

Comparative Analysis of China and Philippine TVET Systems: Implications for Agricultural and Biosystems Engineering and Smart Agriculture Development

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ABSTRACT:

The study focused on analyzing the structural and institutional characteristics of Technical and Vocational Education and Training (TVET) system in China; through this, it evaluated the potential replicability of China's TVET model within the Philippine context with a focus on Agricultural and Biosystems Engineering education, workforce development, and agri-industrial modernization. Using qualitative comparative research design, immersion-based learning from a 20-day international vocational education seminar in China, and document analysis of the National Technical Education and Skills Development Plan (NTESDP) 2023–2028 were utilized. The analysis was informed by frameworks from comparative education and policy transfer, focusing on seven dimensions: integration of industry–education system; lifelong learning and articulation of different systems; governance or institutional coordination strategy to align higher education with regional industrial transformation; digitalization and Industry 4.0; and legal/institutional foundations; and compatibility with Agricultural and Biosystems Engineering education systems. The study researched the applicability of these mechanisms to promising Agricultural and Biosystems Engineering areas including smart agriculture, agricultural mechanization, precision farming, food processing technologies, and sustainable rural development. Results show that the TVET System in China is characterized by its policy coherence, coordinated governance, integrated implementation mechanisms and institutionalized industry participation to support workforce and technology development. The results of the study confirmed the relevance of these institutional mechanisms to improve Agricultural and Biosystems Engineering through reinvigorated industry engagement, interdisciplinary training and integration of precision agriculture. In contrast, while the Philippines shows some similar policy directions, its fragmented governance system, uneven institutional capacity and limited responsiveness to labor-market demands pose important challenges. The transferability analysis revealed that industry–education integration, digital transformation and agricultural modernization are the areas most likely to be beneficial for improving Philippine Agricultural and Biosystems Engineering education systems. The research ends with a suggestion that in order to enable the successful transfer policy it will require

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collaborative governance, institutional capacity building, adaptive integration mechanisms and better partnerships between industry to facilitate sustainable agricultural modernization and rural workforce development.

Keywords: technical vocational education, policy transfer, comparative analysis, Agricultural and Biosystems Engineering, China, Philippines.

1. Introduction

The technical and Vocational Education and Training (TVET) is a key component in the development of workforce, economic growth and social mobility, as it is providing skills and competencies to the people which are relevant to the industry (Bautista & Lepran, 2026; UNESCO, 2021). The rise of a demand for skills that are flexible and future-proof, especially in the context of the fast-paced technological change, has strengthened the importance of investing in TVET systems as important contributors to sustainable development and labour market resilience at a global scale (World Bank, 2023; Wang, 2024). With this regard, China has become a global pioneer in vocational education reform, which is marked by high level of policy coherence, institutional integration, and industry involvement (Xu et al., 2024; Chen et al., 2025). The reforms illustrate the potential for the strategic integration of vocational education into the larger context of economic and industrial development to improve employment outcomes and workforce readiness. Based on recent observations from seminars, it can be seen that China's TVET system is integrated into a chain of interrelated mechanisms, such as industry–education integration, governance coordination, digitalization and legal institutionalization, which make it possible to align education and the labour market demand on a large scale (Chen & Ou, 2026; Wang, 2024). Furthermore, expanding demands at the global level for sustainable food systems and climate-resilient agriculture, along with precision farming as well as modernization of agri-industrial sectors have broadened the relevance of Technical and Vocational Education and Training (TVET) from limited industrial

domains to agriculture / biosystems engineering related fields. Agricultural and Biosystem Engineering (ABE) integrates the principles of engineering with biological, environmental, and agricultural systems to play a vital role in achieving food security by securing sustainable production; renewable energy systems; smart agriculture; postharvest technologies for more biofortified foods that are resilient against climate change (Food & Agriculture Organization, 2022; World Bank, 2023). The industry also requires reliable and technically competent human resources that are trained in mechanization, automation systems, agricultural and biosystems engineering intervention approaches as well as sustainable processing models based on data-driven agriculture.

For developing economies like the Philippines, however, the existing problems in TVET systems are still prevalent, such as skills mismatch, weak articulation of the TVET system, fragmented governance, and limited TVET participation in the industry (Asian Development Bank, 2021; Orbeta & Corpus, 2024). Despite the emphasis on lifelong learning and demand-driven training in national policies like the National Technical Education and Skills Development Plan (NTESDP 2023–2028), there are challenges in implementing these policies, including decentralized governance, unequal institutional capacity, and limited coordination mechanisms (TESDA, 2023; Edralin & Pastrana, 2023). These challenges make it difficult for the TVET system to effectively meet the changing demands of the labour market and the technological changes (Bascon et al., 2026).

Under such circumstances the issue is not if successful models can be transferred, but how they can be adapted in context-specific institutional environments. The transfer of practices is not considered to be a straightforward process, as the effectiveness of the transfer depends on governance arrangements, economic conditions and institutional capacity, not on the mere copying of practices (Minkman et al., 2018; Toepper et al., 2021). Therefore, a systematic and context-sensitive analysis of the elements of China's TVET system that can be used to guide TVET system reforms in the Philippines is needed.

China further integrates vocational education reforms with smart agriculture, digital farming technologies, agricultural mechanization, and rural revitalization initiatives, positioning technical education as an important component of agri-industrial modernization and sustainable rural development (Xu et al., 2024; Wang, 2024). These developments are highly relevant to Agricultural and Biosystems Engineering (ABE), a field that increasingly requires interdisciplinary competencies in automation systems, precision agriculture, renewable energy, food processing technologies, and biosystems innovation. Within the Philippine setting, however, challenges such as fragmented institutional coordination, limited digital infrastructure, weak industry-academe collaboration, and inadequate laboratory and technical training facilities continue to constrain the development of technically skilled human resources in agricultural and biosystems sectors (World Bank, 2023; Bautista & Lepran, 2026). Therefore, evaluating the compatibility and transferability of China's TVET mechanisms provides important insights for strengthening Agricultural and Biosystems Engineering education and workforce systems in the Philippines. This work brings two important contributions to the areas of comparative education and policy transfer: empirically informed understanding of the mechanisms, challenges and possibilities of policy transfer for vocational education reform in various institution and governance settings. It also contributes to the

efforts towards Sustainable Development Goal 4, specifically inclusive, equitable and quality education and lifelong learning opportunities (UNESCO, 2021).

The specific objectives to the study were to (1) identify and analyze important structural features and institutional characteristics of the national TVET system in China; (2) compare different aspects of the Chinese TVET systems with that of the Philippines; (3) examine some selected vocational education practices for their transferability based on a policy-transfer framework, consistent with evidence-based professional practice and theory; (4) assess whether or not such practices are amenable to successful adaptation within the educational sector and workforce system for Agricultural and Biosystems Engineering education; and lastly, (5) formulate a context-sensitive policy-adaptation approach to facilitate meaningful reform of both TVET as well as profitable agri-industrial programs in the Philippines.

2. Materials and Methods

2.1 Research Design and Data Sources

The approach used in this study was a qualitative comparative research design, using immersion-based learning and document analysis. The data for China was collected from a vocational education international seminar held in the People's Republic of China for a period of 20 days organized by the Jiangxi Vocational College for Foreign Studies (JXVCFS) under sponsorship of the Ministry of Commerce. The main data sources were lectures presentations, institutional case discussions, field observations, and policy oriented materials from experts and practitioners. They documented formal policy frameworks and industry-education integration models, governance coordination models, digitalization models, and system development models (Chen & Ou, 2026; Xu et al., 2024; Wang, 2024).

In the Philippines, data were taken from the National Technical Education and Skills Development Plan (NTESDP) 2023-2028 (TESDA, 2023), as the main policy-based

reference. These two different data sources allowed for a structured comparison of China's practice-based TVET system and the Philippines' policy-based system.

2.2 Theoretical and Analytical Framework

Guided by a mix of complementary frameworks (comparative education, policy transfer theory, and a TVET innovation framework), the comparative study adopted a three dimensional analysis based on comparative education-understanding structural and institutional variation between countries and policy transfer theory-examining the transferability of vocational education practices under different governance contexts (Minkman et al., 2018). Applying the TVET innovation framework helps explore key system-level influences for the reforms: industry-education linkage, digital technology uptake, governance coordination, and institutionalization.

Thematic analysis was used to guide the analysis of the qualitative data. Multi-stage thematic coding was undertaken to interpret the themes from the data. The process included; stage 1, open coding where important concepts, themes and comments were noted from the seminars, documents and policy data; stage 2, axial coding where related codes were grouped into themes according to their relatedness and patterns evident in the data; and stage 3, selective coding where the themes were consolidated into seven primary analytic dimensions, i.e. Industry-education integration, system articulation and lifelong learning, governance and institutional coordination, adjustment to industrial transformation, digitalization and industry 4.0, legal and institutional basis and compatibility of Agricultural and Biosystems Engineering Systems.

The dimensions were conceptualized as distinct yet interdependent factors within a socio-technical system which enabled capturing the integrated character of the TVET model in China (Xu et al., 2024). The coding process was performed iteratively and was always being

compared across data sources so that consistency and a clear conceptual understanding were maintained throughout the coding process. The process helped both the dominant patterns to emerge and the variations in the contexts to be noted.

The study also assessed the alignment between identified TVET mechanisms and changing needs of Agricultural and Biosystems Engineering (ABE). Selected TVET dimensions which may aid workforce preparation in areas such as smart agriculture, agricultural mechanization, biosystems automation, food and bioprocessing engineering; precision agriculture, renewable energy systems, and sustainable rural development were examined. A thematic adaptation of observations from the seminars, relevant institutional practices and policies allowed for an assessment of compatibility between principles and competencies needed in Agricultural and Biosystems Engineering.

2.3 Data Analysis Procedure

The steps of the analysis followed a logical flow. The first steps of the analysis involved identifying the main structural aspects of China's TVET system through observations made during the immersion period. These were then compared to those of the Philippine TVET system based on a review of the NTESDP 2023-2028 (TESDA, 2023). Then, a transferability study was carried out in which proposed practices from China were investigated for their applicability in the Philippine setting based on various factors such as the governance framework, institutional capacities, the economy and implementability. The gathered information were compiled to produce a contextually adapted policy transfer framework for Vocational Education.

The data gathered was synthesized into a context sensitive policy transfer and adaptation framework for TVET. A secondary thematic analysis was also performed to see how applicable these TVET practices are and whether they represent Agricultural and Biosystems Engineering education systems in the country.

This analysis focused on models for linking with industry, institutional coordination mechanisms, contemporary practices in engineering digital integration and governance structures that could support engineering-based agricultural education delivery and agri-industrial workforce preparation, technology transfer systems, and smart agriculture development within rural communities.

2.4 Research Rigor and Analytical Validity

In order to ensure the validity of analysis, data triangulation was used in the study from the three sources which were seminar materials, observation and policy documents (Figure 1). Reflective analytical approach was also used so that the findings could be interpreted in wide theory and policy framework. It helped reduce bias and increase the validity and reliability of analysis.

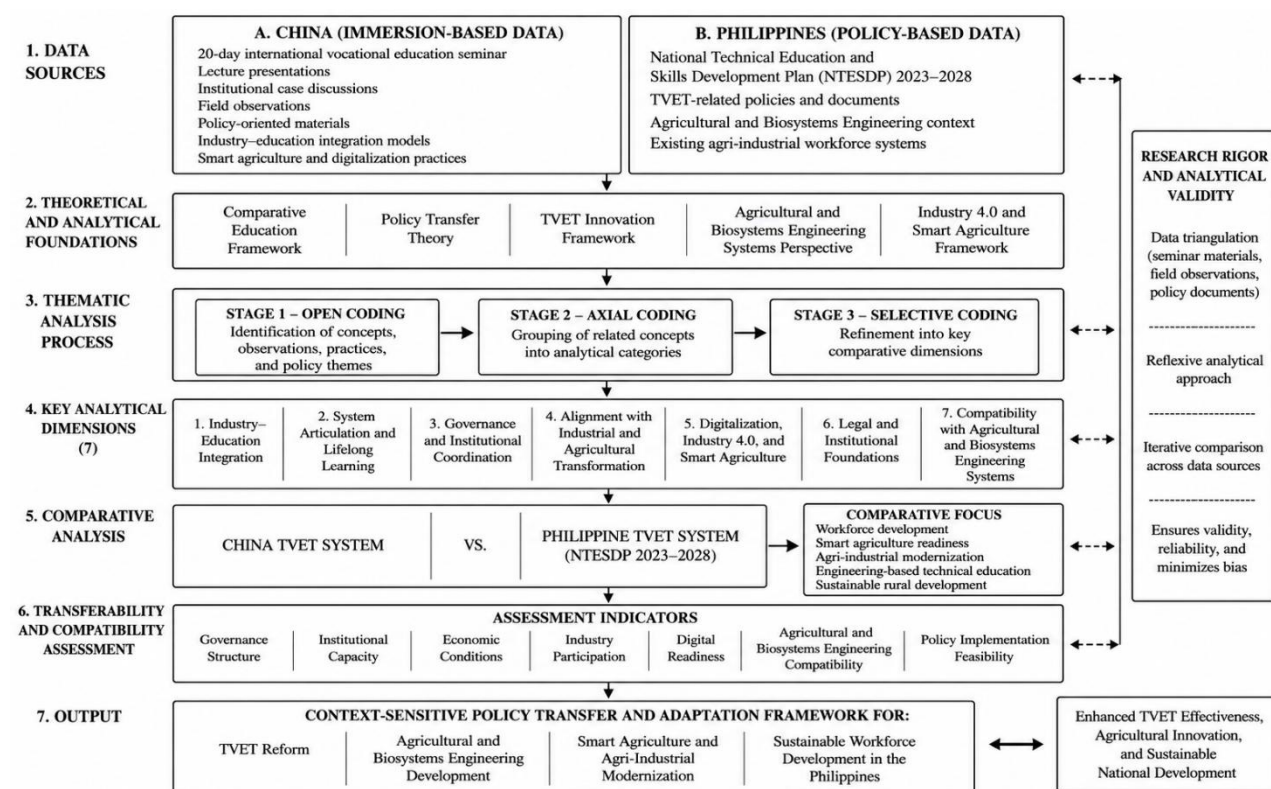


Figure 1. Conceptual framework of the study

The framework (Figure 1) illustrates this process of deploying an immersion-based learning, policy and comparative evaluation to analyze the transferability and applicability of selected technical vocational education training (TVET) practices to effective engineering-based agricultural and technology systems. This framework is grounded on comparative education; policy transfer theory, TVET innovation framework; and Agricultural and Biosystems Engineering systems perspectives. Thematic coding and comparative analysis identified seven central analytical dimensions:

industry–education integration; system articulation and lifelong learning; governance and institutional coordination; contours of industrial and agricultural transformation alignment; digitalization, Industry 4.0, smart agriculture; legal and institutional foundations, and compliance with Agricultural and Biosystems Engineering systems. Altogether these dimensions informed the transferability evaluation and a context-sensitive framework for policy adaptation in formulating TVET reform, smart agriculture integration, and sustainable

workforce development policy options within the Philippine contexts.

3. Results and discussion

The results confirm that there are seven connected dimensions in the Chinese TVET system that provide for such systemization: industry–education integration; industry–education integration, system articulation and lifelong learning, governance and institutional coordination, alignment with industrial transformation, digitalization and Industry 4.0, legal and institutional foundations, and compatibility with Agricultural and Biosystems Engineering systems. These dimensions are not just a reform project, but a system of mutual support mechanisms which allow Chinese government integrate the education, industry and policy to a large scale (Chen et al. 2025).

Compared with the TVET system of the Philippines (NTESDP 2023-2028), the seven dimensions demonstrate differences not only in structure but also in institutional logic, coordination ability, and mechanisms for implementation (TESDA 2023, Edralin & Pastrana, 2023). Although there is an equal pursue for employable ability, lifelong learning, industry alignment etc., the paths of execution differ greatly between two countries (Bautista & Lepran, 2026).

3. 1 Industry–education integration

In China, industry-education integration is defined as a government-managed system with firms integrated into the design, management and provision of vocational education (Chen & Ou, 2026). Firms, and enterprises contribute to the development of curriculum, the delivery of training, and the evaluation of training outcomes (Xu et al., 2024). It can eliminate information asymmetricness between training providers and employers, and the tightness of the link between training and the labor market is relatively high (Wang, 2024).

This is largely verified by direct field trips during the international seminar, where numerous

vocational institutes successfully implement well-institutionalized school-enterprise cooperation modes. The modes observed were "factory-in-school" and "school-in-factory" where training premises imitate real industrial environments and firms collaborate with schools in administering training (Chen et al., 2025). Vocational institutions also apply work-study integration and apprenticeships, so that skills training aligns well with actual industry demands (Xu et al., 2024). It represents much more than a typical intern program, but an organized participation of industry in education provision (Chen & Ou, 2026). The mode of school-enterprise cooperation reflects how the Chinese state applies the principle of industry-education integration not just at the policy level but at a physical, managerial, and curriculum level, bridging the education and employment gap (Wang, 2024). Theoretically, this conforms to a well-coordinated market economy where state intervention seeks to cut down the coordination failures between education and business (Minkman et al., 2018), which helps reduce skill mismatch and skills readiness (Bautista & Lepran, 2026).

On the other hand, TVET in the Philippines focuses on enterprise based training (TESDA, 2023). The recent research and studies further present that the challenges in the enterprise based training in the Philippines still persist, for instance, limited participation of firms, weak incentives for firms' participation, and the disconnect between training provided and industry demands (World Bank, 2025; Orbeta & Corpus, 2024; Bascon et al., 2026). There is a disparity between policy design and its implementation, there are no binding institutional frameworks in the Philippines (Edralin & Pastrana, 2023).

The above observation shows that although the objectives of the two systems are linking industry and TVET institutions, China has already established close linking with industry through institution embedded while the

Philippines only depends on government policy promotion.

Similar integration mechanisms can also provide a solid foundation for Agricultural and Biosystems Engineering-related education and training systems in China. The school through the cooperation with enterprise to carry on the simulation of real industrial and agricultural production environment as far as possible, let students be exposed to actual situation close to the practice processing service environment of actual operation. This could reinforce excellence in areas such as agricultural mechanization, smart irrigation systems, automations, food technology and precision agriculture. It can enhance the technical readiness of the Agricultural and Biosystems Engineering graduates as well as narrow down the industry-academia gap in a Philippine setting (Xu et al., 2024; Chen & Ou, 2026). Khan et al. (2025), stressed that smart agriculture and industry oriented engineering education needs interconnection between educational institutions and industries to help enabling agricultural modernization and work-force development.

3.2 System Integration and Lifelong Learning

The design of China's TVET system is expected to break down the hierarchal division between vocational and academic education, providing for vertical and horizontal progression routes (Xu et al., 2024). This serves the purpose of positioning TVET as a non-terminal path to integrate it into the whole lifelong learning system (Wang, 2024). In addition to the structural articulation mechanisms described above, field investigations revealed that China further encourages its TVET participants through the implementation of the financial supports system, flexible admission policies, and national skill competitions that facilitate participation both on the access and motivation side (Chen et al., 2025). The described mechanisms create a more pluralistic and flexible ecosystem for talent development. In addition, such articulation allows individuals to reskill and adapt their work force skills to technological change in the era of

Industry 4.0, enabling continuous learning among workers (Bautista & Lepran, 2026).

Within the Philippine setting lifelong learning is also stressed in the National Technical Education and Skills Development Plan (NTESDP) 2023-2028 (TESDA, 2023). Recent evaluation suggests, however, that while the concept is being implemented, implementation challenges regarding integration of system, inter-agency collaboration, and operationalization of lifelong learning pathways are present (Generalao et al., 2025). There is emerging evidence, however, that despite the improvement of policies, lack of system coherence between education and training providers and the lack of clarity and consistency in program articulation continue to pose obstacles in learning mobility and skills development (World Bank, 2023; Orbeta & Corpus, 2024).

Lastly, the poor implementation of integrated qualification frameworks and credit transfer schemes remains a critical structural obstacle to mainstreaming lifelong learning and ensuring the flexibility of the labor force (Generalao et al., 2025). The limited actualization of these constraints limits the possibilities for mobility between levels of education and for responsiveness of TVET system to the changes in the demand of the labor market (Edralin & Pastrana, 2023). These show that the policies align more with the global trends of lifelong learning but failed in the sense that they do not always translate well with the actual systems (UNESCO, 2021). This is in contrast to China which actualizes mobility via embedded and integrated systems, while the Philippines has already been advancing mobility but not actually creating the structures for mobility.

Similarly the concept of lifelong learning and system integration are most applicable to Agricultural and Biosystems Engineering with rapidly changing agricultural technologies. To adjust to new technologies like precision farming, digital surveillance systems, renewable energy technologies and automated pieces of land cultivation machinery equipment, agricultural

workers and technicians require ongoing reskilling and technical upgrade (Ronzhin, et al., 2025 ; Karunathilake, et al., 2023, Okolie, et al., 2020). Thus, improving articulation pathways and flexible learning systems in TVET can be a strong measure to sustain the agricultural skills needed for technology adoption at rural level in the long run.

3.3 Governance and Institutional Coordination

The governance structure for TVET in China presents a model of centrally guided but locally administered coordination. This allows for policy coherence while ensuring flexibility at the implementation level (Xu et al., 2024). This system integrates coordination across different sectors and reduces fragmentation by reconciling national objectives with actual practices in institutions (Chen et al., 2025). From a theoretical perspective, this system resembles network governance under a hierarchical structure; Coordination occurs both through regulatory power and through cooperation (Minkman et al., 2018).

Another finding from the seminar showed that governance not only covers administrative control but is now extending to institutional innovation and mechanisms of multi-level coordination. Vocational institutions now operate under integrated structures of linkages between government institutions, enterprises, educational institutions, and expert committees, specifically established for the advancement of vocational education (Chen & Ou, 2026). On one hand, modern governance characterized by digital platforms and decision-making based on data processing, improve on monitoring, evaluating, and adjusting policies to make adjustments based on data (Wang, 2024). On the other hand, this particular structure of governance facilitates the alignment of vocational education with industrial transformation. Field studies of vocational institutions in their linkage with industries have shown the existence of professional training bases associated with booming industries, for instance, advanced manufacturing, robots, e-commerce, logistics and

culture industries (Xu et al., 2024). Moreover, the implementation of national strategies like rural revitalization programs through vocational education makes vocational institutions a tool of achieving local economic development (Chen et al., 2025). The combination of these qualities makes the Chinese TVET system a means to carry out industrial transformation by placing the development of human capital within broader national policies for industry and the local region (Wang, 2024).

Unlike the Philippine TVET framework, the governance is composed of multi-stakeholders that include the Technical Education and Skills Development Authority (TESDA), Department of Education (DepEd), Commission on Higher Education (CHED), industries and other stakeholders (TESDA, 2023). Even though such system offers an inclusive atmosphere for stakeholders, some reviews noted issues with the coordination, duplication of function among institutions, and inconsistency of policy implementation under decentralized governance structure (Generalao et al., 2025; Edralin & Pastrana, 2023).

Recent data also point out that insufficient labor market information systems, disintegrated data-sharing arrangements, and poor inter-agency coordination still limit the ability to plan skills and match workforce. The World Bank (2023) and Orbeta & Corpus (2024) observed that governance gap still translates national policy into institutional actions. Besides the differences show a contrast on governance structure. While China addresses the fragmentation through coordination and aligning mechanisms, the Philippine system, though having multi-stakeholder and participatory governance structures still suffers from decentralized implementation, weak integration of governance structures and institutional capacity of actors (Minkman et al., 2018). This is another point why strong coordination mechanisms and governance integration have to be achieved to boost the impact of TVET reform in the Philippine setting.

The governance and coordination mechanisms observed in China have significance for Agricultural and Biosystems Engineers systems, specifically by enforcing synergy among academic institutions, agricultural industries, research agencies, and local government units. This institutional coordination has a powerful impact in favoring agricultural extension services, technology transfer, innovation in agri-industrial and workforce development strategies responsive to regional agricultural demand (Rivera & Alex, 2004; Davis et al., 2010). Additionally, effective interactions between government, academic and business actors promote the modernization of agriculture and sustainable land-use practices (Yan, 2023).

3.4 Alignment with Industrial Transformation

The development of the Chinese TVET system is rooted in the framework of its wider industrial policy, enabling the training system to be designed in correspondence with national economic policies and regional development goals (Xu et al., 2024; Wang, 2024). This approach aligns with the idea of institutional embeddedness, where the education system is structurally connected to the economy as a part of the production processes and the labor market requirements (Chen et al., 2025). Thus, the vocational training system has been transformed into one component that works with and serves the national economic strategy. The regional strategy of the development of training system serves this purpose as well, tailoring training programs based on specific requirements of the regional economy (Chen & Ou, 2026). It has been identified through field research at the vocational schools and integrated vocational-enterprise training centers, that a number of vocational training centers are equipped with targeted training bases of emerging industries, such as advanced manufacturing, robotics, e-commerce, logistics, culture industry, etc. (Xu et al., 2024).

Furthermore, TVET are subsumed in the wider program of regional development. Programs such as rural revitalization combine TVET systems with community-based economic

activities (Chen et al., 2025). This process allows TVET institutions to not only serve the goal of human capital development and occupational training but also contribute to the sustainability of local economy. Overall, the mechanisms shown above suggest that China TVET system acts as a policy tool to facilitate economic development process where the development of human capital are tied closely to industrial and regional policy goals (Wang, 2024).

In the Philippines, the National Technical Education and Skills Development Plan (NTESDP) 2023-2028, promotes similarly area-based and demand-driven skills development in response to labor market requirements (TESDA, 2023). Nonetheless, recent evidence showed that achievements have been mixed in employment matching, job quality and sectoral matching, even though policies have made progress (World Bank, 2023; Generalao et al., 2025).

More recent assessments also reveal that weak links between training providers and industry, slow responses to new industries, and deficiency in labor market information systems limit the effectiveness of the demand-driven training approach (Generalao et al., 2025; Orbeta & Corpus, 2024). Further, weaknesses in the institutional capacity and coordination between different regions limit the ability of TVET system to respond to localized industrial demands, causing varied implementation of area-based approach (Edralin & Pastrana, 2023). Based on the findings above, although the Philippine TVET strategy is aligned in terms of its intended goal towards industrial development, the strategy seems to be constrained by its operational limitations (World Bank, 2025). China has stronger performance because the TVET strategy is embedded within the economic system through the strengthened coordination of institutions, thereby strengthening the linkage between skills development and industry policy (Minkman et al., 2018). It also points to the fact that aligning education with industry does not only depend on intent but on institutional strength, coordination

mechanisms, and implementation capacity as well (Bautista & Lepran, 2026).

The challenges of integrating vocational education with transformation of industries and agriculture also has critical ramifications to Agricultural & Biosystems Engineering. In the context of China, technical and vocational education and training (TVET) has been integrated into rural revitalization and smart agriculture initiatives following suit for its potential to underpin sustainable agricultural modernization, climate-smart farming systems, agricultural automation, renewable energy utilization alongside postharvest engineering innovations (Wang 2024; Karunathilake et al, 2023). This possible integrated approach can be a development model for enhancing engineering-based agricultural education in the Philippines, with its focus on training future professionals equipped to respond existing and emerging climate vagaries, as well as support technology-driven sustainable agrarian reforms and modernized agriculture sector.

3.5 Digitalization and Industry 4.0

The adoption of digital technologies in China's TVET reforms appears to be a system-wide transformation covering curriculum design, teaching process, and governance (Xu et al., 2024; Wang, 2024). Digitalization itself is not an extra element but an intrinsic part of the system which strengthens the scalability and manageability of the teaching and makes TVET more agile to adapt to the requirements of Industry 4.0 (Chen & Ou, 2026). The data collected during the seminar indicate that many cutting-edge technologies such as artificial intelligence, intelligent teaching platforms and digital administration systems are adopted by many TVET institutions in their teaching and administrative work (Wang, 2024). By doing this, the data-driven decisions can be applied for dynamic curriculum adjustments, performance evaluations and industrial adaptation (Xu et al., 2024). A system-wide transformation approach has been used which covers not only classroom teaching but also the institutional administration

and policy practice (Chen et al., 2025), thus building an adaptive learning system based on a continuous feedback loop (Wang, 2024).

Digital transformation has been acknowledged as equally important in the Philippine context in strengthening reskilling and upskilling as it addresses technological disruption (TESDA, 2023), though implementation is challenged by infrastructure constraints, uneven access to technology, and uneven capacity among institutions (Edralin & Pastrana, 2023). As it appears, recent reports also find that the country remains weak in digital readiness in terms of lack of digital infrastructure, limited connectivity especially in rural areas, and imbalanced development of digital skills, that impedes successful adoption of digital transformation in education and work system (World Bank, 2025).

These limitations point to the need for a step-by-step and participatory approach to digitalization in the Philippines. These will focus on establishing the basics (infrastructure, capacity building, and accessibility) prior to full system integration (UNESCO, 2021). These discrepancies highlight that both nations recognize the strategic advantage of digitalization; however, the differences in their readiness and capacity differ vastly leading to different speed of implementation (B Bautista & Lepran, 2026).

The mechanisms of digital transformation have noticeable counterparts in Agricultural and Biosystems Engineering, including sensors, automation systems, artificial intelligence (AI), geographic information systems (GIS), Internet of Things (IoT) and precision agriculture technologies (Karunathilake, et al., 2023; Khan et al., 2025; Li, 2025). These technologies when integrated into vocational education may strengthen wider adoption of a smart farming workforce development approach; automated agricultural machinery, environmental sensing systems (including weather pattern forecasting), and agricultural data analytics all come into play here. Yet, as with the larger TVET system they face significant challenges in terms of infrastructure, availability and readiness of digital

services, and access to technology that constrain their operation (World Bank, 2023). According to UNESCO (2021), engineering values, equitable access to technical education and digital technologies have become imperative for an inclusive and sustainable workforce transition in Industry 4.0.

3.6 Legal and Institutional Foundations

Another key feature of China's TVET reforms is the established legal framework, which has served as a guarantee for the continuity of policies, integrity of institutions, and co-ordination of implementation (Chen et al. 2025). They clearly delineate strategic directions and set concrete requirements, responsibilities, and accountabilities among the stakeholders involved within the TVET system (Wang, 2024). In this context, legal frameworks are essentially governing tools shaping the conduct of institutions and underpinning a lasting reform endeavor (Minkman et al., 2018). It is within the scope of a seminar discussion where the importance of the Vocational Education Law of the People's Republic of China (2022) was highlighted, which legally entrenched the critical reform measures, such as the integration of industries and education, professional development of teachers and modernization of system (Chen & Ou, 2026). It institutionalizes and normalizes these reform concerns as strategic imperatives for the development of the national economy rather than a marginalized pathway for education (Xu et al., 2024). The law institutionalizes procedures for the distribution of funds, restructure of institutions and development of a quality assurance system thus making TVET system more resilient and sustainable (Wang, 2024). In institutional terms, these provisions eliminate the element of uncertainty and ensure both commitment and commitment to implementing the policy across the nation (Minkman et al., 2018).

Similarly, the TVET system in the Philippines has a legal and policy framework composed of Republic Act No. 7796 (TESDA Act) and NTESDP 2023-2028 (TESDA, 2023), that

identifies national priorities and provides guidance for skills development. Nevertheless, coordination between agencies and the execution of policies create hurdles in the enforcement of these legal regulations which result in inconsistent applications across regions (Generalao et al., 2025; Edralin & Pastrana, 2023).

In general, it can be observed that despite both countries having a formal legal framework for TVET, China's enforcement is considerably better than that of the Philippines (World Bank, 2023). Therefore, legal provisions alone are not adequate to enhance TVET's effectiveness; there must be mechanisms for coherent governance, coordination, and execution of the policy (Minkman et al., 2018).

It is also important for Agricultural and Biosystems Engineering development and agricultural modernization initiatives to have strong legal and institutional foundations. Intelligent agriculture and agri-industrial transformation programs may also be more sustainable in the longer-term if backed by policies that strengthen technical education, digital infrastructure, research collaboration and agricultural innovation systems. In this sense, better policy coordination and more effective institutional enforcement mechanisms in regard to engineering-based agricultural development and technology-driven rural innovation may be among the types of support that catalyze resilience in the country's agriculture sector.

3.7 Transferability Assessment and Policy Adaptation Framework

Deriving from the comparisons across the six dimensions presented, a context-aware policy transfer and adaptation framework is set as an analytical output of this research. It takes in the structural features in the Chinese TVET system and applies it to the Philippines context through transferability factors such as the governance structure, institutional capability, economic condition and implementability of policies (Toepper et al., 2021). This follows closely to the

theories of policy transfer that stress policy transfer success heavily reliant on suitability with context, and not copying without considering context (Minkman et al., 2018).

Analysis of the data shows that industry-education alignment and fit with industrial transformation has high transferability (Table 1) since both components already have already been included in Philippine policies but there is a need

to deepen the institutionalization, enforcement mechanisms and industry involvement to have the same outcomes (TESDA, 2023; World Bank, 2025). Digitalization is also moderately transferable as identified in earlier sections where implementation of digitalization is affected by limited infrastructure, unequal digital capacity, and institutional imbalances (Edralin & Pastrana, 2023; World Bank, 2025).

Table 1. Transferability Assessment of China's TVET Practices to the Philippine Context

TVET Dimension	Key Practice (China)	Transferability Level	Rationale (Philippine Context)
Industry–Education Integration	Institutionalized industry participation (e.g., school–enterprise co-management)	High	Strong policy alignment under NTESDP, but constrained by limited firm participation, weak incentives, and lack of binding mechanisms for industry engagement
System Integration and Lifelong Learning	Seamless vertical and horizontal mobility pathways	Moderate	Policy frameworks exist, but limited by fragmented delivery systems, weak articulation across sectors, and incomplete implementation of credit transfer and qualification frameworks
Governance and Institutional Coordination	Centralized and coordinated governance system	Low	Structural incompatibility due to decentralized, multi-agency governance, compounded by coordination gaps, weak labor market intelligence, and uneven regional implementation
Alignment with Industrial Transformation	Integration with regional and national industrial strategies	High	Conceptually aligned with NTESDP, but constrained by weak industry linkage at local levels, limited responsiveness to emerging sectors, and inconsistent regional implementation capacity
Digitalization and Industry 4.0	System-wide digital integration and smart learning platforms	Moderate	Applicable but limited by infrastructure gaps, digital divide, uneven digital skills development, and varying institutional readiness
Legal and Institutional Foundations	Strong legal enforcement and policy continuity	Moderate	Legal frameworks exist, but effectiveness is constrained by weak enforcement, inter-agency coordination challenges, and inconsistencies in policy implementation

In the other hand, systems integration and life long learning can be transferred at moderate levels because there is still an existing fragmented delivery systems and little application of credit transfer mechanism, poor systems coordination (Generalao et al., 2025, Orbeta & Corpus, 2024), the transferability is weak due to systems coordination and institutional linkages between sectors are weak, the transferability of governance and institutional co-ordination are weak due to difference in fundamental structures: highly centralized coordinated model in China compared to fragmented multi-agency coordination system in the Philippines (Minkman et al., 2018), the problem with labor market intelligence, institutional coordination and regional execution capabilities (World Bank, 2023). And finally, legal and institutional basis is transferred at moderate level due to existence of well-structured policies in the Philippines but are undermined by poor execution and coordination among agencies (Edralin & Pastrana, 2023).

In sum, the study confirms that effective policy transfer is not merely replication, but adaptation, where selected practices need to be compatible with the local institutional context (Minkman et al., 2018). This framework emphasizes the importance of good governance coordination, institutional capacities and the integration of systems and institutions if the TVET reforms are to be effectively implemented and scaled up in the Philippines (Bautista & Lepran, 2026).

The transferability analysis points to the fact that although many aspects of China's TVET system show significant prospects of transferability, effective application in the Philippine setting requires reinforcing institutional capability, coordination among different stakeholders and effective policy implementation (Table 1). This reconfirms that policy transfer is selectively adapted rather than universally replicated.

Assessment of this transferability shows that many of the practices found in China could potentially be effectively implemented in a systems approach to Agricultural and Biosystems Engineering education and technical training

systems in the Philippines. In particular, instituting industry participation, integrating digital learning and updating with regional industrial transformation would reinforce agricultural mechanization programs, agri-industrial processing systems (AIPS), biosystems innovation and smart agriculture. But for effective adaptation to take place, better coordination now at the institutional level, investment in lab and digital infrastructure, stronger industry partnerships and increased capacity among academic institutions and local government units are needed (Bautista & Lepran, 2026; World Bank, 2023). Institutional readiness, interdisciplinary technical training, and mechanism for long-term policy support is an essential precursor to sustainable implementation of smart agriculture systems (Karunathilake et al., 2023).

3.8 Synthesis

The analyses carried in this study demonstrate the highly coordinated institutional arrangements that characterize China's TVET system, which result in faster skills formation, greater industry alignment and better labour market outcomes (Wang, 2024; Chen & Ou, 2026). Also supported by recent studies, coordinated governance and integrating training systems with industry are successful in improving skills mismatch and readiness of the workforce (Bautista & Lepran, 2026; Minkman et al., 2018).

In comparison, the Philippine TVET system operates in far more complicated institutional context of fragmented governance, institutional plurality and variable implementation capacity (Edralin & Pastrana, 2023). Despite national plans like the NTESDP 2023–2028 that promote a focus on lifelong learning, aligning education with industry needs, and strengthening demand-driven training programs, challenges such as fragmented delivery systems, weak skills-labor market matching or labor market intelligence, limited industry participation and policy implementation that is uneven across regions persist (World Bank 2023; Generalao et al., 2025).

The comparative analysis also shows that the success of TVET systems rests on the degree of match between governance structures, industry or private sector buy-in and policy implementation mechanisms (Bautista & Lepran, 2026). China experience shows how complementary institutional arrangements can provide effective responses to rapid industrial transformation under the all-round challenge of Industry 4.0 (Xu et al., 2024; Wang, 2024). On the other hand, the Philippine experience shows how hard it can be to institutionalize similar reforms in a decentralized and under-resourced setting (World Bank, 2025; Edralin & Pastrana, 2023).

The synthesis also highlights that the strength of China's TVET system does not lie in any one reform mechanism but through an integrated socio-technical framework of coordinated governance, institutionalized industry participation, lifelong learning pathways, digital transformation and policy continuity. Altogether, these mechanisms build responsiveness of the workforce technology and industrial competitive edge. These dimensions are also particularly relevant to Agricultural and Biosystems Engineering, especially as enablers of smart agriculture, agricultural mechanization, precision farming, and renewable energy systems that facilitate agri-industrial modernization. The results also imply that policy transfer cannot be understood as straightforward transposition, but should rather be seen as a context-sensitive adaptation process influenced by existing institutional frameworks, political economies and governance modes (Minkman et al. 2018; Toepper et al., 2021) Evidence shows that successful education reforms in developing economies depend on context-appropriate approaches, balancing the needs for policy coherence and institutional adaptability to be effectively implemented over time, at scale, and with positive learning effects (UNESCO, 2021). It thus stresses that the reform of TVET is a continuous and context-specific exercise. To make TVET systems in the Philippines, more efficient, responsive and scalable for youth (World Bank, 2023; Generalao et al., 2025),

authorities should strengthen institutional coordination, introduce greater coherence between governance arrangements with the conflicting nature of skills provision and labor markets within it, larger industry engagement and solid labour market intelligence systems.

3.9 Limitations

This study is constrained by qualitative observation and document review; findings might not reflect all stakeholder perceptions and need to be analyzed carefully. The more significant structural dissimilarities in governance models, macroeconomic indicators and availability of data between China and the Philippines make it difficult to compare them directly. Direct empirical assessment from Agricultural and Biosystems Engineering institutions, agricultural industries, or rural workforce stakeholders did not enhance the assessment of compatibility and transferability in this study as well. Future research employing a mixed-method design involving in-depth interviews with stakeholders, tracer studies, survey analysis and quantitative workforce indicators could provide more robust empirical evidence upon which to base policy change and TVET reform.

4. Conclusions

The Chinese vocational education system exemplifies effective alignment of education with the labor market through strong policy coherence, industry linkages and coordinated governance but these have to be adapted not adopted directly in the Philippine setting as both the institutional capacity and the structures in the country differ. The analysis reiterates that to achieve effective TVET reform, a system level harmonization of policy, governance and industry is needed along with context sensitive implementation and continuous monitoring. Through presenting an adaptive policy transfer framework, this study further adds to the global discourse on TVET reform and contribute to the attainment of the SDG4 as it advocates for inclusive, equitable quality education and life-

long learning in addressing the skills gap and enhancing the workforce development in the developing countries. The results additionally underscore the notable significance of TVET reforms and institutional collaboration mechanisms to Agricultural and Biosystems Engineering education and workforce development. A culture of industry exposure, digital technologies and smart systems alongside well-coordinated governance structures may be more effective in prepping future professionals for agricultural mechanization, biosystems automation, food and bioprocess engineering rehabilitation of renewable energy systems and precision agriculture. In the Philippine setting, these mechanisms can reinforce sustainable agricultural modernization, climate-smart food systems, rural innovations and agri-industrial competitiveness. In conclusion, the study suggests that stylized adaptive and responsive TVET reforms merged with fundamentals of Agricultural and Biosystems Engineering may play a strategic role in the SMART agriculture paradigm, sustainable workforce renewal, as well as long-term rural and national development for nation-building in the Philippines.

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