VTE VOCATION, TECHNOLOGY & EDUCATION

CASE STUDY

Innovation and practice of industry education integration under belt and road: Case study on experiential, work-based, apprenticeship programs

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ABSTRACT

The Belt and Road Initiative (BRI) has significantly advanced Malaysia's connectivity and economic development through large-scale infrastructure projects. However, a critical yet often overlooked dimension of the BRI is the alignment of workforce development with the evolving skill demands and long-term sustainability of these initiatives. This study examines the integration of three industry-education models: experiential learning, work-based learning (WBL), and apprenticeships, as strategic mechanisms for bridging the gap between higher education and industry. These models aim to strengthen workforce readiness by equipping graduates with practical, industry-relevant competencies. Drawing on a case study of bachelor-level technology programs at Malaysia's technical universities, developed in partnership with key industry stakeholders, the study illustrates how structured academia-industry collaboration can cultivate a skilled, adaptable, and globally competitive workforce. Ultimately, such integrative approaches contribute to Malaysia's national development objectives and align with the broader human capital goals of the BRI.

Key words: Belt and Road Initiative, industry-education integration, experiential learning, work-based learning, apprenticeships

INTRODUCTION

The Belt and Road Initiative (BRI) is China's ambitious strategy to enhance global economic integration through two main corridors which are the Silk Road Economic Belt and the 21st Century Maritime Silk Road. These corridors aim to connect Asia, Europe, and Africa *via* expansive infrastructure networks and thereby foster collaboration in trade, logistics, technology, education, and development. As a result, BRI is reshaping the global economic landscape by improving connectivity and stimulating cross-border investment and growth. The BRI is a transformative global development strategy aimed at enhancing economic cooperation, infrastructure development, and cross-cultural exchanges across 63 countries in Asia, Europe, and Africa. With its broad scope and ambitious goals, the BRI has become a cornerstone of international collaboration in trade, logistics, and innovation (Yue *et al.*, 2022).

At the core of its long-term success lies a fundamental requirement: the development of a skilled and industry-

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ready workforce capable of supporting large-scale infrastructure and technology projects. This demand has highlighted the critical importance of industry-education integration, particularly in sectors such as construction, engineering, and advanced technologies. Traditional education institutions fail to satisfy the continuously changing needs of modern industry. As a result, innovative models, such as experiential learning, work-based learning (WBL), and apprenticeships, have emerged as essential mechanisms for aligning education with real-world labor market demands.

While apprenticeships, WBL and experiential learning all offer structured, hands-on experiences in real-world settings, they differ in scope and focus. Specifically, apprenticeships emphasize direct preparation for specific occupational roles by bridging theory and practice. In contrast, WBL equips students with industry-relevant skills, which in turn contribute to high job placement rates and improved job readiness. Meanwhile, experiential learning, often centered around real-world problem-solving, additionally fosters critical thinking, adaptability, and greater employability (Omar *et al.*, 2022).

Through integrating these models, industry and education partnerships foster education systems that are both responsive and adaptable, thereby ensuring graduates possess the technical and soft skills necessary to thrive in a fast-changing global workforce. In this case study, we explored how these educational models have been successfully implemented in the context of the BRI, with a particular focus on technology programs in Malaysia Technical Universities (MTUN). It highlights how the synergy of experiential learning, WBL, and apprenticeship models contributes to producing industry-relevant graduates and supporting the broader goals of the BRI on sustaining the projects.

LITERATURE REVIEW

BRI projects in Malaysia

Malaysia hosts a diverse range of BRI projects across several sectors, which highlights its strategic importance within China's BRI. These projects are briefly described below.

Transportation infrastructure

One of the most prominent BRI projects in Malaysia is the East Coast Rail Link (ECRL). It is a flagship rail project connecting Port Klang on the west coast to Kota Bharu on the east coast and spanning over 600 kilometers. Launched in 2016, the project was suspended in 2018 due to cost concerns but resumed in 2019 at a reduced cost of RM 44 billion (USD 10.68 billion) following renegotiations. Other transportation rail project is the Gemas to Johor Bahru Electrified Double-Tracking Project (CJ-B). It aims to modernize and improve rail connectivity in southern Peninsular Malaysia, which aligns with the BRI goals of enhancing regional connectivity (Ministry of Transport Malaysia, 2019).

Additionally, the Sultan Abdul Halim Muadzam Shah Bridge (Penang Second Bridge opens to traffic), which was completed in 2014, was built with significant financing and technical support from China Harbour Engineering Company. The project was to strengthen logistics links between Penang Island and the mainland (Ministry of Transport Malaysia, 2019).

Port and maritime development

The expansion of Kuantan Port, initiated with the development of a new deepwater terminal in late 2013, is scheduled for completion by 2026. Valued at approximately USD 943 million, the project is designed to increase the port's annual capacity to 52 million freight weight tonnes, reinforcing its role as a strategic logistics hub along Malaysia‘s east coast (Ministry of Transport Malaysia, 2019).

The Melaka Gateway project, launched in 2014 with an initial investment estimate of USD 10.5 billion, was envisioned as a major integrated development featuring a deep-sea port, cruise terminal, and commercial zones. After encountering prolonged delays, legal disputes, and a suspension, the project was revived in 2023 with a streamlined scope, now centered primarily on the completion of the Melaka International Cruise Terminal (MICT) and related infrastructure. Although the original timeline targeted full completion by 2025, the schedule has since shifted, and a new official completion date has not been announced (Ministry of Transport Malaysia, 2019).

Industrial parks and urban development

Established in 2013, the Malaysia-China Kuantan Industrial Park (MCKIP) represents a bilateral industrial cooperation model under the BRI, with a focus on heavy and medium industries (Ministry of Transport Malaysia, 2019).

Forest City in Johor, which was launched in 2016 by China's Country Garden Holdings, is a large-scale urban development that integrates residential, commercial, and industrial zones. In 2024, it was designated Malaysia's first tax-free Special Financial Zone to attract global investment (Ministry of Transport Malaysia, 2019).

Energy pipeline projects

The Trans Sabah Gas Pipeline project was intended to transport natural gas across Sabah but was suspended in 2018 over viability and cost concerns. Nevertheless, it

remains part of the broader energy strategy under the BRI. The Multi-Product Pipeline (MPP) was also suspended in 2018 due to financial irregularities, but the initial aim was to improve the petroleum distribution infrastructure across Peninsular Malaysia (Ministry of Transport Malaysia, 2019).

Aviation and logistics

The purpose of the Air Silk Road China-Malaysia Freight Hub Project was to enhance air cargo logistics and connectivity, thus supporting the BRI's broader objective of strengthening global trade routes.

The BRI projects demonstrate Malaysia's integral role in the BRI's Southeast Asian strategy and reflect the country's multifaceted cooperation with China in infrastructure, trade, energy, and industrial development (Ministry of Transport Malaysia, 2019).

Demand for a skilled workforce for BRI projects

The expanding scale and increasing technical complexity of BRI infrastructure projects in Malaysia underscore the nation's strategic importance within the region. However, the success of these initiatives hinges not only on robust capital investment but, more crucially, on cultivating a highly skilled, future-ready workforce capable of supporting long-term development.

The increasing complexity of BRI projects, particularly in areas such as construction, transportation, logistics, energy, and digital infrastructure, has led to a surging demand for skilled professionals, including engineers, technicians, data analysts, logistics managers, and project coordinators roles that require both theoretical expertise and hands-on capabilities. In response, industry-education integration has emerged as a vital strategy. By aligning academic curricula with industry requirements, educational institutions can produce graduates with job-ready competencies, thereby reducing the mismatch between what is taught in classrooms and requirements in the field. Integration models, such as experiential learning, WBL, and apprenticeships play critical roles in this transformation, as they offer students real-world exposure, technical skills, and enhanced employability (Omar *et al.*, 2022).

Given the transnational nature of BRI projects, the need for cross-border workforce development programs has grown. These initiatives bridge local skills gaps and promote international knowledge exchange and technical collaboration to further sustain the long-term impact and effectiveness of BRI investments. In sum, the BRI has intensified the need for systematic, industry-aligned workforce development strategies. Countries like Malaysia, with their active participation in the BRI, have prioritized adaptive educational models to ensure a continuous pipeline of skilled talent capable of meeting the evolving demands of the large-scale, multinational infrastructure projects.

The need for industry-education integration

The need to develop a skilled, adaptable, and industry-relevant workforce for the BRI has created an urgent demand for education systems, particularly technical and vocational education and training (TVET), to evolve in alignment with local economic ecosystems and global industry trends. This creates an urgent demand for education systems, particularly TVET, to evolve in alignment with local economic ecosystems and global industry. The study by Boahin *et al.* (2013) found that these models significantly improve the employability of TVET graduates by focusing on practical skills acquisition and workplace relevance.

The integration of digital tools and emerging technologies, including artificial intelligence, has further accelerated the success of these models by offering personalized, real-time learning experiences (Gössling & Emmler, 2019). However, it is equally important that these technological advances are implemented in line with international standards. Guidelines set by organizations such as UNESCO in 2025 and the guidelines emphasize that sustainable and globally competitive workforce development requires quality assurance, industry relevance, and lifelong learning pathways.

The challenges and best practices in aligning educational frameworks with industry demands have been identified in the recent literature. According to Lasker (2021), effective integration occurs when curricula are designed in close collaboration with industry stakeholders to ensure that graduates possess job-ready competencies across high-demand sectors, such as construction, logistics, engineering, and information technology (IT). This alignment is especially crucial for BRI-participating countries, like Malaysia, where the scale and complexity of the infrastructure projects demand technically proficient and adaptable workers.

The adoption of globally recognized models of industry-education integration supports not only national workforce development but also regional economic integration. These models empower graduates to compete in the international labor market, which fosters long-term economic resilience and sustainability for the receiving countries. Industry-education integration is not just a strategic response to labor market demands; it is a foundational requirement for the long-term success of BRI projects. By aligning educational outputs with industry needs and international standards, countries can ensure that their workforces are equipped to contribute meaningfully to both national development and the

broader objectives of the BRI.

Challenges in industry-education integration

The success of the BRI is shaped by both its strategic vision and a complex interplay of economic, political, and educational factors. While the initiative holds transformative potential, its implementation across diverse regions has revealed several challenges. Local policies and financial constraints have significantly impacted BRI infrastructure projects. For example, the Thai-Chinese high-speed railway in Thailand encountered obstacles due to labor policy issues and funding concerns (Busbarat *et al.*, 2023). Similarly, political unrest and local resistance have hampered investment and limited opportunities for academic collaboration in the China-Pakistan Economic Corridor. In the Philippines, the progress of BRI projects has been closely tied to political leadership, with the government withdrawing in 2023 to reevaluate several projects (Busbarat *et al.*, 2023).

In the educational context, the BRI faces a unique set of challenges. These include inconsistent quality assurance frameworks, a lack of recognition for academic qualifications, and significant cultural and language barriers. With over 63 countries involved in both "hard" infrastructure and "soft" academic projects under the BRI umbrella (Yue *et al.*, 2022), variations in national policies and standards present substantial hurdles to cohesive educational integration. The absence of consensus on higher education policy among the participating nations impedes cross-border recognition and quality assurance efforts. Additionally, differences in language, academic traditions, and cultural expectations have created obstacles for the internationalization of education in the BRI context.

The diversity of industry needs across the BRI countries has complicated efforts to align educational systems with labor market demands. Many developing nations struggle to reform their educational institutions fast enough to meet the evolving requirements of global industries. This misalignment has led to persistent skills gaps, which undermine the workforce readiness needed for successful BRI implementation. A lack of effective collaboration between educational institutions and industries has exacerbated this issue and resulted in inefficiencies and a disconnect between the skills being taught and those required in practice (Thomas *et al.*, 2021). Overall, while the BRI offers a promising platform for international cooperation, its effectiveness is limited by a range of structural, cultural, and policy-related challenges, particularly in terms of infrastructure development and educational alignment. Addressing these obstacles is essential to achieving the long-term goals of the initiative.

Models of industry-education integration

Various integration models have been proposed and tested globally to address the skills gap; however, it is important in the BRI context to address its unique challenges. One prominent approach is the dual education system, in which students split their time between classroom instruction and work placements. It ensures students acquire both theoretical and practical skills by combining classroom-based education with on-the-job training. This approach has increased graduate readiness to be competent members of the workforce (Tastanbekova *et al.*, 2021).

Ibrahim *et al.* (2022) highlighted that the dual education system has been successfully implemented in Europe and increasingly in China and Malaysia to align educational programs with the skills demanded by the industries involved in the BRI. This training system focuses on employers' involvement and standardized certification to enhance the quality of the workforce development programs across the BRI partner countries.

The German dual system model has improved students' academic performance and skills. This model has been accepted and adopted across the world, although challenges have been experienced in its adaptation to local contexts. A comparative study among Austria, the Czech Republic, and Germany indicated that the dual system in Germany and Austria benefited graduates seeking places in the labor market (Hoidn & Šťastný, 2023).

In Japan, close partnerships between universities and private entities were mainly initiated to foster innovation and align university curricula with industry needs (Jung, 2022). The main focuses are research innovation and development partnerships that inspire BRI projects, that is more on innovation and technology transfer, in addition to the international internship program (Jung, 2022).

Singh *et al.* (2021) emphasized learning that ensures students acquire specific, measurable competencies that industries require. WBL is highly effective in fields like engineering, IT, and construction are sectors critical for the success of the BRI. They found that WBL provides flexibility in tailoring curricula to meet the changing demands of industries, which makes it adaptable for BRI projects.

Through a comparison of these global perspectives, the discussion on industry-education integration models would be more comprehensive and actionable and

thereby offer practical insights for policymakers and stakeholders involved in BRI workforce development initiatives.

Experiential learning

Experiential learning is a critical model for preparing students for the workforce. The model improves both technical and soft skills, like teamwork and communication, which are essential in collaborative industries, such as construction and technology. Experiential learning, including internships and project-based learning, offers students the opportunity to apply theoretical knowledge in real-world settings, which makes them more adaptable and job-ready. A report from Kowang *et al.* (2023) showed that internship programs change and improve participants' values and characteristics for the betterment of their employability.

WBL

The focus of WBL is on ensuring that students achieve specific competencies aligned with industry standards. Singh *et al.* (2021) reviewed the effectiveness of WBL, particularly in fields such as construction, engineering, and IT, which are sectors that are critical to BRI projects. They found that WBL allows for flexible, industry-tailored curricula, which ensure that graduates possess the specific skills needed by industries, thus improving their employability and workforce readiness. WBL is a key driver of innovation in industry-education integration. By ensuring that students acquire specific, demonstrable competencies, WBL fosters innovation in industries by creating a workforce that can adapt to rapidly changing technologies and practices. A systematic literature review (SLR) by Fernandez and Hu (2021) emphasized that WBL's adaptability is particularly useful in sectors like construction and technology, where new skills and tools emerge regularly.

Apprenticeships

Apprenticeships are a well-established model in which students combine classroom learning with practical, on-the-job experience. A SLR by Smith and Richards (2020) explored the effectiveness of apprenticeships in bridging the skills gap, particularly in developing economies. They concluded that apprenticeships offer valuable, real-world experience and have been integral to workforce development strategies in countries like China and Malaysia. This model helps ensure that students acquire the skills necessary to meet the specific demands of the industries involved in BRI projects.

In a wider context, although the implementation of apprenticeships has consistently faced challenges, including successful completion rates (Osuizugbo *et al.*, 2022), apprenticeships benefit students' academic outcomes in college and shorten the time taken to secure a position in the workplace (Ullibarriarana-Garate *et al.*, 2023).

A success story from Malaysia's apprenticeship program is that it has had a significant impact on enhancing apprentices' employability. The National Apprenticeship Scheme was introduced in July 2020, and of 397 apprentices, 376 (94.7%) were successfully placed in jobs and worked for the participating companies. A report from Abd Rozan (2022) highlighted that the Digital Entrepreneurship Apprenticeship Program (IDEA@KPT) by the Ministry of Higher Education in 2021 had a significant impact on micro and small enterprises by improving their business value through enhanced digital marketing strategies.

Malaysia's apprenticeship guidelines ensure that apprenticeships are consistent, high quality, and aligned with industry needs. These guidelines, combined with industry partnerships, create a seamless pathway for students from education to employment. The integration of apprenticeships into the education system provides BRI industries with a skilled labor force that is equipped to contribute to infrastructure and development projects.

CASE STUDY

As part of the BRI, an innovative approach to industry-education integration was implemented in MTUN through the development of Bachelor of Technology programs. This involved the adoption of a synergistic model that combines experiential learning, WBL, and apprenticeships, with the aim of aligning academic education with dynamic industry needs and ensuring graduate workforce readiness. Each program was designed through a strategic partnership between academia and key industry leaders. Five leading industry representatives were engaged in curriculum development workshops for each program to ensure that the content and learning outcomes were closely aligned with current professional standards and practical requirements.

This collaborative framework ensures that graduates are not only academically competent but also possess hands-on experience and the job-specific skills required by the respective sectors. By integrating these three educational models, the programs cultivate graduates who are well prepared to meet real-world challenges and contribute effectively in their fields. In terms of the curriculum structure, each Bachelor of Technology program is designed to span three years, with a strong emphasis on industry immersion. Phase 1: students undergo six months of academic instruction at the university, where the focus is on theoretical foundations and essential skills. Phase 2: the academic instruction is followed by

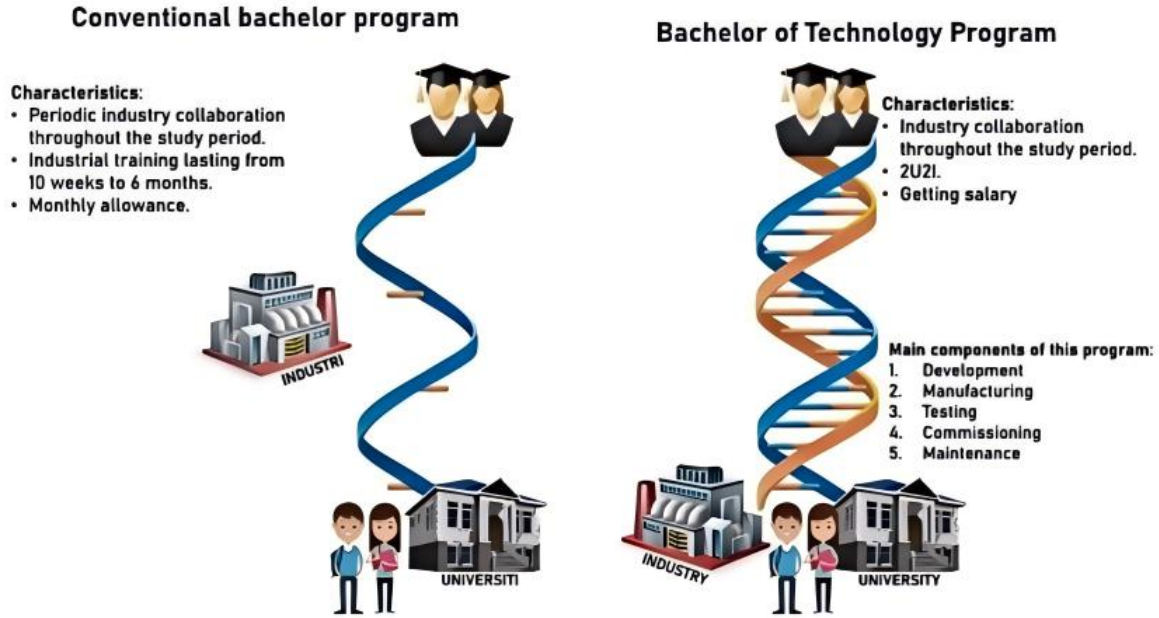

Figure 1. Bachelor of Technology programs adopts concept of 2 years in University and 2 years in lndustry.

two years and six months of industry-based training, where the students engage in structured placements, supervised tasks, and job rotations within partnering organizations.

This structure ensures continuous engagement between the university faculty and industry trainers to enable real-time feedback, curriculum relevance, and the development of highly employable graduates. The programs offered are: (1) Bachelor in Food Service Technology (BBS); (2) Bachelor of Technology in Building Construction; (3) Bachelor of Technology in Refrigeration and Air Conditioning; (4) Bachelor of Technology in Welding; (5) Bachelor of Technology in Electrical System Maintenance; (6) Bachelor of Technology in Industrial Electronic Automation; (7) Bachelor of Technology in Industrial Machining.

A comparison of the conceptual frameworks of the conventional bachelor's degree and the Bachelor of Technology program is presented in Figure 1.

Integration of the educational models

In the context of BBS program, it synergistically integrates the three educational models of experiential learning, WBL, and apprenticeship (Figure 2). These models collectively enhance students' learning by blending academic theory with practical industry engagement with the related industry. The students are studying and working partially 50% of the study duration in the industry. This resulted to job-ready graduates with strong technical and managerial competencies.

Experiential learning

The experiential learning model forms the foundational approach of the BBS program. It emphasizes active participation, hands-on learning, and reflective practice. Students engage in a dynamic educational process that combines classroom-based theoretical instruction with practical laboratory work and reflective exercises to encourage deeper understanding and critical thinking. As an example, the BBS program was developed in close collaboration with Gerbang Alaf Restaurant Sdn Bhd, Serai Group Sdn Bhd, and Palace Butcher Sdn Bhd. Through these partnerships, students are exposed to applied learning modules that closely simulate real-world challenges and operational scenarios in the food service industry.

WBL

A core element of the BBS program, WBL offers students the opportunity to apply their academic knowledge in authentic industry settings. Students participate in structured placements and on-the-job training, where they gain valuable workplace exposure. These placements are carefully monitored through a joint academic-industry supervision framework to ensure alignment with the program's learning outcomes. Students in the BBS program spend 2.5 years in the food industry, during which they engage in supervised tasks, job rotations, and industry projects that directly support their academic progression and career development.

Apprenticeship

The apprenticeship model strengthens the bridge

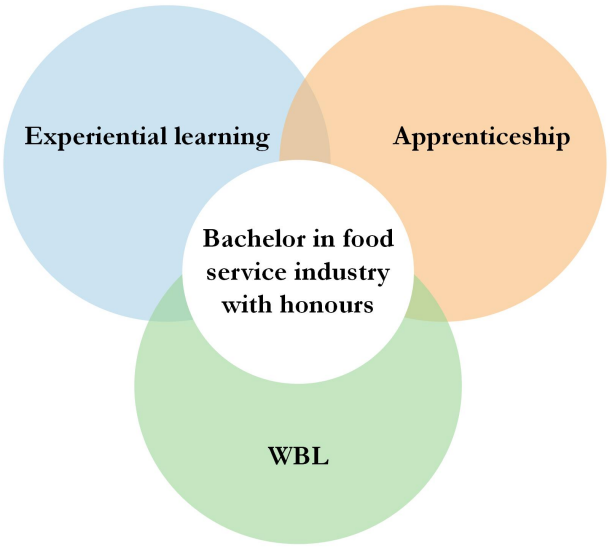

Figure 2. Integration of the three educational models in implementing the BBS program. BBS, Bachelor in Food Service; WBL, work-based learning.

between education and employment by formalizing the relationship among students, universities, and industry partners. Under this model, a training agreement between university and industry clearly outlines the students' expected competencies, training duration, and mutual responsibilities. Students undergo regular competency assessments to ensure they are meeting industry benchmarks. Upon successful completion of the apprenticeship, they receive industry-recognized certification or endorsements. In the context of the BBS program, this model ensures that graduates are not only academically qualified but also possess verified job-specific skills, particularly those required for managerial roles within the food service sector.

CONCLUSION

BRI poses both major potential and complicated challenges for participating countries, including Malaysia, particularly in terms of workforce development. As proven in this case study, there is an urgent need to align education systems with the practical and changing needs of large-scale BRI infrastructure initiatives. Malaysia may effectively bridge the skills gap by implementing integrated industry-education models such as experiential learning, WBL and apprenticeships, resulting in a workforce that is both technically competent and adaptive to industry changes.

For example, the Bachelor of Technology programs demonstrate how strategic collaborations between academia and industry can develop graduates with the skills needed to succeed in BRI-related areas. Furthermore, collaborative methods maintain curriculum relevance, promote practical skill learning, and improve employability. In doing so, they contribute not just to national development but also to the larger aims of regional economic integration outlined in the BRI framework.

Looking ahead, long-term commitment to these integrative techniques, together with adherence to worldwide best practices and constant innovation, will be critical. Finally, this will allow Malaysia and other BRI partner nations to develop resilient, future-ready workforces capable of generating long-term prosperity and fully leveraging the benefits of global connectivity.

DECLARATIONS

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