



Modeling Motivation Strategies for Enhancing Employee Management and Training Effectiveness in Guangxi Metal Processing Enterprises: A Structural Equation Modeling Approach

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Abstract

Background and Aims: Guangxi's metal processing sector is key to its economic shift but faces workforce challenges in adapting to Industry 4.0, particularly in digital readiness, motivation, and training. Guided by an integrated framework drawing on TAM, SDT, Hofstede's cultural dimensions, and the TOE perspective, this study examines how culture, ICT competence, policy support, and motivation relate to employee management and training.

Methodology: A cross-sectional survey of 411 employees was collected via convenience sampling; content validity was established by three experts with an index of item objective congruence of 0.81, a pilot with 30 participants was conducted, and reliability was high with Cronbach's alpha above 0.90. SEM and CFA were used to analyze key variable relationships.

Results: All four predictors—cultural dimensions, ICT competence, policy support, and intrinsic/extrinsic motivation—were positive and significant for employee management and training effectiveness ($p < 0.001$). Motivation showed the largest standardized effect ($\beta = 0.234$), followed by culture ($\beta = 0.226$), policy support ($\beta = 0.221$), and ICT competence ($\beta = 0.220$). Model fit was excellent, with CFI and TLI equal to 1.000 and RMSEA equal to 0.002, values that indicate near-perfect comparative fit and a close approximate fit, and the model explained 62.6% of the variance ($R^2 = 0.626$).

Conclusion: Motivation, both intrinsic and extrinsic, has the strongest effect on employee management and training effectiveness. Together with culture, ICT competence, and policy support, it constitutes a core set of levers for workforce development. Prioritizing motivation-centered practices alongside cultural alignment, clear policy signals, and role-relevant ICT skills supports sustained digital transformation in the metal processing sector.





Keywords: Cultural Dimensions; ICT Competence; Policy Support; Task Technology Fit; Intrinsic and Extrinsic Motivation; Training Effectiveness; Structural Equation Modeling; Guangxi Metal Processing

Introduction

The metal processing industry plays a vital and strategic role in the broader economic development agenda of Guangxi, particularly through the establishment and growth of development zones, as discussed by Tritto and Camba (2022). This regional plan identifies metal processing as a key pillar for future industrial transformation and emphasizes the modernization and upgrading of core materials such as high-performance steel, refined calcium carbonate, and nonferrous metals. These materials are essential for a wide array of downstream industries, making them critical to the province's economic integration with national and global value chains. The sector is characterized by its depth and diversity, encompassing multiple forms of ferrous and nonferrous processing that serve prominent industries such as automotive manufacturing, electronic components, aerospace, shipbuilding, and residential and commercial construction. Reflecting this breadth, enterprises commonly utilize an increasingly complex range of techniques, including casting, forging, extrusion, and advanced precision engineering, to produce customized, high-performance components, and together the sector's diversity and process sophistication underscore its strategic importance within China's industrial modernization (Li & Yu, 2020).

Over the past few years, policy directives in Guangxi have shifted strategically away from traditional extractive mining practices. Instead, they now place greater emphasis on downstream innovation and advanced integration in processing methods and material sciences, with particular attention to applications based on aluminum, steel, and copper (Xu, Xue & Wu, 2022; Zhang & Li, 2021). This policy transformation aligns with national directives under China's "Made in China 2025" strategy, which promotes technological self-reliance and smart manufacturing. While this shift fosters value opportunities added production and growth driven by innovation, it simultaneously intensifies operational complexity, competition among firms, and pressure on human capital adaptability. Against this backdrop, a research gap remains. Despite strong policy momentum, limited empirical work examines how human capital readiness and motivation strategies condition the effectiveness of employee management and training in Guangxi's metal processing firms. Addressing this gap, the present study therefore investigates how factors related to employees shape digital adoption and organizational outcomes in this sector.

According to the most recent figures from the Guangxi Bureau of Statistics (2023), the economic value derived from upstream and midstream industries related to mining and metal refinement has increased by 21.3%, while downstream value-added metal processing has grown





by 31%. These figures indicate the dynamic transformation unfolding in the region's industrial ecosystems. In parallel with this industrial acceleration, the rise of the Fourth Industrial Revolution (Industry 4.0) has ushered in a new era characterized by the integration of digital technologies into traditional manufacturing environments. This includes the widespread deployment of technologies such as cyber-physical systems, the Internet of Things (IoT), cloud computing, industrial robotics, artificial intelligence (AI), and big data analytics (Liao, Deschamps, Loures, & Ramos, 2017). The integration of these technologies into shop floor production and enterprise decision making represents a paradigm shift aimed at achieving enhanced flexibility, transparency, efficiency, and customer responsiveness. However, despite these advancements, many enterprises in Guangxi face significant obstacles in implementing Industry 4.0 technologies. One of the most pervasive and pressing issues is the limitation of human capital and workforce readiness. Challenges related to limited digital competence, fear of technological obsolescence, employee resistance to change, and lack of access to structured training mechanisms have emerged as critical barriers (García-Muiña, Medina-Salgado, Ferrari, & Villalobos, 2020). These barriers are often magnified in traditional firms where older systems, legacy workflows, and inertia toward automation persist. To frame these challenges within a stronger academic foundation without preempting the Literature Review, the study draws on perspectives of technology acceptance and work motivation (Davis, 1989; Deci & Ryan, 2000) to explain how perceived usefulness and ease, cultural context, and motivational dynamics jointly shape readiness for digital adoption.

Specifically, Guangxi's metal processing firms encounter pressing difficulties in both upskilling current employees and retaining high-level talent essential for digital transformation efforts (Zhao, Jing, & Wang, 2019). Employees with experience in conventional manufacturing workflows often report disorientation and frustration when confronted with modern digital interfaces, cloud-based control systems, or automated diagnostics (Choi, Wallace, & Wang, 2017). This unfamiliarity not only leads to operational inefficiencies but also undermines workplace morale and productivity, which in turn increases turnover. Moreover, many metalworking businesses, especially small and medium-sized enterprises (SMEs), suffer from inconsistent access to high-quality digital training platforms and support systems. These deficits, coupled with regional imbalances in ICT infrastructure and variation in e-learning capabilities, contribute to motivational disparities and significantly heighten employee attrition risks (Appaya & Rao, 2020; Huang, 2018; Liu, Li, & Wang, 2021). Against this backdrop, there remains a clear empirical gap in understanding how capability and infrastructure constraints jointly shape workforce readiness and training effectiveness during digital upgrading in Guangxi's metal processing sector. Methodologically, the specific research problem addressed is to identify and quantify the joint influence of cultural





dimensions and motivational factors within organizations facing ICT and infrastructure constraints on training effectiveness under Industry 4.0 conditions.

Given these structural and operational concerns, there is a growing academic and managerial need to investigate how organizational and psychological factors, particularly internal motivation strategies, can enhance employee engagement, knowledge absorption, behavior change, and digital readiness. Motivation plays a critical role in facilitating learning, adaptability, and retention in technology-saturated environments. Organizational variables such as cultural support, task technology fit, leadership policies, and ICT infrastructure can shape an employee's willingness and ability to participate fully in training and skill adaptation processes (Gagné & Deci, 2005; Venkatesh et al., 2012). Existing literature lacks empirical validation of how cultural dimensions and motivational factors jointly influence training outcomes in Chinese industrial settings, particularly in Guangxi's metal processing sector amid Industry 4.0. Building on this gap, the present study examines how culture, ICT-related capabilities, policy support for task technology fit, and intrinsic and extrinsic motivation align to influence employee management and training effectiveness in this context. Rather than only filling an empirical void, the study also anticipates a theoretical contribution by clarifying how the joint effects of cultural dimensions, ICT competence, policy support for task technology fit, and intrinsic and extrinsic motivation operate within an industrializing region. This integration extends motivation and human resource-oriented theories to account for digital transformation pressures and region-specific constraints on workforce readiness. It also links motivation strategies with organizational and infrastructural conditions to explain adoption behavior and training outcomes in traditional manufacturing contexts.

Accordingly, this study addresses the empirical and theoretical gap by developing and validating a structural equation model (SEM) to estimate the relationships among organizational culture dimensions, ICT competence, institutional support for task technology fit, and intrinsic and extrinsic employee motivation, and to assess their effects on the effectiveness of employee management and training practices. By situating the model in Guangxi's metal processing industry, the study aims to generate practical insights for enterprise leaders, policymakers, and educators seeking to improve talent retention, workforce productivity, and innovation capabilities during industrial transformation and digital upgrading. The SEM provides testable linkages that inform managerial practice and contribute to theory refinement in motivation and human resource development in digitally transforming, resource-uneven environments. The model also offers empirical validation of the joint effects of cultural dimensions and motivational factors on training effectiveness, thereby addressing the gap identified above.





Objectives

This study examines how motivation strategy components influence employee management and training effectiveness in Guangxi's metal processing enterprises. The objectives are as follows.

1. To examine the direct effect of culture dimensions on employee management and training effectiveness.
2. To examine the direct effect of ICT competence on employee management and training effectiveness.
3. To examine the direct effect of policy support for task technology fit on employee management and training effectiveness.
4. To examine the direct effect of intrinsic motivation and extrinsic motivation on employee management and training effectiveness.

Literature Review

Theoretical Foundation

This study is grounded in the Technology Acceptance Model developed by Davis (1989), which identifies perceived usefulness and perceived ease of use as determinants of attitude toward use and behavioral intention to use technology. The model has been widely validated in organizational and educational contexts (Venkatesh & Davis, 2000), and it explains user acceptance in training and adoption settings (King & He, 2006; Park, 2009). In this study, the model is applied to assess training and management effectiveness in industrial contexts such as metal processing. Perceived usefulness, perceived ease of use, attitude, and behavioral intention are used to evaluate employee perceptions and engagement with digital systems. Prior research indicates that favorable beliefs about usefulness and ease are associated with stronger adoption intentions and improved job performance (Davis, 1989; Venkatesh & Bala, 2008).

To extend explanatory power, this study incorporates Cultural Dimensions, ICT Competence, Policy Support for Task Technology Fit, and Intrinsic and Extrinsic Motivation as antecedents that inform perceived usefulness and perceived ease of use. Supportive culture can lower perceived effort and uncertainty and thereby improve perceived ease of use, while norms that value learning and participation can strengthen perceived usefulness when employees view digital tools as instrumental for performance; ICT competence shapes self efficacy and the ability to navigate interfaces and workflows, which relates to perceived ease of use and can also enhance perceived usefulness as tasks are completed more effectively (Venkatesh & Bala, 2008). Policy support for task technology fit clarifies alignment between tools and work requirements and can increase the instrumental value that employees attribute to digital systems, which links to





perceived usefulness and facilitates adoption in structured training settings (Legris, Ingham, & Colletette, 2003). Intrinsic and extrinsic motivation influence engagement and sustained participation in training and practice and can translate into more favorable beliefs about usefulness and ease during adoption and learning processes (Venkatesh & Davis, 2000).

While the acceptance model offers a clear path from beliefs to intention, it focuses on individual cognition and may understate organizational arrangements and policy context. The present extension addresses this boundary by treating culture, competence, policy support, and motivation as belief antecedents while maintaining the original causal ordering of the model (Davis, 1989; Venkatesh & Davis, 2000; Venkatesh & Bala, 2008).

Hofstede's Cultural Dimensions Theory

Hofstede's framework provides a foundational perspective for understanding how cultural values influence human behavior, particularly in organizational and technology adoption contexts. The model comprises four core dimensions, namely power distance, individualism versus collectivism, uncertainty avoidance, and indulgence versus restraint, which are widely applied in cross-cultural research to explain differences in attitudes, decision making, and openness to innovation (Hofstede, 2011; Huang et al., 2018). Power distance reflects societal acceptance of hierarchy, with high power distance cultures favoring authority and conformity, while low power distance environments support equality and participation (Khatri, 2009; Tarhini et al., 2017). The individualism-collectivism dimension highlights autonomy versus group orientation and shapes technology use through differing social norms (Hofstede, 2001).

Uncertainty avoidance (UA) refers to a society's tolerance for ambiguity. High uncertainty avoidance cultures prefer order and are less receptive to change, whereas low uncertainty avoidance cultures are more flexible and innovation-friendly. The indulgence restraint (IR) dimension addresses societal attitudes toward gratification, where indulgent cultures embrace lifestyle technologies and restrained cultures emphasize control and tradition. Together, these dimensions offer a comprehensive lens to understand how cultural context shapes behavioral intentions and patterns of technology use (Hofstede, 2011; Huang et al., 2018).

In high power distance settings, employees follow top-down training and rely on supervisors, increasing participation but limiting bottom-up feedback. Individualism supports self-directed learning and accountability, whereas collectivism strengthens peer support and team-based practice that sustains transfer. High uncertainty avoidance favors structured curricula and clear procedures, reducing resistance to digital training, while low uncertainty avoidance enables faster experimentation. Indulgence promotes engagement, whereas restraint reinforces adherence and discipline. Because this framework is usually applied at national or regional levels and can mask





within-firm variation, this study treats the dimensions as contextual cues and focuses on enterprise practices in Guangxi metal processing (Al Thnayan & Alarifi, 2024).

ICT Competence

ICT competence comprises digital literacy, technical skills, relevant training, and contextual alignment, which are essential for applying digital tools in data-driven tasks (Neuvonen & Pecoraro, 2024). It supports the “5 Ds of Digital”, namely devices, platforms, media, data, and technology, each requiring domain-specific capabilities (Stratedia, 2024). Small and medium-sized enterprises depend on these skills to manage SEO, social media, and automation, yet effective application requires more than access, since hands-on experience with tools such as CRM and analytics software is crucial (Sharabati et al., 2024; Royle & Laing, 2014). Within the acceptance path, higher ICT competence can lower perceived effort and raise the instrumental value of digital tools, which strengthens perceived ease of use and perceived usefulness during training and adoption.

Organizational alignment is key. When digital skills match strategic goals, firms gain agility, innovation, and improved outcomes (Wang, Park, & Gao, 2025). Structural barriers need to be addressed to ensure task technology fit, and workforce engagement, and true transformation requires embedding ICT competence within organizational culture and vision to enable long-term, value-driven innovation (Gajanova & Michulek, 2023; Westerman, Bonnet, & McAfee, 2014). Low competence heightens difficulty and obsolescence risk, weakening uptake and slowing adoption by shaping beliefs about usefulness and ease. Treating ICT competence as a belief antecedent clarifies its role relative to infrastructure and policy, while variation across roles and units limits generalization.

Conceptual Foundation for Policy Support Factors in Digital Adoption

The Technology Organization Environment (TOE) framework (Tornatzky & Fleischer, 1990) offers a structured lens for analyzing digital adoption and highlights the environmental role of public policy. Through regulatory clarity, infrastructure investment, and standardization, policy shapes readiness for cloud computing, big data, the Internet of Things, blockchain, and intelligent systems, including AI, VR, and AR (Zhu & Kraemer, 2005). In practice, policies that support cloud computing and big data strengthen infrastructure and cybersecurity and enable scalable deployment models such as hybrid clouds (Zhang et al., 2010). National data centers and open data initiatives expand access to analytical resources and are complemented by workforce development programs that address skills gaps in data science and strategic decision making (Wang et al., 2018). Policy measures also enable the Internet of Things and the industrial internet by fostering connectivity such as 5G, interoperability, and real-time integration (Li et al., 2018). Emerging technologies such as blockchain and AI benefit from regulation that promotes transparency, ethical use, and legal certainty (Dwivedi et al., 2021). Overall, the framework





underscores the need for policy alignment with organizational tasks and contexts to mitigate resistance, improve digital readiness, and support sustainable transformation.

The framework concentrates on the organizational level context, so it may not capture individual motivation or learning. In this study, policy support is treated as a contextual factor that clarifies task technology fit and prepares conditions for training and adoption, while other determinants are addressed in their respective sections. This positioning justifies the use of the framework for specifying policy and infrastructure conditions without conflating them with individual-level processes.

Self-Determination Theory (SDT)

Self Determination Theory (SDT) explains human motivation through a continuum of autonomy that ranges from amotivation to intrinsic and extrinsic motivation (Deci & Ryan, 2000). Extrinsic motivation is further categorized into external, introjected, identified, and integrated regulation, which reflect varying degrees of internalization and personal alignment (Ryan & Connell, 1989). This framework provides a nuanced understanding of how motivation drives behavior in organizational contexts, especially when adaptability and sustained engagement are required. To apply SDT empirically, Gagné et al. (2010) developed the Multidimensional Work Motivation Scale, which captures six types of motivation that include two intrinsic types, learning and accomplishment, and four extrinsic types, external, introjected, identified, and integrated regulation. Identified and integrated forms, representing autonomous motivation, are consistently linked to enhanced performance and well-being, whereas controlled forms, external and introjected, often correlate with stress and disengagement (Deci & Ryan, 2008; Vansteenkiste et al., 2005). The scale thus offers a reliable tool for assessing work motivation across cultural and organizational settings. While Self Determination Theory highlights internal regulation and autonomy, it offers limited guidance on task structure and infrastructure constraints. In this study, the perspective is used to explain engagement and effort, while contextual conditions are specified through constructs addressed in other sections (Deci & Ryan, 2000; Deci & Ryan, 2008).

Table 1 Summary of constructs and expected effects

Construct	Primary theory anchor	Expected link to the acceptance path	Expected effect
Cultural dimensions	Hofstede, 2011; Hofstede, 2001; Khatri, 2009; Tarhini et al., 2017; Huang et al., 2018	Antecedent to perceived ease of use through norms on authority, participation, and uncertainty	Positive where culture supports learning and participation





Construct	Primary theory anchor	Expected link to the acceptance path	Expected effect
ICT competence	Venkatesh & Bala, 2008	Antecedent to perceived ease of use through skills and self-efficacy	Positive
Policy support for task technology fit.	Tornatzky & Fleischer, 1990; Zhu & Kraemer, 2005; Legris, Ingham, & Collette, 2003	Antecedent to perceived usefulness through alignment of tools with tasks	Positive
Intrinsic and extrinsic motivation	Deci & Ryan, 2000; Venkatesh & Davis, 2000	Antecedent to perceived usefulness and perceived ease of use through engagement and effort	Positive

In this study, the principles of Self Determination Theory guide motivation strategies for training and management in Guangxi metal processing. Autonomy supportive design with meaningful choice and goal setting strengthens intrinsic motivation, while competence support through scaffolding, digital practice, and timely feedback builds confidence and persistence. Clear standards and recognition align extrinsic motivation with desired skill use. Within the acceptance path, intrinsic and extrinsic motivation shape beliefs about usefulness and ease, and in turn contribute to employee management and training effectiveness; Table 1 summarizes the constructs and expected effects that guide the framework and hypotheses.

Conceptual Framework and Research Hypotheses

This study proposes a conceptual framework to assess digital adaptability in Guangxi metal processing. The model comprises four antecedents, namely cultural dimensions, ICT competence, policy support for task technology fit, and intrinsic and extrinsic motivation, which relate to employee management and training effectiveness, conceptualized as a second-order construct. It specifies direct paths from all antecedents to the outcome and indirect paths whereby culture, ICT, and policy support act through motivation to influence that outcome, as illustrated in Figure 1.

H1: Culture dimensions positively influence employee management and training effectiveness.

H2: ICT competence positively influences employee management and training effectiveness.



H3: Policy support for task-technology fit positively influences employee management and training effectiveness.

H4: Intrinsic and extrinsic motivation positively influence employee management and training effectiveness.

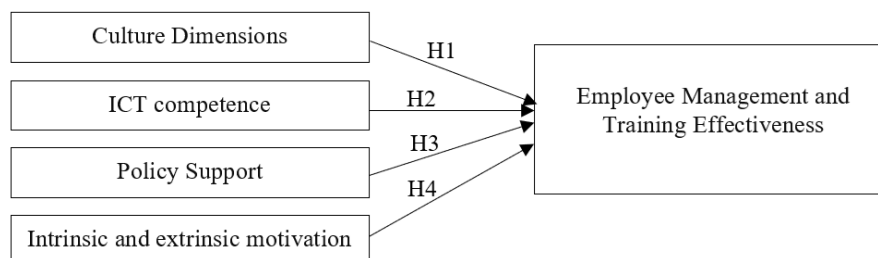


Figure 1 Conceptual Framework of the Proposed Model

Methodology

Research Design

This study uses a cross-sectional quantitative design to examine the effects of organizational and motivational factors on employee management and training effectiveness in Guangxi metal processing. Structural Equation Modeling is the primary analytical approach because it estimates multiple relations simultaneously, represents latent constructs, and reduces measurement error. This capability aligns with the complex relationships specified in the conceptual framework.

Population and Sample

The target population comprises employees in Guangxi metal processing enterprises. A minimum sample size of 385 was calculated using Cochran's formula (1977) with a 95 percent confidence level and a 5 percent margin of error. Data were collected through non-probability convenience sampling. Professional networks were used to identify employees in selected enterprises, and email invitations were sent directly to those employees. A total of 411 valid responses were obtained, which exceeds the minimum requirement. The sample included 50.1 percent male and 49.9 percent female respondents. Convenience sampling facilitates access in a specialized industrial setting but may introduce sampling bias that limits generalizability. Future studies can strengthen rigor by using stratified or random sampling and by reporting robustness checks such as sensitivity analysis or bootstrapping.

Research Instruments

The survey instrument consisted of six sections, namely demographics, culture dimensions, ICT competence, policy support, intrinsic and extrinsic motivation, and training effectiveness. All items were drawn from validated sources and rated on a five-point Likert scale. Cultural dimensions were measured using Hofstede's framework (Hofstede, 2011; Huang et al., 2018;



Tarhini et al., 2017). ICT competence followed Neuvonen and Pecoraro (2024) and covered digital literacy, skills, training, experience, and contextual fit (Stratedia, 2024; Wang, Park, & Gao, 2025). Content validity was assessed by three experts using the index of item objective congruence, yielding an overall IOC of 0.81, and a pilot with 30 participants was conducted. Cronbach's alpha exceeded 0.90 for all constructs.

Employee management and training effectiveness was operationalized as a second-order construct reflected by four acceptance dimensions, namely perceived usefulness, perceived ease of use, attitude toward using, and behavioral intention to use, each measured with five-point Likert items from validated sources. Representative items included "You feel that ICT technology increases your productivity" and "You feel that ICT technology allows you to work faster and more efficiently" for perceived usefulness, "You feel that ICT technology is easy to use and understand" and "You feel that you do not have to spend a lot of time learning to use ICT technology" for perceived ease of use, "You find the use of ICT technology fun and exciting" and "You are confident that ICT technology will benefit your work" for attitude toward using, and "You intend to learn and use ICT technologies in your future work" and "You intend to support the use of ICT technologies in your organization" for behavioral intention to use. Linguistic clarity in the local context was addressed through expert review and pilot feedback to ensure comprehension and cultural appropriateness consistent with the validated scales cited above.

Data Collection Procedures

Data were collected in October 2024 through an online survey distributed via professional networks and email to employees in Guangxi metal processing enterprises. Participants received an information sheet and an informed consent form, and confidentiality was assured. A total of 411 usable responses were obtained using convenience sampling. To maximize participation within convenience sampling, invitations were disseminated broadly through professional networks and email. This distribution mode may introduce sampling bias and may underrepresent employees with limited digital access. The implications for generalizability are acknowledged in the limitations section.

Data Analysis Techniques

Data were analyzed using SPSS version 27 and AMOS version 28. Descriptive statistics summarized demographics and study variables. Confirmatory factor analysis assessed the measurement model using composite reliability, average variance extracted, and the Fornell-Larcker criterion, with thresholds of $CR \geq 0.70$, $AVE \geq 0.50$, and the square root of AVE exceeding inter-construct correlations (Fornell & Larcker, 1981; Brown, 2015). Structural equation modeling estimated the hypothesized paths, and model fit was judged by $\chi^2/df \leq 3$, CFI and TLI ≥ 0.90 , GFI



≥ 0.90 , and $RMSEA \leq 0.08$ (Kline, 2016; Brown, 2015). Given the self-report design, potential common method bias was considered when interpreting results.

Results

Respondent Demographics

Among 411 valid responses, gender was balanced at 50.1 percent male and 49.9 percent female. The largest age group was 31 to 40 years at 26.8 percent, followed by under 20 at 24.6 percent and 41 to 50 at 23.4 percent. In total, 42.8 percent were 30 or below, and 7.1 percent were over 50. Industry experience was diverse, with 29.2 percent reporting 6 to 10 years, 22.9 percent 16 to 20 years, and 1.9 percent more than 30 years. Educational attainment was high, with 34.1 percent holding a master's degree, 25.1 percent a vocational diploma, 20.4 percent a bachelor's degree, 14.8 percent secondary education, and 5.6 percent a doctorate. This profile suggests the capacity to engage with ICT-based training and motivation strategies in Guangxi metal processing. Sector-wide benchmarks were not available for direct comparison, so representativeness should be interpreted cautiously and will be contextualized where such statistics are accessible.

Measurement Model Assessment

This subsection evaluates the adequacy of the measurement model through confirmatory factor analysis (CFA), ensuring that the latent constructs are theoretically grounded and empirically supported. The model consists of five latent constructs: Cultural Dimensions (CD), ICT Competence (ICT), Policy Support (PSE), Intrinsic and Extrinsic Motivation (IEM), and Employee Management and Training Effectiveness (EMTE). Each construct was measured using multiple observed indicators adapted from validated instruments in prior studies.

Model fit was assessed using standard indices. The confirmatory factor analysis indicated excellent fit, with $\chi^2 = 265.615$, $df = 265$, $\chi^2/df = 1.002$, $GFI = 0.950$, $NFI = 0.972$, $TLI = 1.000$, $CFI = 1.000$, and $RMSEA = 0.002$. All indices meet or exceed commonly accepted benchmarks for structural equation modeling evaluation (Kline, 2011; Byrne, 2010; Hu and Bentler, 1999). These results confirm the structural adequacy of the measurement model and support proceeding to the structural path analysis.

Table 2 Fit Indices for the Confirmatory Factor Analysis

Fit Indices	χ^2	df	χ^2/df	GFI	NFI	TLI	CFI	RMSEA
Value	265.615	265	1.002	0.950	0.972	1.000	1.000	0.002



Construct Reliability and Convergent Validity

Convergent validity and internal consistency were evaluated using composite reliability and average variance extracted following Fornell and Larcker with benchmarks of $CR \geq 0.70$ and $AVE \geq 0.50$ (Fornell & Larcker, 1981). As shown in Table 3, all constructs met these criteria, with CR between 0.920 and 0.951 and AVE between 0.711 and 0.764. Each AVE exceeded its maximum shared variance, satisfying discriminant validity and the Fornell-Larcker criterion that the square root of AVE is greater than inter-construct correlations (Fornell & Larcker, 1981). Substantively, these results indicate that the measures capture their intended concepts consistently and distinctly within the context of employee management and training. The measurement model is therefore adequate for subsequent structural analysis.

Table 3 Construct Reliability and Convergent Validity

Constructs	CR	AVE	MSV	MaxR(H)
ICT Competence (ICT)	0.939	0.756	0.337	0.945
Culture Dimensions (CD)	0.920	0.743	0.322	0.928
Policy Support (PSE)	0.951	0.764	0.316	0.954
Intrinsic and Extrinsic Motivation (IEM)	0.936	0.711	0.340	0.940
Employee Management and Training Effectiveness (EMTE)	0.924	0.752	0.340	0.929

Discriminant Validity

1) Fornell–Larcker Criterion

Discriminant validity was first assessed using the Fornell-Larcker criterion, which requires the square root of AVE for each construct to exceed its correlations with any other construct (Fornell & Larcker, 1981). As shown in Table 4, all constructs meet this condition. For example, the square root of AVE for EMTE is 0.867, higher than its correlations with ICT at 0.580, CD at 0.567, PSE at 0.563, and IEM at 0.583.

Table 4 Discriminant Validity – Fornell–Larcker Criterion

	ICT	CD	PSE	IEM	EMTE
ICT	0.869				
CD	0.490	0.862			
PSE	0.536	0.495	0.874		
IEM	0.559	0.531	0.477	0.843	
EMTE	0.580	0.567	0.563	0.583	0.867

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

2) Heterotrait-Monotrait Ratio (HTMT)

Given the well-documented limitations of the Fornell–Larcker criterion in detecting insufficient discriminant validity, the HTMT ratio was also assessed. Following the threshold of 0.85 proposed by Henseler et al. (2015), the results in Table 5 indicate that all HTMT values fall below this cut-off. As HTMT is less susceptible to Type II error when constructs are closely related, these findings provide stronger evidence that the constructs are empirically distinct.

Table 5 HTMT Values Among Constructs

	ICT	CD	PSE	IEM	EMTE
ICT	-				
CD	0.488	-			
PSE	0.537	0.490	-		
IEM	0.559	0.529	0.476	-	
EMTE	0.579	0.573	0.571	0.586	-

Note: Values are HTMT ratios between constructs, and diagonal cells are empty because HTMT is defined only between constructs.

In summary, the combined evidence from CR, AVE, MSV, the Fornell-Larcker criterion, and the HTMT ratio supports the psychometric adequacy of the measurement model. Culture, ICT competence, policy support, and motivation are measured as distinct factors, which support the interpretation of unique effects in the structural analysis that follows.

Structural Model Assessment

This section evaluates the structural relationships among the latent constructs as hypothesized in the research model, using structural equation modeling (SEM). Figure 2 illustrates the standardized path coefficients among the proposed constructs, depicting the direct and indirect influences from culture dimension (CD), ICT competence (ICT), policy support (PS), and intrinsic and extrinsic motivation (IEM) on employee management and training effectiveness (EMTE).

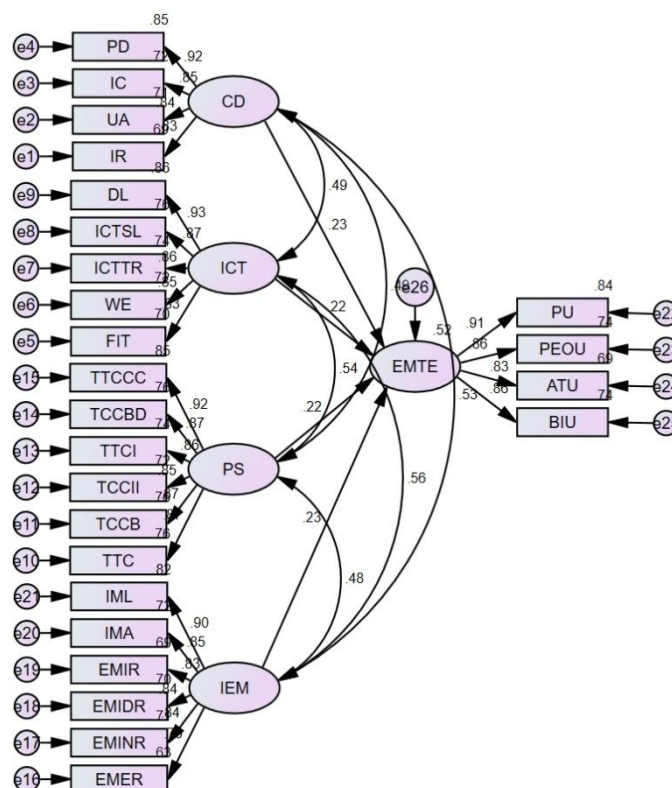


Figure 2 Path Coefficient Diagram

The standardized path coefficients and related statistics are presented in Table 6. All four hypothesized paths were positive and significant at p less than 0.001. The model accounted for 62.6 percent of the variance in EMTE, indicating substantial explanatory power.

Table 6 Path Coefficient Values

Hypothesis	Path	β	b	S.E.	C.R.	P
H1	CD $\rightarrow$ EMTE	0.226	0.245	0.056	4.395	***
H2	ICT $\rightarrow$ EMTE	0.220	0.253	0.061	4.165	***
H3	PS $\rightarrow$ EMTE	0.221	0.243	0.055	4.418	***
H4	IEM $\rightarrow$ EMTE	0.234	0.284	0.064	4.427	***

Note: β is the standardized estimate, b the unstandardized estimate, S.E. standard error, C.R. critical ratio, and *** indicates significance at $p < 0.001$.

Structural equation modeling results indicate that all four exogenous variables—culture dimensions (CD), ICT competence (ICT), policy support (PS), and intrinsic/extrinsic motivation (IEM)—exerted significant positive effects on employee management and training effectiveness (EMTE), with standardized path coefficients ranging from $\beta = 0.220$ to 0.234 (C.R. > 4.1, $p < 0.001$), thereby supporting Hypotheses H1–H4. Among these, IEM had the strongest effect ($\beta = 0.234$), followed by CD ($\beta = 0.226$), PS ($\beta = 0.221$), and ICT ($\beta = 0.220$). Although the coefficients are close in magnitude, the ordering suggests that motivational strategies may yield slightly greater gains. This finding is consistent with Self-Determination Theory, which underscores the importance of autonomous motivation for sustained employee engagement. Overall, the model explained 62.6% of the variance in EMTE ($R^2 = 0.626$), underscoring the critical role of cultural factors, digital competence, supportive policy, and motivation in enhancing training and management effectiveness.

Summary of Hypotheses

The structural model results demonstrated that all four hypothesized relationships (H1–H4) were supported at the 0.001 significance level, thereby confirming the robustness of the proposed theoretical framework.

Table 7 Summary of Hypothesis Testing

Hypothesis	β	Result
H1: Culture dimensions $\rightarrow$ employee management and training effectiveness	0.226	Supported
H2: ICT competence $\rightarrow$ employee management and training effectiveness	0.220	Supported
H3: Policy support $\rightarrow$ employee management and training effectiveness	0.221	Supported
H4: Intrinsic and extrinsic motivation $\rightarrow$ employee management and training effectiveness	0.234	Supported

Discussion

This study confirmed that intrinsic and extrinsic motivation (IEM), cultural dimensions, policy support, and ICT competence significantly influence employee management and training effectiveness (EMTE), with path coefficients ranging from $\beta = 0.220$ to 0.234 . IEM emerged as the strongest predictor, underscoring the centrality of motivation. The integrated framework draws on the Technology Acceptance Model (TAM), explaining how perceived usefulness and ease of use guide behavior (Venkatesh & Davis, 2000; King & He, 2006), and incorporates Self-Determination Theory (SDT) via the Multidimensional Work Motivation Scale (MWMS), highlighting autonomous motivation as a driver of engagement and knowledge transfer (Deci & Ryan, 2008; Gagné et al.,



2010). Hofstede's cultural dimensions—particularly power distance and collectivism—shape openness to innovation and collective learning (Hofstede, 2011), while policy support and ICT competence align with the Technology–Organization–Environment (TOE) model, reinforcing the role of regulatory clarity and organizational readiness (Zhu & Kraemer, 2005; Oliveira & Martins, 2011). Empirical evidence further confirms that skilled ICT personnel and supportive policies enhance innovation and continuous learning (Gangwar et al., 2015). Together, these constructs illustrate how motivation, culture, policy, and technology interact to promote EMTE, with autonomous motivation as a core driver and the remaining factors as key enablers in digital transformation.

The significant effect of cultural dimensions ($\beta = 0.226$) underscores the influence of power distance, uncertainty avoidance, and collectivism on employee responses to training and digital adoption, with participatory cultures fostering greater alignment and success (Hofstede, 2011). Policy support ($\beta = 0.221$), consistent with the TOE framework, highlights the importance of regulatory clarity, infrastructure, and risk management in sustaining digital transformation (Tornatzky & Fleischer, 1990). ICT competence, particularly in the context of Industry 4.0, enhances skill development, knowledge exchange, and innovation capacity, enabling firms with strong digital transformation competence—including technical, business, and meta-skills—to implement change more effectively (Bettiol et al., 2020). Empirical studies confirm that manufacturing SMEs with supportive policy environments and capability-building initiatives achieve superior transformation outcomes (Li et al., 2018), reinforcing Hofstede's and TOE's emphasis on the interplay between cultural and environmental enablers in driving digital success.

Although ICT competence had the lowest beta value ($\beta = 0.220$), its impact remains statistically significant and conceptually vital. Comprising digital literacy, targeted training, and contextual fit, ICT competence emphasizes that technology access alone is insufficient; organizational benefits emerge when employees apply digital skills effectively within job roles. Barba-Sánchez (2024) highlights that ICT capabilities enhance firm performance only when integrated with strategic goals and learning. Similarly, Wei and Shen (2025) report that digital transformation yields gains in sales, cost efficiency, and innovation, contingent on skill–role alignment. Chaffey and Ellis-Chadwick (2019) further stress that role-specific upskilling and experiential learning are essential for sustaining transformation. Therefore, organizations must embed ICT competence into daily operations through continuous, context-specific development to unlock meaningful digital value.

This study identifies intrinsic and extrinsic motivation (IEM) as the strongest predictor of employee management and training effectiveness ($\beta = 0.234$), affirming its central role in





organizational outcomes. Consistent with Self-Determination Theory (SDT), autonomous motivation—comprising intrinsic motivation and identified/integrated regulation—enhances commitment, adaptability, and learning engagement (Ryan & Deci, 2020; Van den Broeck et al., 2016). The Multidimensional Work Motivation Scale (MWMS) is widely recognized for measuring work motivation across different cultures, linking various forms of motivation to positive organizational outcomes (Ryan & Deci, 2017). To maximize these benefits, organizations should align extrinsic incentives with employees' intrinsic goals, provide meaningful feedback, and support autonomy, thereby enhancing digital adoption, employee retention, and workforce resilience.

Research Contributions

This study integrates TAM, SDT, Hofstede's cultural dimensions, and the TOE perspective to explain employee management and training effectiveness in digital transformation. Culture, ICT competence, and policy support act as antecedents shaping perceived ease of use and perceived usefulness, while motivation is the most proximal driver. The unified view links individual mechanisms from SDT with organizational and policy conditions in an industrializing region. Structural results show all four predictors are significant, with motivation having the largest standardized effect.

The findings guide practice. Autonomy supportive training with meaningful choice and shared goal setting strengthens engagement. Scaffolded digital practice and timely feedback build competence. Task-specific upskilling aligned with standard procedures, cultural alignment through leadership communication and peer coaching, and clear policy signals help link tools to outcomes. When resources are constrained, prioritizing motivation levers can yield slightly greater gains while continuing ICT skill development and policy alignment.

Conclusion

This study examined factors that shape employee management and training effectiveness in the digital transformation of the metal processing sector. Using structural equation modeling within an integrated framework that draws on TAM, SDT, Hofstede's cultural dimensions, and the TOE perspective, the analysis showed that culture, ICT competence, policy support, and intrinsic and extrinsic motivation each have significant positive effects on effectiveness. Motivation had the largest standardized effect, and the model explained 62.6 percent of the variance in effectiveness. These findings underscore the importance of aligning technology with organizational culture, policy, skills, and employee motivation to improve training outcomes in digital environments and to support sustained transformation.





Recommendation

Drawing on structural results with all paths significant and motivation strongest, the following actions are recommended

- 1) Organizations and HR emphasize motivation-centered design with meaningful choice and shared goal setting, short digital practice with feedback, peer mentoring and supervisor coaching, and recognition for applied tool use;
- 2) Line managers and teams align culture with digital work by linking tools to team goals, running cross-functional improvement groups, holding open forums, and protecting practice time.
- 3) Policymakers and industry associations provide targeted SME subsidies, tax incentives tied to upskilling hours, shared training centers with access to industrial software and equipment, and clear task tool guidelines;
- 4) ICT capability building delivers role-based curricula aligned with standard operating procedures, microlearning anchored in production data, on-the-job drills, and protected learning time with progress tracking.

Limitations and Future Research Directions

This study uses a cross-sectional design, a single regional industry, and convenience sampling, which limits causal inference and generalizability. Self-reported single-source data raise risks of measurement error and common method variance, and unobserved factors may induce endogeneity despite good model fit.

Future work should employ longitudinal or experimental designs to track change over time and to identify causal mechanisms. Multi-source and multi-method data that combine employee surveys with supervisor ratings and administrative records can reduce the same source bias. To address endogeneity, use instrumental variables, lagged predictors, or panel-based specifications. Assess measurement invariance across groups such as age, tenure, firm size, and enterprise type, and use stratified or probability sampling to improve representativeness. Extend the model to test mediation by motivation and moderation by policy support, and incorporate leadership, organizational support, and digital readiness to explain variation in training and adoption across sectors and regions.

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