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Human Capital Capability and Digital Transformation in Enhancing SME Performance: A System Dynamics Perspective

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Abstract: Small and medium enterprises (SMEs) are expected to use digital technology while maintaining business performance. However, technology investment does not automatically produce better results. The benefits of digital transformation depend on whether employees have the knowledge and skills needed to use technology, whether the organization can learn from digital information, and whether improved performance creates resources for further development. This study develops a system dynamics model to explain the interaction between human capital capability, digital transformation, and SME performance. A systematic literature review is used to identify the main variables and causal relationships, followed by causal loop and stock-flow modelling. The proposed model contains reinforcing and balancing feedback structures. The reinforcing loop shows how human capital development can strengthen digital capability, learning, innovation, and performance, which in turn can increase resources for further capability development. The balancing loop captures the digital skill gap that may slow transformation when technology develops faster than employee capability. The model provides a basis for scenario simulation and future empirical validation using SME data.

Keywords: Human Capital Capability, Digital Transformation, SME Performance, System Dynamic, Digital Capability, Organizational Learning

INTRODUCTION

Digital transformation has become an important part of how small and medium enterprises compete, serve customers, and organize their daily activities. SMEs use digital tools for marketing, payments, customer communication, bookkeeping, production, and decision-making. Yet the presence of technology alone does not guarantee better performance. Research on SME digital transformation shows that outcomes depend on organizational capability, strategic alignment, learning, and the firm's ability to absorb and use technology effectively (Sagala & Óri, 2024; Kallmuenzer et al., 2025).

Human capital is central to this process because digital systems are used by people. Employees and managers need digital knowledge, problem-solving skills, willingness to learn, and the ability to adjust work routines. Evidence from SMEs indicates that managerial human

capital can support innovation and productivity, while recent research on digital transformation identifies human resources as both an enabler and a possible constraint of transformation (Bananuka et al., 2022; Kaiser & Kanbach, 2026).

The problem becomes more complicated when digital transformation is viewed over time. An SME may invest in technology today, improve some processes tomorrow, generate better performance later, and then use the additional resources to invest again in people and technology. At the same time, technology can develop faster than employee skills, creating a digital skill gap that can reduce the benefits of the investment. These feedback relationships are difficult to capture with a simple linear model (Kurniawan et al., 2021; Arranz et al., 2023).

System dynamics is useful for this type of problem because it represents feedback, accumulation, delays, and changing behavior over time. Previous research has used system dynamics to study SME digitalization and has shown that skills development, digital adoption, and organizational resources can interact dynamically (Kurniawan et al., 2021). More recent research also emphasizes that SME digital transformation is a capability-building process rather than a one-time technology adoption decision (Saeedikiya et al., 2024; Paoloni et al., 2024).

Therefore, this study asks three questions: (1) how does human capital capability influence digital transformation in SMEs; (2) how do digital capability, organizational learning, innovation, and performance interact over time; and (3) how can these relationships be represented in a system dynamics model? The objective is to develop a transparent conceptual model that can later be calibrated with real SME data and tested under alternative management scenarios (Sagala & Öri, 2024; Saeedikiya et al., 2024).

Literature Review

Human Capital Capability

Human capital refers to the knowledge, skills, experience, and learning capacity carried by people in an organization. In SMEs, this resource is particularly important because owners and employees often perform several functions at the same time. Better human capital can therefore influence innovation, productivity, and the ability to adopt new ways of working (Bananuka et al., 2022).

Digital transformation increases the need for human capital because employees must understand new technologies and translate them into practical work. A recent systematic review of HRM in SME digital transformation concludes that human resources can become a strategic enabler, a source of innovation, a cultural mechanism, or a constraint when capability development is insufficient (Kaiser & Kanbach, 2026).

Digital Transformation and Digital Capability

Digital capability is the organization's ability to use digital resources in a repeatable and useful way. It is broader than individual digital skills because it includes routines, coordination, managerial decisions, and the ability to integrate digital tools with business processes. Empirical research on small businesses links digital capability with digital business transformation and business performance (Prakasa & Juman, 2024).

Digital transformation is broader than simply adopting software or hardware. It can change processes, customer relationships, decision-making, and the way value is created. A systematic review of technological transformation in SMEs identifies the connection between technology assimilation and business model innovation, while another review highlights the importance of incremental transformation and continuous learning (Paoloni et al., 2024; Sagala & Öri, 2024).

Dynamic Capabilities and Organizational Learning

Dynamic capability theory helps explain why SMEs with similar technologies can achieve different results. The ability to sense changes, seize opportunities, and reconfigure resources allows an organization to turn technology into action. Research on SME digital transformation shows that dynamic capabilities can strengthen the effect of digitalization on performance (Saeedikiya et al., 2024; Soluk et al., 2023).

Organizational learning connects human capital with digital transformation. Employees learn to use technology, managers learn from digital information, and the organization learns which processes need to change. When this learning becomes routine, it can support innovation and organizational adaptability (Arranz et al., 2023; Mendoza et al., 2024).

SME Performance

SME performance can include financial outcomes, productivity, customer outcomes, market development, and the ability to survive and adapt. Digital transformation can contribute to performance, but the relationship is not necessarily immediate or linear because capability development takes time and resources (Kallmuenzer et al., 2025).

Recent studies also show that digital transformation can improve SME performance through dynamic capabilities and innovation. This supports the use of an integrated model in which human capital and digital capability are treated as mechanisms rather than isolated predictors (Mustapha, 2026; Salim et al., 2025).

METHOD

This study uses a system dynamics research approach supported by a systematic literature review. The literature review identifies the main constructs, causal relationships, feedback mechanisms, and possible delays reported in research on human capital, digital transformation, dynamic capabilities, organizational learning, innovation, and SME performance. The system dynamics stage then translates these relationships into a causal loop diagram and a stock-flow structure (Sagala & Óri, 2024; Kurniawan et al., 2021).

The model follows four steps: problem definition, causal structure development, stock-flow formulation, and scenario analysis. At this stage, the model is conceptual rather than statistically calibrated. Parameter values used for future simulation should be estimated from primary SME data or validated expert estimates rather than treated as empirical findings (Arranz et al., 2023).

The model is intended for implementation in Vensim because Vensim is suitable for representing stocks, flows, auxiliaries, causal links, feedback loops, and time delays. The CLD in Figure 1 is the first representation of the model. The next modelling stage is to translate the causal structure into a stock-flow diagram and then test the model under different investment assumptions (Kurniawan et al., 2021).

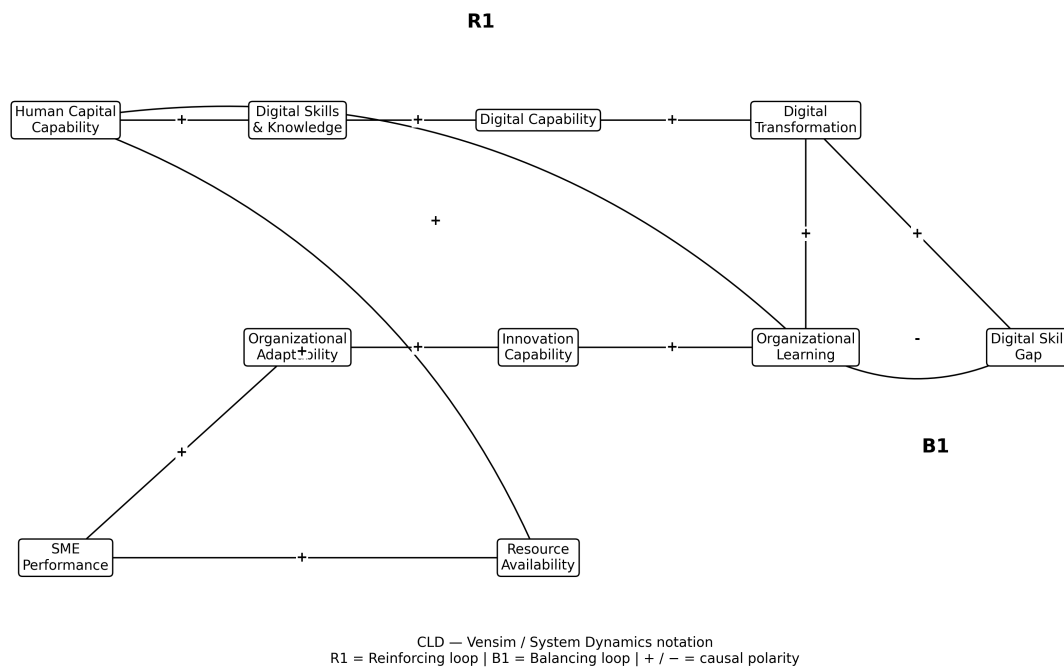


Figure 1. Causal Loop Diagram of Human Capital Capability and Digital Transformation in SME Performance.

Source: Author's synthesis based on Kurniawan et al. (2021), Arranz et al. (2023), Saeedikiya et al. (2024), and Kaiser and Kanbach (2026).

Model Structure

The reinforcing loop R1 begins with human capital capability. Better human capital supports digital skills, which strengthen digital capability and make digital transformation more effective. Digital transformation creates opportunities for organizational learning and innovation. These capabilities improve adaptability and SME performance. Better performance can increase resource availability for additional human capital development, closing the reinforcing loop (Bananuka et al., 2022; Saeedikiya et al., 2024).

The balancing loop B1 represents the digital skill gap. As digital transformation accelerates, the skills required to operate new technologies also increase. If employee capability does not grow at the same pace, the gap becomes larger. A larger gap can reduce the effective use of technology and slow organizational learning, creating a balancing effect (Kaiser & Kanbach, 2026; Sagala & Öri, 2024).

Main Variables and Proposed Model Logic

Variable	Type	Meaning in the model	Supporting references
Human Capital Capability	Stock	Accumulated employee and managerial knowledge and skills	Bananuka et al. (2022); Kaiser & Kanbach (2026)
Digital Capability	Stock/Auxiliary	Ability to use digital resources effectively	Prakasa & Jumanı (2024); Mendoza et al. (2024)

Digital Transformation	Flow/Auxiliary	Rate and intensity of organizational digital change	Paoloni et al. (2024); Sagala & Öri (2024)
Organizational Learning	Auxiliary	Ability to convert experience and data into improved routines	Arranz et al. (2023); Saeedikiya et al. (2024)
Innovation Capability	Auxiliary	Ability to turn knowledge and technology into new value	Bananuka et al. (2022); Rahman et al. (2024)
SME Performance	Stock/Outcome	Accumulated business performance resulting from capability and transformation	Kallmuenzer et al. (2025); Salim et al. (2025)
Digital Skill Gap	Auxiliary	Difference between required and available digital capability	Kaiser & Kanbach (2026); Sagala & Öri (2024)
Resource Availability	Auxiliary	Resources available for further people and technology investment	Arranz et al. (2023); Kurniawan et al. (2021)

Source: Author's synthesis from the literature cited in the table.

Model Formulation

The model is formulated around accumulated capability rather than a single-period relationship. Human capital capability increases through training, experience, knowledge sharing, and learning, but it can decline when skills become obsolete or employees leave. Digital capability increases through technology adoption and practice, while its effectiveness can be reduced by the digital skill gap (Kurniawan et al., 2021; Kaiser & Kanbach, 2026).

A simple stock-flow formulation for human capital capability is: $\text{Human Capital}(t) = \text{Human Capital}(t-dt) + (\text{Human Capital Development} - \text{Skill Depreciation}) \times dt$. This equation is a modelling structure, not an empirical estimate. The same logic can be used for digital capability and organizational performance, with parameters later estimated from real SME observations (Arranz et al., 2023).

The digital transformation rate can be represented as a function of technology investment, digital capability, and management support, reduced by the digital skill gap. The performance improvement rate can depend on digital capability, innovation capability, and organizational adaptability. These relationships should be calibrated and validated before the model is used for prediction (Saeedikiya et al., 2024; Al-Surmi et al., 2024).

Scenario Design

Three scenarios are proposed for future Vensim simulation. The baseline scenario represents limited investment in human capital and digital technology. The moderate scenario assumes balanced and gradual investment. The high-investment scenario assumes stronger investment in both capability development and digital technology. The purpose is not to declare

one scenario as universally best, but to observe how different investment paths change model behavior over time (Sagala & Öri, 2024; Kallmuenzer et al., 2025).

Scenario	Human Capital Investment	Digital Investment	Expected model question
Baseline	Low	Low	How does performance behave with limited capability development?
Moderate	Medium	Medium	What happens when people and technology grow together?
High	High	High	What happens when transformation is accelerated while capability is also developed?

Source: Author's scenario design based on Sagala and Ori (2024), Kallmuenzer et al. (2025), and Saeedikiya et al. (2024).

RESULT AND DISCUSSION

The central message of the model is that human capital and digital transformation should be developed together. Digital technology provides tools, but people determine whether those tools become useful organizational routines. This interpretation is consistent with evidence showing that human capital and dynamic capabilities strengthen the relationship between digital transformation and firm performance (Kallmuenzer et al., 2025; Kaiser & Kanbach, 2026).

The reinforcing loop explains how capability development may have effects beyond the immediate training period. When employees become more capable, the organization can use technology better, learn faster, innovate more effectively, and improve performance. If performance releases additional resources, the organization can reinvest in people and technology, creating a positive feedback cycle (Bananuka et al., 2022; Arranz et al., 2023).

The balancing loop provides an important management warning. Digital transformation can move faster than human learning. If the skill gap becomes large, employees may underuse systems, make errors, or continue using old routines. Technology adoption and capability development should therefore be synchronized (Sagala & Öri, 2024; Kaiser & Kanbach, 2026).

The system dynamics perspective adds a time dimension. Instead of asking only whether digital transformation is associated with performance, managers can ask when the benefits appear, how long capability development takes, what delays exist, and which feedback loops strengthen or weaken transformation (Kurniawan et al., 2021; Arranz et al., 2023).

Theoretical And Managerial Implications

The theoretical contribution is the integration of human capital, digital capability, organizational learning, dynamic capability, and SME performance in a feedback-based model. Existing studies provide evidence for individual relationships, while system dynamics makes it possible to examine how these relationships interact over time (Saeedikiya et al., 2024; Mendoza et al., 2024).

For managers, technology investment should be evaluated together with employee capability. Before introducing a new system, management should identify who will use it, what skills are required, what training is needed, and which business indicator will show whether the investment is useful (Kaiser & Kanbach, 2026; Prakasa & Jumaní, 2024).

SMEs should monitor the digital skill gap as a management indicator. If technology adoption grows faster than employee capability, additional training and organizational learning may be needed before further technology expansion. This can reduce the risk of investing in systems that are not fully used (Sagala & Öri, 2024).

Limitations And Future Research

This paper presents a conceptual system dynamics model and does not claim that the proposed parameters have already been empirically estimated. The model should therefore not be treated as a forecasting tool until it has been calibrated and validated using primary SME data. This limitation is deliberate because invented coefficients would create a false appearance of empirical precision (Arranz et al., 2023).

Future research should collect longitudinal data on training expenditure, employee digital skills, technology investment, digital adoption, innovation activity, and SME performance. These data can be used to estimate parameters, conduct sensitivity analysis, validate the model, and run Vensim scenarios (Kurniawan et al., 2021; Saeedikiya et al., 2024).

CONCLUSION

Human capital capability and digital transformation should be understood as parts of the same SME development system. Human capital supports digital skills, digital skills strengthen digital capability, and digital capability enables digital transformation. Transformation can then stimulate organizational learning, innovation, adaptability, and performance (Bananuka et al., 2022; Prakasa & Jumaní, 2024).

The model contains two important feedback mechanisms. R1 is a reinforcing loop in which capability and performance strengthen each other through reinvestment. B1 is a balancing loop in which a growing digital skill gap can slow transformation when technology develops faster than employee capability (Kurniawan et al., 2021; Kaiser & Kanbach, 2026).

The model provides a foundation for future Vensim simulation and empirical validation. Its main value is to help researchers and managers understand how investment, learning, capability, technology, and performance interact over time.

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