

DISTRIBUTED LEADERSHIP COMPONENTS FOR CHINESE VOCATIONAL EDUCATION

Feifei PAN¹ and Thada SITHTHADA²

1 Student of Master in Educational Administration, Suan Sunandha Rajabhat University, Thailand; 335772606@qq.com

2 Graduate School, Suan Sunandha Rajabhat University, Thailand; Thada.si@ssru.ac.th

ARTICLE HISTOR

Received: 31 July 2026

Revised: 10 August 2026

Published: 28 August 2026

ABSTRACT

Technical and Vocational Education and Training (TVET) has become increasingly important in developing a highly skilled workforce capable of meeting the demands of Industry 4.0, digital transformation, and the knowledge economy. These rapid changes have created unprecedented challenges for vocational education institutions, requiring leadership approaches that extend beyond traditional hierarchical management. Distributed leadership has emerged as an effective model for enhancing organizational capacity by promoting shared responsibility, collaborative decision-making, and collective expertise. However, existing studies have primarily focused on distributed leadership within general education, while limited research has examined its application in vocational education, where close collaboration with industry, continuous curriculum innovation, and competency-based learning create distinctive leadership requirements. This conceptual study synthesizes distributed leadership literature and vocational education research to develop a context-specific framework for vocational education institutions. Drawing upon major leadership theories, including Distributed Leadership Theory, Activity Theory, Organizational Learning Theory, Distributed Cognition Theory, and Social Practice Theory, the study identifies eight interrelated components that underpin effective distributed leadership in Technical and Vocational Education and Training (TVET). These components comprise shared vision, collaborative decision-making, teacher leadership, professional learning communities, trust and organizational culture, communication and knowledge sharing, industry partnership and stakeholder collaboration, and innovation and digital leadership.

Keywords: Distributed Leadership; Vocational Education; Technical and Vocational Education and Training (TVET); Educational Leadership; Organizational Effectiveness

CITATION INFORMATION: Pan, F., & Siththada, T. (2026). Distributed Leadership Components for Chinese Vocational Education. *Procedia of Multidisciplinary Research*, 4(8), 49.

INTRODUCTION

Technical and Vocational Education and Training (TVET) has become a strategic component of national workforce development and economic competitiveness. The emergence of Industry 4.0, artificial intelligence, automation, digital technologies, and global economic integration has fundamentally transformed occupational skill requirements, compelling vocational education institutions to prepare graduates who possess not only technical competencies but also adaptability, innovation, problem-solving ability, and lifelong learning skills. Consequently, leadership has become a critical determinant of institutional effectiveness and educational quality. Unlike general education institutions, vocational education operates within a complex ecosystem involving governments, industries, employers, accreditation agencies, professional organizations, and local communities. Curriculum development, competency assessment, workplace learning, and graduate employability depend heavily on sustained collaboration among these stakeholders. As a result, leadership responsibilities increasingly extend beyond the formal authority of school principals and require active participation from teachers, department heads, industry experts, and external partners.

Traditional leadership models, characterized by centralized authority and hierarchical decision-making, are often insufficient to address the complexity and rapid change experienced by contemporary vocational education institutions. Modern educational organizations require leadership systems that promote collaboration, shared expertise, organizational learning, and continuous innovation. Distributed leadership has therefore emerged as a promising approach that conceptualizes leadership as a collective organizational practice rather than the responsibility of a single individual. Instead of concentrating leadership within formal administrative positions, distributed leadership encourages individuals to contribute according to their professional expertise and contextual knowledge.

Over the past two decades, distributed leadership has become one of the most influential perspectives in educational leadership research. Previous studies have demonstrated that distributed leadership contributes to teacher empowerment, professional collaboration, organizational learning, school improvement, and institutional sustainability. By distributing leadership responsibilities among multiple organizational members, schools can enhance decision quality, strengthen innovation capacity, and improve responsiveness to environmental change. Although distributed leadership has been widely discussed in educational research, most existing studies focus primarily on primary and secondary education or higher education. Comparatively little attention has been devoted to vocational education, despite its distinctive characteristics, including competency-based education, close industry collaboration, rapid technological development, and continuous curriculum renewal. These unique contextual factors suggest that distributed leadership in vocational education may involve specific leadership components that differ from those emphasized in general education settings. Accordingly, a comprehensive conceptual framework specifically designed for vocational education remains underdeveloped. Existing literature provides valuable theoretical insights into distributed leadership but offers limited guidance regarding the essential leadership components required for effective implementation within Technical and Vocational Education and Training (TVET) institutions. Addressing this gap is important because leadership practices that fail to consider the distinctive characteristics of vocational education may be less effective in responding to industrial transformation and workforce development demands.

LITERATURE REVIEW

1. Concept of Distributed Leadership

Distributed leadership has become one of the most influential leadership paradigms in educational administration because it views leadership as a collective organizational process rather than the responsibility of a single formal leader. Unlike traditional hierarchical leadership, distributed

leadership emphasizes the interaction of multiple organizational members who contribute according to their expertise, professional knowledge, and contextual experience. The theoretical development of distributed leadership has been shaped by several influential scholars. Gronn (2002) argued that leadership should be understood as a collective social process emerging through collaborative practice rather than individual action. Building on this perspective, Spillane, Halverson, and Diamond (2001), and later Spillane (2006), proposed that leadership practice results from interactions among leaders, followers, and situational contexts. Harris (2008) further emphasized that distributed leadership strengthens school improvement by empowering teachers and encouraging collaborative decision-making. Bolden (2011) subsequently highlighted the importance of organizational culture, trust, and professional relationships in supporting the distribution of leadership responsibilities.

Despite differences in emphasis, these perspectives share several common principles. First, leadership is distributed across multiple organizational members instead of being concentrated in formal administrative positions. Second, leadership responsibilities are allocated according to professional expertise rather than organizational hierarchy. Third, collaboration, shared responsibility, and collective decision-making are fundamental mechanisms through which leadership influences organizational performance. Finally, leadership is viewed as a dynamic organizational practice that evolves through continuous interaction among individuals and their working environment. Within vocational education, these characteristics are particularly significant because institutional effectiveness depends upon the collaboration of teachers, department heads, technical specialists, industry representatives, and external stakeholders. Consequently, distributed leadership provides an appropriate conceptual foundation for managing increasingly complex vocational education systems.

1.2 Theoretical Foundations of Distributed Leadership

Distributed leadership is supported by several complementary theoretical perspectives that explain how leadership emerges through organizational interaction, collective expertise, and continuous learning. Rather than relying on a single theory, distributed leadership integrates concepts from organizational studies, educational leadership, cognitive psychology, and social learning.

Distributed Leadership Theory (Spillane, 2006) provides the primary conceptual foundation for this study. It conceptualizes leadership as organizational practice produced through interactions among leaders, followers, and situational contexts. Leadership effectiveness therefore depends less on individual authority than on the quality of professional collaboration.

Activity Theory (Engeström, 1987) further explains leadership as collective activity mediated by organizational structures, cultural norms, and shared objectives. Within vocational education, curriculum development, workplace learning, and competency assessment require coordinated participation among teachers, administrators, employers, and government agencies, illustrating the collaborative nature of leadership practice. Distributed Cognition Theory (Hutchins, 1995) suggests that organizational knowledge is distributed across individuals rather than residing within a single leader. Educational improvement therefore depends upon integrating diverse professional expertise through communication, collaboration, and collective problem-solving. This perspective is particularly relevant to vocational education, where technical knowledge is shared among educators, engineers, industry specialists, and curriculum developers.

Organizational Learning Theory (Senge, 1990) emphasizes that successful educational organizations continuously generate, share, and apply knowledge to improve institutional performance. Distributed leadership facilitates this process by encouraging teacher leadership, professional learning communities, collaborative reflection, and continuous professional development. Finally, Social Practice Theory views leadership as a relational process embedded within everyday organizational activities. Leadership capacity develops gradually through professional interaction, mutual trust, and collaborative practice rather than through formal

delegation of authority alone. This perspective highlights the importance of organizational culture in sustaining distributed leadership.

Collectively, these theoretical perspectives demonstrate that distributed leadership is fundamentally characterized by shared expertise, collaboration, organizational learning, and adaptive decision-making. These characteristics closely align with the leadership requirements of vocational education institutions operating within rapidly changing technological and industrial environments.

Table 1. Major Theoretical Foundations Supporting Distributed Leadership

Theory	Principal Scholar(s)	Main Perspective	Relevance to TVET
Distributed Leadership Theory	Spillane (2006)	Leadership emerges through interactions among leaders, followers, and situations.	Supports collaborative leadership and shared expertise.
Activity Theory	Engeström (1987)	Organizational outcomes result from collective activity.	Explains collaboration among schools, industry, and communities.
Distributed Cognition Theory	Hutchins (1995)	Knowledge is distributed across individuals and organizational systems.	Encourages multidisciplinary teamwork and knowledge integration.
Organizational Learning Theory	Senge (1990)	Continuous learning improves organizational performance.	Promotes teacher professional development and innovation.
Social Practice Theory	Gronn (2002)	Leadership develops through everyday professional practice.	Strengthens collaborative culture and sustainable leadership capacity.

The integration of these theories indicates that distributed leadership extends beyond the delegation of administrative tasks. Instead, it represents an organizational capability that mobilizes collective expertise, supports continuous learning, and strengthens institutional adaptability. These theoretical foundations provide the basis for examining why distributed leadership is particularly suitable for vocational education institutions.

LEADERSHIP CONTEXT OF VOCATIONAL EDUCATION

Vocational education differs from general education because it is directly connected to workforce development, industrial innovation, and national economic competitiveness. Contemporary TVET institutions operate within environments characterized by rapid technological advancement, evolving occupational standards, and increasing expectations for graduate employability. Consequently, leadership must extend beyond school administration to include collaboration with employers, professional associations, government agencies, and community stakeholders. Several characteristics distinguish vocational education from other educational sectors. First, competency-based education requires continuous curriculum revision to reflect industrial standards and technological developments. Second, strong school–industry partnerships are essential for workplace learning, internships, curriculum design, and graduate employment. Third, digital transformation and Industry 4.0 technologies require institutions to integrate emerging technologies into teaching and learning while continuously upgrading teachers' technical competencies. Finally, vocational education involves multidisciplinary collaboration among educators, engineers, technicians, and industry practitioners, making collective leadership particularly important.

These characteristics create leadership challenges that are difficult to address through centralized administrative structures alone. Educational leaders must coordinate multiple stakeholders, manage organizational change, encourage innovation, and support continuous professional learning. Accordingly, vocational education requires leadership approaches that emphasize

collaboration, shared responsibility, trust, and organizational learning. Distributed leadership closely aligns with these requirements. By mobilizing the expertise of teachers, administrators, and external partners, distributed leadership enhances institutional flexibility, improves curriculum responsiveness, strengthens industry collaboration, and promotes sustainable organizational development. For these reasons, it represents an appropriate leadership approach for vocational education institutions responding to the demands of Industry 4.0 and the rapidly evolving labor market.

DISTRIBUTED LEADERSHIP COMPONENTS FOR VOCATIONAL EDUCATION

Based on the synthesis of distributed leadership literature and the distinctive characteristics of Technical and Vocational Education and Training (TVET), this study proposes an integrated conceptual framework comprising eight interrelated components. These components represent the organizational conditions required to establish effective distributed leadership in vocational education institutions. Rather than functioning independently, they operate as a mutually reinforcing system that strengthens organizational effectiveness, instructional quality, institutional innovation, and graduate employability.

1.Shared Vision

A shared vision provides the strategic direction for distributed leadership by aligning organizational members around common educational goals. Unlike traditional leadership models in which institutional vision is developed primarily by senior administrators, distributed leadership encourages teachers, middle managers, industry representatives, and other stakeholders to participate in formulating institutional priorities.

Within vocational education, a shared vision should integrate educational objectives with workforce development strategies, industrial expectations, and technological advancement. Such alignment ensures that curriculum reform, resource allocation, teacher development, and industry collaboration contribute to common institutional goals. A clearly articulated shared vision also promotes organizational commitment, strengthens employee engagement, and provides a foundation for sustainable school improvement.

2.Collaborative Decision-Making

Distributed leadership requires educational decisions to be made through professional dialogue rather than hierarchical authority. Collaborative decision-making enables administrators, teachers, curriculum specialists, and external stakeholders to contribute their expertise to institutional planning and problem-solving.

In vocational education, collaborative decision-making is particularly important because curriculum design, competency assessment, technology investment, and industry partnerships require multidisciplinary expertise. Inclusive participation improves decision quality, increases organizational transparency, and strengthens staff commitment to institutional objectives. Moreover, involving industry representatives in strategic planning helps ensure that educational programs remain responsive to changing labour-market demands.

3.Teacher Leadership

Teacher leadership is one of the central mechanisms through which distributed leadership improves institutional performance. Teachers possess practical knowledge of curriculum implementation, student learning, and occupational competency development that cannot be fully replaced by administrative leadership.

In TVET institutions, teacher leadership extends beyond classroom instruction to include curriculum development, mentoring colleagues, conducting classroom-based research, leading professional development activities, coordinating industry projects, and participating in institutional governance. Empowering teachers to assume leadership responsibilities not only

enhances instructional quality but also develops sustainable leadership capacity across the organization.

4. Professional Learning Communities

Professional Learning Communities (PLCs) provide the organizational structure through which distributed leadership promotes continuous learning and knowledge exchange. PLCs encourage teachers to collaborate through lesson study, peer observation, action research, collaborative curriculum design, and reflective practice.

Because vocational education operates within rapidly changing technological environments, teachers must continuously update both pedagogical knowledge and occupational expertise. Effective PLCs enable educators to share industrial experiences, evaluate instructional innovations, and collectively solve emerging educational challenges. Consequently, professional learning communities strengthen organizational learning while improving teaching effectiveness and curriculum relevance.

5. Trust and Organizational Culture

Trust represents the foundation upon which distributed leadership can be successfully implemented. Leadership responsibilities cannot be effectively shared unless organizational members perceive fairness, mutual respect, psychological safety, and professional support.

A collaborative organizational culture encourages open communication, collective responsibility, and willingness to participate in leadership activities. In vocational education, trust is equally important for maintaining productive relationships with employers, industrial partners, and community organizations. Institutions characterized by high levels of organizational trust are more likely to demonstrate innovation, professional collaboration, and sustainable improvement.

6. Communication and Knowledge Sharing

Effective communication facilitates collaboration by ensuring that organizational knowledge is exchanged efficiently across different professional groups. Distributed leadership therefore depends upon both formal and informal communication mechanisms that support collective learning and coordinated decision-making.

Within vocational education, communication extends beyond internal administrative processes to include continuous interaction with employers, professional associations, accreditation bodies, and government agencies. Digital communication platforms, collaborative planning meetings, professional workshops, and institutional knowledge-management systems all contribute to effective knowledge sharing. Such mechanisms strengthen organizational responsiveness and support continuous institutional improvement.

7. Industry Partnership and Stakeholder Collaboration

Industry partnership distinguishes distributed leadership in vocational education from leadership models commonly applied in general education. Vocational institutions rely extensively on collaboration with employers, industrial experts, professional organizations, and government agencies to maintain curriculum relevance and improve graduate employability.

Distributed leadership extends leadership beyond organizational boundaries by encouraging shared responsibility among internal and external stakeholders. Collaborative partnerships support curriculum development, workplace learning, internship programs, competency assessment, teacher industrial attachment, and technology transfer. Strong stakeholder engagement therefore enables vocational education institutions to respond more effectively to labour-market changes and emerging occupational requirements.

8. Innovation and Digital Leadership

Digital transformation has fundamentally reshaped vocational education by introducing advanced technologies, including artificial intelligence, automation, robotics, virtual simulation, cloud computing, and intelligent manufacturing systems. Consequently, distributed leadership must encourage innovation while supporting institutional digital transformation.

Innovation-oriented leadership promotes experimentation, continuous improvement, technology integration, and collaborative problem-solving. Rather than relying exclusively on administrative initiatives, distributed leadership enables teachers, technical specialists, and industry partners to contribute innovative ideas that enhance curriculum modernization and teaching practice. This collaborative approach strengthens institutional adaptability and improves organizational competitiveness within the rapidly evolving Industry 4.0 environment.

9. Proposed Conceptual Framework

The eight components identified above form an integrated leadership system rather than isolated organizational practices. Shared Vision provides the strategic foundation that aligns institutional goals and stakeholder expectations. Collaborative Decision-Making, Teacher Leadership, and Professional Learning Communities collectively develop internal leadership capacity by encouraging participation, shared expertise, and continuous professional learning.

These internal leadership processes are reinforced by Trust and Organizational Culture together with Communication and Knowledge Sharing, which establish the organizational conditions necessary for effective collaboration. At the organizational boundary, Industry Partnership and Stakeholder Collaboration connects vocational institutions with external environments, while Innovation and Digital Leadership enhances institutional adaptability by supporting technological integration and continuous improvement.

Collectively, these eight components contribute to enhanced organizational effectiveness through improved instructional quality, stronger professional collaboration, greater institutional innovation, more responsive curriculum development, and higher graduate employability. The framework therefore provides a comprehensive conceptual model for understanding how distributed leadership can strengthen leadership capacity within vocational education institutions.

Shared Vision

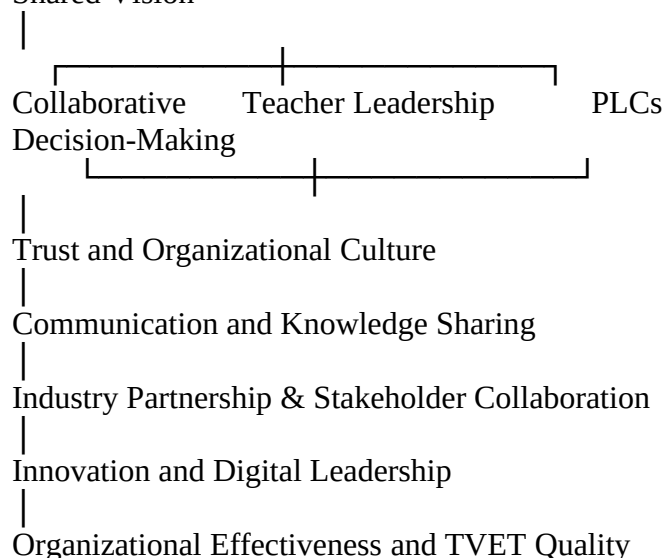


Figure 1. Proposed Distributed Leadership Framework for Vocational Education

DISCUSSION

This study developed a conceptual framework comprising eight interrelated components of distributed leadership specifically designed for Technical and Vocational Education and Training (TVET). While previous research has extensively examined distributed leadership within general educational settings, this study extends the literature by contextualizing distributed leadership within vocational education, where institutional effectiveness depends heavily on industry collaboration, technological innovation, and competency-based learning.

The proposed framework suggests that distributed leadership should not be interpreted merely as the delegation of administrative responsibilities. Instead, it represents an organizational capability

that mobilizes the collective expertise of teachers, administrators, technical specialists, industry practitioners, and other stakeholders. Leadership is therefore viewed as a collaborative process embedded within organizational routines, professional interactions, and continuous learning rather than as an individual attribute associated with formal leadership positions.

Compared with traditional hierarchical leadership models, the proposed framework emphasizes participation, shared responsibility, organizational trust, and collaborative decision-making. These characteristics are particularly important for vocational education because curriculum modernization, workplace learning, digital transformation, and competency assessment require multidisciplinary expertise that cannot be effectively coordinated by a single administrator. By distributing leadership responsibilities according to professional expertise, vocational education institutions can improve institutional responsiveness while strengthening organizational resilience in rapidly changing industrial environments.

A notable contribution of the framework is the inclusion of Industry Partnership and Stakeholder Collaboration together with Innovation and Digital Leadership as core components of distributed leadership. Although collaboration and teacher leadership have been widely discussed in previous educational leadership studies, relatively few conceptual models explicitly recognize external stakeholder engagement and digital transformation as essential dimensions of distributed leadership. In vocational education, however, these components are fundamental because institutional quality is closely associated with industrial relevance, technological capability, and graduate employability. Consequently, the framework expands existing distributed leadership theory by incorporating contextual characteristics unique to TVET institutions.

The framework also demonstrates that effective distributed leadership depends upon organizational conditions rather than isolated leadership behaviours. Shared vision, trust, communication, and professional learning communities create the organizational infrastructure through which collaborative leadership can be sustained. Without these enabling conditions, leadership responsibilities may be formally distributed but remain ineffective in practice. Thus, distributed leadership should be understood as a comprehensive organizational system in which structural, cultural, and relational factors interact to support institutional improvement.

Overall, the proposed framework provides an integrated explanation of how distributed leadership can enhance organizational effectiveness in vocational education. By combining internal leadership capacity with external stakeholder collaboration and innovation-oriented leadership, the framework offers a comprehensive perspective that responds to the leadership challenges created by Industry 4.0 and the digital transformation of vocational education.

THEORETICAL AND PRACTICAL IMPLICATIONS

1. Theoretical Implications

This study contributes to the distributed leadership literature in three important ways. First, it extends existing distributed leadership theory by positioning vocational education as a distinctive organizational context with unique leadership requirements. While previous conceptual studies have largely focused on general educational settings, this framework demonstrates that distributed leadership in TVET must integrate educational leadership with industrial collaboration and workforce development. Second, the study synthesizes multiple theoretical perspectives—including Distributed Leadership Theory, Activity Theory, Organizational Learning Theory, Distributed Cognition Theory, and Social Practice Theory—into a unified conceptual framework. Rather than relying on a single theoretical lens, the framework explains distributed leadership as an organizational capability emerging from interactions among people, organizational structures, and external environments. And Third, the proposed framework identifies eight integrated leadership components that provide a foundation for future empirical research. These components may serve as dimensions for developing measurement instruments and testing structural

relationships among distributed leadership, teacher professional development, organizational innovation, institutional effectiveness, and student outcomes in vocational education.

2. Practical Implications

The proposed framework also offers practical guidance for policymakers, educational administrators, and vocational education leaders. For policymakers, the framework provides a strategic reference for leadership development policies that emphasize collaborative governance, teacher empowerment, and industry engagement. Leadership development programmes should therefore focus not only on principals but also on middle leaders, teacher leaders, and professional learning communities.

For institutional leaders, the framework highlights the importance of establishing organizational cultures characterized by trust, open communication, shared decision-making, and continuous professional learning. Such environments encourage teachers and technical specialists to participate actively in institutional leadership and educational innovation. Finally, the framework underscores the importance of strengthening long-term partnerships with industry. Employers, professional associations, and community organizations should be recognized as strategic leadership partners rather than external stakeholders alone. Their active participation in curriculum development, competency assessment, workplace learning, and technological innovation is essential for maintaining the relevance and quality of vocational education.

CONCLUSION

The increasing complexity of vocational education requires leadership approaches capable of responding to rapid technological advancement, industrial transformation, and changing workforce expectations. Traditional hierarchical leadership models are increasingly insufficient for addressing these challenges because institutional success depends upon collaboration among educators, administrators, industry partners, policymakers, and other stakeholders. This study has proposed a conceptual framework comprising eight interrelated components of distributed leadership for vocational education: shared vision, collaborative decision-making, teacher leadership, professional learning communities, trust and organizational culture, communication and knowledge sharing, industry partnership and stakeholder collaboration, and innovation and digital leadership. Together, these components establish an integrated leadership system that strengthens organizational effectiveness, enhances instructional quality, supports institutional innovation, and improves graduate employability. The framework contributes to educational leadership scholarship by contextualizing distributed leadership within the distinctive environment of Technical and Vocational Education and Training. By integrating multiple theoretical perspectives with the organizational characteristics of vocational education, the study provides a comprehensive conceptual model that extends existing distributed leadership theory while offering practical guidance for leadership development in TVET institutions. Although the framework is conceptual, it establishes a foundation for future empirical investigation and leadership practice. Its application may assist vocational education institutions in developing more collaborative, adaptive, and sustainable leadership systems capable of responding effectively to the opportunities and challenges of Industry 4.0.

REFERENCE

- Bolden, R. (2011). Distributed leadership in organizations: A review of theory and research. *International Journal of Management Reviews*, 13(3), 251–269.
- Fullan, M. (2016). *The new meaning of educational change* (5th ed.). Teachers College Press.
- Hargreaves, A., & Fullan, M. (2012). *Professional capital: Transforming teaching in every school*. Teachers College Press.
- Harris, A. (2008). *Distributed leadership: According to the evidence*. Routledge.

- Harris, A. (2013). Distributed leadership: Friend or foe? *Educational Management Administration & Leadership*, 41(5), 545–554.
- Hutchins, E. (1995). *Cognition in the wild*. MIT Press.
- Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven strong claims about successful school leadership revisited. *School Leadership & Management*, 40(1), 5–22.
- OECD. (2021). *Teachers and school leaders as valued professionals*. OECD Publishing.
- UNESCO. (2021). *Reimagining our futures together: A new social contract for education*.
- UNESCO-UNEVOC. (2022). *Transforming TVET for successful and just transitions*. UNESCO-UNEVOC International Centre.
- UNESCO-UNEVOC. (2023). *Skills for a resilient future: Transforming TVET for sustainable development*. UNESCO-UNEVOC International Centre.
- World Economic Forum. (2023). *The future of jobs report 2023*. World Economic Forum.
- Yukl, G. (2013). *Leadership in organizations* (8th ed.). Pearson.
- Zhang, T., Tian, M., & Risku, M. (2023). Distributed leadership in education: A systematic review of recent research and future directions. *Educational Management Administration & Leadership*, 51(4), 789–809.
- Zhu, C., & Liu, A. (2024). Digital transformation and leadership in technical and vocational education and training: Challenges and opportunities. *Journal of Vocational Education & Training*, 76(2), 215–233.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.



Copyright: © 2026 by the authors. This is a fully open-access article distributed under the terms of the Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0).