to digital transformation initiatives such as BIM or digital project-management systems, and a direct supervisory relationship. The full study estimated a target population of approximately 769,460 employees from provincial construction-employment statistics.

A multi-source enterprise frame was assembled from regulatory and industry-association directories. Enterprises were stratified by size, selected within strata, and asked to circulate the survey to eligible employees; convenience sampling was used at the employee level because complete personnel lists were unavailable. Krejcie and Morgan's population-based benchmark indicated a minimum of approximately 384 responses, while power and PLS-SEM rules produced lower thresholds. The study therefore targeted at least 385 valid cases and distributed 500 questionnaires. After screening, 484 usable responses were retained for analysis.

The sampling procedure sought to balance feasibility with coverage of different enterprise conditions. Stratification by enterprise size was intended to avoid overrepresenting only the most accessible small firms or the largest organizations with mature digital systems. Eligibility criteria ensured that respondents had sufficient organizational experience, direct contact with digital-transformation initiatives, and a supervisory relationship relevant to the leadership measures. The target of at least 385 valid cases followed the conventional population-based benchmark, while distribution of 500 questionnaires allowed for nonresponse and screening losses (Krejcie & Morgan, 1970).

3.2 Measures

Table 1. Measurement instruments

Construct	Items	Scale and source	Main content
Digital Leadership	8	6-point Likert; adapted from Claassen et al. (2021)	Participation in digital decisions, literacy support, information, feedback, and application support
Psychological Safety	7	5-point Likert; Edmondson (1999, 2019)	Speaking up, error discussion, help seeking, interpersonal risk-taking, and inclusion
Employee Performance	10	5-point Likert; adapted from Koh (2018)	Accuracy, timeliness, problem-solving, competence, quality, compliance, and extra-role effort

The instruments were translated into Simplified Chinese through forward and backward translation and reviewed for construction-industry relevance. The item counts in this condensed article follow the final measurement model used in Chapter IV: eight digital-leadership indicators, seven psychological-safety indicators, and ten employee-performance indicators. Negatively phrased psychological-safety items were simplified during pretesting while their conceptual meaning was preserved.

All constructs were operationalized as reflective measures because the indicators were treated as manifestations of their underlying concepts. Digital-leadership items captured employees' perceptions of participation, guidance, feedback, information, and support for digital work. Psychological-safety items assessed whether speaking up, asking for help, and discussing mistakes were interpersonally acceptable. Employee-performance items covered task accuracy, timeliness, competence, adaptability, problem solving, and discretionary contribution. Using employee perceptions was appropriate because the proposed mechanism concerns the work resources and interpersonal conditions that employees actually experience.

3.3 Pilot Study and Data Collection

A pre-survey recruited 50 eligible employees, of whom 42 provided valid responses. Preliminary Cronbach's alpha values were 0.87 for digital leadership, 0.81 for psychological safety, and 0.90 for employee performance. Cognitive interviews identified confusing negative wording in several psychological-safety items, and demographic questions were moved to the end of the instrument. The average completion time was 11.3 minutes.

Main data collection took place over four weeks in March 2026. The finalized Questionnaire Star link and QR code were distributed through individual WeChat and QQ invitations and through professional groups serving Guangdong construction personnel. The invitation explained the academic purpose, voluntary nature, anonymity, and confidentiality of the study. Platform controls were used to discourage duplicate or incomplete submissions, and the dataset was exported for analysis after the field period.

Several procedural safeguards were used to improve response quality. The questionnaire introduction emphasized that participation was voluntary and that answers would be analyzed in aggregate, reducing pressure to provide socially desirable evaluations. Screening conditions limited participation to employees with relevant organizational and digital experience. Pretesting checked wording, completion time, and the interpretation of negatively phrased items before the main survey. Distribution through both individual and professional-group channels also broadened access beyond a single enterprise or project while retaining the defined population boundary.

3.4 Data Analysis and Ethical Safeguards

SPSS 29.0 was used for data screening, demographics, construct descriptives, internal consistency, and preliminary method-bias checks. SmartPLS 4.1 was used to evaluate indicator loadings, Cronbach's alpha, composite reliability, average variance extracted (AVE), Fornell-Larcker discriminant validity, collinearity, model fit, R-squared, effect sizes, predictive relevance, and structural paths. The indirect effect was assessed through bootstrapping with 5,000 resamples and bias-corrected confidence intervals. Participation was voluntary; respondents could stop at any time, no personally identifying information was requested, and results were reported only in aggregate.

Analysis proceeded in stages. Data screening and descriptive analysis were completed before evaluating the measurement model, thereby separating basic data-quality checks from hypothesis testing. Reliability and convergent validity were assessed using indicator loadings, Cronbach's alpha, composite reliability, and AVE, while the Fornell-Larcker criterion was used to examine discriminant validity. The structural model was then evaluated through collinearity, explanatory power, predictive relevance, and bootstrapped path estimates. The indirect effect was interpreted only after both its confidence interval and the remaining direct effect had been considered.

4. RESULTS AND DISCUSSION

4.1 Respondent Profile

The final sample comprised 484 respondents. Gender was nearly balanced, and most participants were aged 25-44. Technical staff and engineering professionals formed the majority, while the sample also included supervisory and managerial employees. More than 72% reported moderate or high exposure to digital technology, indicating that most respondents could evaluate leadership in a digitally changing work context.

The profile also indicates that the respondents were positioned to observe digital leadership in practice. The concentration of participants in technical, engineering, supervisory, and managerial roles means that many were involved in workflows where digital information, coordination, and managerial guidance are directly relevant. The predominance of moderate or high digital exposure further reduces the likelihood that responses were based only on abstract impressions of transformation. Although the sample is not intended to reproduce every category of the provincial construction workforce, it provides substantial variation in age, education, job position, experience, and exposure for the proposed model.

Table 2. Condensed demographic profile (n = 484)

Characteristic	Distribution
Gender	Male 234 (48.35%); Female 250 (51.65%)
Age	Below 25: 29 (5.99%); 25-34: 180 (37.19%); 35-44: 199 (41.12%); 45+: 76 (15.70%)
Education	Diploma or below: 55 (11.36%); Bachelor's: 326 (67.36%); Master's or above: 103 (21.28%)
Job position	Technical: 224 (46.28%); Engineering professional: 155 (32.02%); Supervisor: 69 (14.26%); Manager: 36 (7.44%)

Characteristic	Distribution
Work experience	<3 years: 122 (25.21%); 3-5: 146 (30.17%); 6-10: 155 (32.02%); >10: 61 (12.60%)
Digital exposure	Low: 135 (27.89%); Moderate: 221 (45.66%); High: 128 (26.45%)

4.2 Descriptive Statistics

Table 3. Descriptive statistics for the study variables

Variable	N	Min	Max	Mean	SD	Skewness	Kurtosis
Digital Leadership	484	1.38	5.63	3.983	0.967	-0.777	-0.260
Psychological Safety	484	1.14	4.86	3.503	0.968	-0.597	-0.792
Employee Performance	484	1.20	4.80	3.295	0.869	-0.533	-0.791

Digital leadership recorded the highest mean (M = 3.983), followed by psychological safety (M = 3.503) and employee performance (M = 3.295). Standard deviations were similar across constructs, and skewness and kurtosis values remained between -1 and +1, indicating no severe univariate distribution problems.

4.3 Measurement Model

Table 4. Reliability and convergent validity

Construct	Indicators	Loading range	Cronbach's alpha	CR	AVE
Digital Leadership	8	0.782-0.862	0.933	0.945	0.682
Psychological Safety	7	0.808-0.863	0.926	0.941	0.694
Employee Performance	10	0.711-0.840	0.929	0.940	0.612

All indicator loadings exceeded 0.70. Cronbach's alpha and composite reliability were above 0.90 for every construct, while AVE ranged from 0.612 to 0.694, exceeding the 0.50 benchmark. The measures therefore demonstrated strong internal consistency and convergent validity. Fornell-Larcker results also supported discriminant validity: the square roots of AVE for digital leadership (0.826), psychological safety (0.833), and employee performance (0.782) were greater than the corresponding inter-construct correlations (0.330-0.465).

Taken together, the measurement results indicate that the three constructs were empirically distinguishable without sacrificing internal consistency. The comparatively high reliability estimates suggest that the items captured coherent perceptions, while AVE values above the accepted threshold show that the constructs explained a substantial proportion of indicator variance. At the same time, the inter-construct correlations remained below the square roots of AVE. This pattern supports the interpretation that digital leadership, psychological safety, and employee performance are related but not interchangeable concepts.

Table 5. Fornell-Larcker discriminant validity matrix

Construct	DL	PS	EP

Construct	DL	PS	EP
Digital Leadership (DL)	0.826		
Psychological Safety (PS)	0.330	0.833	
Employee Performance (EP)	0.397	0.465	0.782

Note: Diagonal values are the square roots of AVE; off-diagonal values are construct correlations.

4.4 Structural Model and Hypothesis Testing

The estimated model showed satisfactory approximate fit (SRMR = 0.046; NFI = 0.934). Inner-model VIF values ranged from 1.067 to 1.309, indicating no material collinearity. The model explained 15.2% of the variance in psychological safety and 42.5% of the variance in employee performance. Q-squared predict values were positive for psychological safety (0.142) and employee performance (0.356), supporting predictive relevance.

The structural results should be interpreted in terms of both significance and explanatory contribution. Bootstrap confidence intervals excluded zero for every hypothesized path, providing consistent evidence for the proposed directions. Digital leadership retained a significant direct association with employee performance after psychological safety entered the model, while the indirect path was also significant. The simultaneous presence of these effects indicates partial rather than complete mediation: psychological safety explains part of the relationship, but other resource, capability, and coordination mechanisms are also likely to connect digital leadership with performance.

Table 6. Structural paths and hypothesis decisions

Hypothesis / relationship	beta	SE	t	p	95% CI	Decision
H1: DL -> PS	0.276	0.043	6.414	<.001	[0.192, 0.361]	Supported
H2: DL -> EP	0.215	0.047	4.547	<.001	[0.124, 0.309]	Supported
H3: PS -> EP	0.236	0.042	5.648	<.001	[0.158, 0.320]	Supported
H4: DL -> PS -> EP	0.065	0.016	4.067	<.001	[0.038, 0.101]	Supported

All four hypotheses were supported. Digital leadership had positive direct effects on psychological safety and employee performance, and psychological safety had a positive direct effect on employee performance. The indirect effect was significant because its confidence interval excluded zero. Since the direct path from digital leadership to employee performance remained significant after psychological safety entered the model, the mediation was partial rather than complete. Conventional f-squared values for the three direct paths (0.061-0.084) indicate small but practically meaningful incremental effects.

4.5 Summary of Findings

The measurement model established that the three constructs were reliable, convergent, and empirically distinct. The structural model then confirmed the proposed resource pathway: employees who perceived stronger digital leadership also reported greater psychological safety, and both variables contributed independently to employee performance. Psychological safety explained a statistically significant portion of the leadership-performance association, revealing a mechanism through which leader behavior helps digital transformation become productive employee action.

4.6 Discussion of Findings

H1 showed that digital leadership was positively associated with psychological safety. This result is consistent with the JD-R view that leadership supplies resources which shape employees' experience of the work environment. In practical terms, leader support for digital questions, employee involvement in decisions, useful feedback, and visible encouragement of learning appear to signal that responsible interpersonal risk-taking is acceptable. The result extends psychological-safety research beyond traditional supportive or empowering leadership by showing that digitally oriented leader behaviors have similar relevance in civil engineering construction.

H2 confirmed a positive direct relationship between digital leadership and employee performance. Digital leaders can improve performance by reducing ambiguity, connecting technological change to work goals, ensuring access to information, and helping employees develop applicable digital skills. This aligns with evidence that digital leadership supports engagement and digitally enabled performance (Li et al., 2024; Shao et al., 2022). The finding is important for construction enterprises because the benefits of BIM, smart-site platforms, and data systems depend on everyday leader behaviors that translate corporate digital strategy into usable resources at project level.

H3 showed that psychologically safe employees reported higher performance. Psychological safety frees employees to focus on task execution, request assistance early, surface errors, and adapt unfamiliar tools rather than devote effort to impression management or concealment. The result is consistent with the established role of psychological safety in learning and performance-related behaviors (Edmondson & Bransby, 2023). It also has distinctive relevance in high-reliability construction settings, where open communication must coexist with strong accountability and procedural discipline.

H4 identified significant partial mediation. Digital leadership therefore operates through two complementary routes: a direct resource route that enables employees to perform, and an indirect interpersonal route that makes it safer to use those resources actively. The indirect coefficient was smaller than the direct paths, but it was precise and statistically significant. This result constitutes the study's central contribution because it specifies psychological safety as one answer to how digital leader behavior becomes performance in a digitally transforming construction context.

The magnitude and pattern of the coefficients reinforce a balanced interpretation. Psychological safety is a meaningful mechanism, but it is not a substitute for usable technology, information, training, or managerial direction. Employees may feel safe to speak yet remain unable to perform if systems are poorly designed or resources are unavailable. Equally, advanced tools may yield limited benefit when employees expect blame for raising implementation problems. The findings therefore support a complementary view in which digital resources and interpersonal conditions jointly enable performance. This interpretation is especially pertinent to civil engineering projects, where technical interdependence and operational risk make both accurate systems and candid communication necessary.

4.7 Theoretical Implications

The study contributes in three ways. First, it connects digital leadership and psychological safety in a single tested model, moving the literature from simple association toward mechanism explanation. Second, it extends JD-R theory by treating digital leadership as a context-specific job-resource bundle and psychological safety as a proximal interpersonal resource. The significant direct and indirect paths are consistent with the theory's proposition that resources both enable goal attainment and generate motivating psychological conditions. Third, the research provides evidence from privately owned civil engineering construction enterprises in Guangdong, an industrial and regional context that is underrepresented in digital-leadership studies despite intense digitalization pressure.

A further theoretical contribution lies in the level at which the mechanism is specified. Rather than treating digital transformation only as an organizational capability or technology-investment decision, the model connects leader behavior with employees' immediate experience of the work environment. This employee-level pathway helps explain why firms with similar technologies may obtain different performance outcomes. It also suggests that digital leadership can be integrated with established resource theories without assuming that technological change operates independently of social relationships.

4.8 Practical Implications

Construction enterprises should treat digital leadership development as part of transformation implementation, not as a separate management initiative. Training should combine technical literacy with four observable practices: explaining the digital vision in project terms, involving employees in decisions that affect their workflows, supplying timely feedback and information, and responding constructively to questions or early-stage mistakes. Leader evaluation can include employee feedback on these behaviors rather than relying only on technology deployment milestones.

Psychological safety should also be managed deliberately. Project leaders can establish routine learning reviews, invite concerns before presenting their own judgments, distinguish responsible experimentation from negligence, and close the feedback loop when employees raise a problem. Anonymous or mobile reporting channels may be useful for dispersed sites, but they should supplement—not replace—visible leader responsiveness. Because partial mediation was observed, enterprises should invest in both resource provision and interpersonal climate: neither technological support without voice nor voice without adequate tools is likely to maximize performance.

Implementation can be staged. Enterprises may first diagnose whether performance barriers arise primarily from access to digital resources, unclear leader behavior, or reluctance to speak. Leader-development activities can then combine technical demonstrations with scenario-based practice in responding to errors, questions, and conflicting project information. Progress should be monitored through employee feedback, learning-review records, and evidence that reported problems are resolved. Such indicators provide a more behaviorally meaningful assessment of digital leadership than counting software installations alone.

4.9 Limitations and Future Research

The cross-sectional design cannot establish temporal order or rule out reciprocal effects; employees who perform well may also evaluate leaders and team climate more positively. All focal constructs were self-reported, so shared method may inflate some relationships despite procedural and statistical precautions (Podsakoff et al., 2024). The sample was limited to privately owned civil engineering construction enterprises in Guangdong, and the simple model omitted factors such as organizational digital maturity, employee digital literacy, team virtuality, safety climate, and enterprise size.

Future research should use multi-wave designs, supervisor or objective performance measures, and cross-regional samples. Multi-level analysis could distinguish leader, team, project, and enterprise effects. Moderated-mediation models could test whether digital literacy, project complexity, bureaucratic structure, or virtuality changes the strength of the indirect pathway. Intervention studies are particularly valuable: leadership-development or speaking-up programs could determine whether purposeful changes in leader behavior produce later gains in psychological safety and performance.

Future studies could also connect employee perceptions with project-level indicators such as rework, schedule reliability, quality events, safety observations, or digital-platform usage. Linking survey and operational data would provide a stronger test of whether changes in leadership and psychological safety correspond with observable performance. Repeated measurement before and after leadership or speaking-up interventions would further clarify temporal order and strengthen practical conclusions.

5. CONCLUSION

Based on 484 respondents, this study found that digital leadership was positively associated with both psychological safety and employee performance, while psychological safety was positively associated with performance and partially mediated the leadership-performance relationship. Digital transformation in construction is therefore not only a question of acquiring advanced tools. It is also a question of whether leaders provide usable resources and create a climate in which employees can ask, learn, disclose, and improve. For Guangdong's civil engineering construction enterprises, the most productive digital leader is both technologically capable and interpersonally enabling.

Empirically, the study provides a concise model supported by reliable and distinct measures. The direct paths from digital leadership to psychological safety and employee performance, together with the path from psychological safety to performance, were all statistically significant. The significant indirect effect further showed that psychological safety explains part of the leadership-performance relationship without eliminating the direct association. These results support a resource-based interpretation in which leaders improve performance by supplying direction, information, feedback, and learning support while also reducing the interpersonal risk of using those resources actively.

For practice, the findings imply that technology implementation and people management should be designed together. Construction enterprises should develop leaders who can explain digital priorities in project language, involve employees in workflow decisions, respond constructively to questions and early-stage errors, and ensure that reported problems receive visible follow-up. Such behaviors can help organizations obtain greater value from digital investment while preserving accountability for quality and safety. Because the evidence is cross-sectional and based on self-reports from privately owned enterprises in Guangdong, the conclusions remain bounded to statistically supported associations. Longitudinal, multi-source, and cross-regional research is needed to test whether deliberate improvements in digital leadership and psychological safety produce sustained gains in employee and project performance.

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