

The Implementation of Apprenticeship in Vocational Education: A Systematic Review

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Abstract

This systematic review investigates the implementation, adaptability and challenges of apprenticeship systems in vocational education with a particular interest in their use in underdeveloped regions. From the Scopus database, fifteen empirical studies published between 2018 and 2024 were selected by using the PRISMA framework for analysis. The review identifies key themes: The role of public-private partnerships, integration of technology, the cultural and regional adaptability of apprenticeship models, and dual training systems as a core framework. Results show that dual training systems enhance employability and education meets industry requirements, and Germany and Malaysia are excellent examples. Resource sharing and curricula alignment with labor market demands, it was argued, required public-private partnerships. Innovative technologies such as virtual reality fill infrastructure gaps in resource limited areas. Nevertheless, there are still major challenges, including policy misalignments, funding deficits, and socio-cultural barriers. The implications of these findings for policymakers and educators interested in improving apprenticeship models in vocational education are actionable. The review suggests localized, context sensitive strategies and more integration of emerging technologies to scale and increase the effectiveness of these systems.

Keywords: Apprenticeship Systems, Dual Training Systems, Vocational Education, Public-Private Partnerships (PPP), Technology Integration, Skill Development, Workplace Training, Cultural Adaptability, Educational Policy

Introduction

Today, the demand for skilled workforce is higher than ever in today's rapidly changing economies. Not only does vocational education address this need by providing individuals with the specific skills needed for different industries (Ferns & Zegwaard, 2014), but it also offers a tangible solution to the problem of unemployment in young adults. Apprenticeship is one of the most effective and best known vocational education approaches (Muehlemann & Wolter, 2014). Apprenticeships bridge the gap between what you learn in the classroom and what you gain through practical experience in real workplaces by using classroom instruction combined with practical experience in real workplaces. In addition, apprenticeships provide

a close collaboration of education providers and employers, and thereby provide an adaptive and responsive approach to workforce development (Dennen & Burner, 2008).

Apprenticeship has re-emerged as a vital component of vocational education systems worldwide, especially in the context of preparing youth for the demands of the modern labour market (Smith, 2010). In an era marked by rapid technological change and skill shortages, apprenticeship serves as a bridge between theoretical learning and workplace practice, addressing the persistent mismatch between graduate skills and industry expectations (Papier, 2017). Understanding how apprenticeship is implemented and evolved across contexts provides valuable insights for educators, curriculum developers, and policymakers (Chankseliani & James Relly, 2016). However, despite its growing significance, the structure, delivery, and impact of apprenticeship programs remain underexplored in comparative, evidence-based literature.

As an example, Switzerland and Austria have adopted similar dual education systems, which have achieved comparable results in matching vocational training with the labor market demand (Bonoli and Wilson 2019). By contrast, countries such as Australia have developed apprenticeship programs which have been tailored to meet industry specific needs, for example health and digital technology, reflecting their particular economic priorities (Gospel 1994). The Singapore government has put a lot of money into its SkillsFuture initiative, which combines apprenticeships with lifelong learning programs to keep their workforce up to date (Tan, 2017). Yet implementation of apprenticeship programs is very different from place to place, depending on socio-economic conditions and cultural context (Valiente & Scandurra, 2017). These international variations highlight the necessity of a systematic review to synthesize lessons, identify effective practices, and inform policy decisions across diverse vocational education systems.

The findings of this study will be particularly beneficial for vocational educators, curriculum developers, education policy-makers, and institutional administrators. By understanding the critical components and successful models of apprenticeship, they can better design, implement, and evaluate programs that bridge the gap between classroom learning and workplace practice. Furthermore, this review contributes to strengthening vocational education systems by informing decision-makers of adaptable strategies that meet both global trends and local needs.

Literature Review

Apprenticeship Development in Different Economies and Regions

Apprenticeship systems have developed very differently across economies and regions and are shaped by levels of economic development, policy environments, cultural contexts and industry needs. Unlike in high income economies, systems of apprenticeships in low income economies usually do not have established policy support and robust infrastructure. As an example, Germany's dual education system is a model of success consisting of vocational school education combined with enterprise based training that links skill development with labor market needs (Bonoli & Wilson, 2019). Several similar models in Switzerland and Austria have worked well to reduce youth unemployment rates (Fuller & Unwin, 2011).

That said, middle income economies face structural and policy related barriers to expanding apprenticeship systems. For example, although government efforts exist in Malaysia, its apprenticeship programs have been hindered by uneven industry participation and insufficient resource allocation (Kaprawi et al., 2021). For example, in China, vocational education reforms that are modeled on the German one have improved apprenticeship systems. Despite these challenges, rural areas face significant resource shortages and unequal distribution of resources, which limits more widespread implementation (Ji, 2014).

Traditionally, apprenticeship systems in low income countries like Kenya and India operate informally based on master apprentice relationships. However, these systems are not standardized in policies, formalized training structures and resources, which results in skills development that does not always respond to the rapidly changing demands of the labor market (Fuller & Unwin, 2011). This contrast highlights the need for region specific policy interventions that take into account socio economic and cultural context.

Apprenticeship Advantages & Challenges

As such apprenticeship systems offer unique advantages, combining theoretical instruction with practical training, and helping to make employees more employable, as well as facilitating collaboration between education institutions and industries (Fuller & Unwin, 2011). The most prominent example of this is Germany's dual apprenticeship system that provides students with transferable skills and increases labor market mobility and innovation (Bonoli & Wilson, 2019). As in Malaysia, apprenticeship programs combined with high tech sectors have played a role in Malaysia's economic transformation (Kaprawi et al., 2021). However, such benefits of apprenticeship systems are also accompanied by their limitations, especially in dealing with regional issues.

The implementation of apprenticeship systems presents different challenges by region, due to differences in resources, policy framework and industry engagement. Uneven resource distribution and poor infrastructure in rural areas in China has hampered equitable development of programs (Song, 2023). Although diverse, U.S. apprenticeship programs are largely concentrated in traditional industries like construction and manufacturing, and do not yet extend to emerging industries like information technology (Smith & Kemmis, 2013). In low income countries the lack of standardized training frameworks makes skill mismatches worse. This challenge becomes more difficult for workers to meet the changing demands of dynamic labor markets (Fuller & Unwin, 2011). Besides, there are systemic challenges like lack of good mentorship and lack of government investment which are still huge problems in both developing and developed economies.

Little Comparative Studies on Cross National Models

Germany's dual education model is considered a benchmark for apprenticeship systems, but its adaptability to non-European contexts needs to be further investigated, in particular, in low income countries. For example, both China and Malaysia have implemented this model, but policy environments, cultural norms, and economic structures have made implementation of this model very difficult (Hummelsheim & Baur, 2014; Yang & Dong, 2024).

These challenges are more pronounced in low income countries like Kenya and India. Due to lack of formalized institutional frameworks, limited employer engagement and resource constraints, it is difficult to replicate the dual education model effectively.

Additionally, socio-economic and cultural factors that influence the success of apprenticeship systems are rarely considered in cross national studies, thereby filling significant gaps in understanding how such systems can be localized (Labrique et al., 2018).

The absence of comparative research limits the development of universally applicable frameworks for apprenticeship systems, in particular, in contexts that differ dramatically from Europe. Future research should investigate not only what policy and institutional adjustments are required to localize, but also how technology might overcome these hurdles (Hummelsheim & Baur, 2014; Clarke et al., 2020).

Lack of Integration of Technology

Advances in technology are accelerating the need to integrate advanced technologies into the apprenticeship system. Virtual reality (VR), artificial intelligence (AI) and online learning platforms are tools that can help deliver training in resource constrained regions in a transformative way. (Smith & Kemmis, 2013). VR simulations can offer apprentices in manufacturing sector hands on experience in a safe controlled environment while AI driven personalized learning can help personalize training programs to individual needs. Online learning platforms have also been helpful in overcoming geographical barriers, providing remote access to vocational education in areas with limited physical infrastructure (Kovalchuk et al., 2023).

Although these technologies have great potential, their adoption has been limited, especially in low income and middle income countries. However, the implementation is challenged by inadequate digital infrastructure, high implementation cost and the lack of trained personnel to manage these systems (Labrique et al., 2018). For example, in Sub-Saharan Africa there are large digital divides, in the sense that limited internet access and dated hardware prevent the roll out of online learning tools (Labrique et al., 2018). However, resistance to change and investment concerns surrounding the upfront investment necessary to integrate such technologies into existing traditional apprenticeship models continue to persist even in high income countries, making it difficult to modernize vocational education systems (Singh et al., 2023).

Furthermore, access to training can be increased by technology, but its effectiveness across cultural and economic contexts has not been well studied. For instance, in places with limited digital literacy, online platforms might not reach their desired outcomes without simultaneous investments in basic ICT education (Labrique et al., 2018). Similarly, the acceptance of the technology is also limited by cultural perceptions of the technology, such as mistrust in AI driven assessments (Ragolane & Patel, 2024).

In addition, technology integration has implications for cross national models that have been discussed earlier. Digital tools can help customize training content and delivery methods as apprenticeship systems adapt to different contexts and take into account socio-economic and cultural considerations in local contexts. A critical gap in the literature, however, is empirical evidence on how to effectively deploy these tools across different contexts (Clarke et al., 2020). This study attempts to fill these gaps through a systematic review of global practices, and practical recommendations for the integration of advanced technologies into vocational education systems.

Research Objectives and Questions

RO: To explore the core characteristics of mature apprenticeship models and their adoption in underdeveloped regions to improve vocational education.

RQ: (1)What are the core characteristics and successful practices of existing mature apprenticeship models? (2)How can these models be effectively adopted to meet the needs of underdeveloped apprenticeship regions and improve their vocational education systems?

Methodology

Following a systematic review approach guided by PRISMA (Preferred Reporting Items for Systematic review and Meta-Analyses) this study is conducted in a transparent and replicable manner (Page et al., 2021). The Scopus database was chosen as it is a comprehensive coverage of peer reviewed academic literature (Falagas et al., 2008), and articles related to the implementation of apprenticeship in vocational education were retrieved. The review process involved four phases: Predefined search terms are used to identify relevant articles, duplicates are removed and irrelevant studies are excluded based on titles and abstracts; full texts are reviewed against specific inclusion and exclusion criteria; only studies meeting all criteria are included. This approach allows for a focused synthesis of literature into which insights are drawn regarding apprenticeship implementation strategies, challenges and impacts in vocational education.

The Review Protocol (PRISMA)

In accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, a widely adopted protocol for systematic review transparency and methodological rigor, this study adhered to these guidelines. The review process was structured through PRISMA, which provides a comprehensive and replicable synthesis of the literature on the implementation of apprenticeship in vocational education (Moher et al., 2009).

In order to review the research topic with explicit inclusion and exclusion criteria, the review adopted. The articles were included if they were empirical studies published in peer-reviewed journals between 2018 and 2024, written in English and directly addressed the implementation of apprenticeship programs in vocational education. The time frame was chosen to capture recent developments, and to align with current educational practices (Falagas et al., 2008). Vocational education studies unrelated to the topic of study, historical reviews, theoretical papers or about alternative education systems were excluded. Moreover, the literature, including book chapters, conference proceedings, and non-peer-reviewed publications was excluded to maintain the quality and validity of the findings (Higgins et al., 2011).

The PRISMA framework focused only on vocational education and therefore only studies of relevance to the field were synthesized. The methodology also highlights the gap and trend in the implementation of apprenticeship programs to provide a strong basis for answering the research objectives. The structured approach used here increases the validity and reliability of the review and provides useful insights into strategies, challenges and impacts in the field.

Resources

The research objectives were considered relevant to the Scopus database, which was chosen as the sole resource for this systematic review, because it covers a wide range of peer reviewed academic literature. According to Falagas et al. (2008), Scopus is certainly one of the world's most comprehensive and multidisciplinary databases covering various fields of science, education, social sciences and vocational studies. This is aligned to the methodological rigor of systematic reviews, and the selection of Scopus avoids the inclusion of high quality, credible sources. Its advanced search capabilities and comprehensive indexing make it possible to retrieve literature that directly addresses the implementation of apprenticeship in vocational education in a precise manner. This study is restricted to Scopus only so that one maintains consistency and reliability in data collection and there is a minimum risk of duplications or irrelevant findings. Boolean operators and predefined keywords such as 'apprenticeship', 'vocational education' and 'implementation' were used in the search strategy to identify relevant studies. The database allowed access to a wide variety of empirical studies, which were needed to answer the research questions and synthesize current knowledge in the field.

Systematic Searching Strategies

There are three main stages in the systematic searching strategies, namely identification, screening, and eligibility (Figure 1)

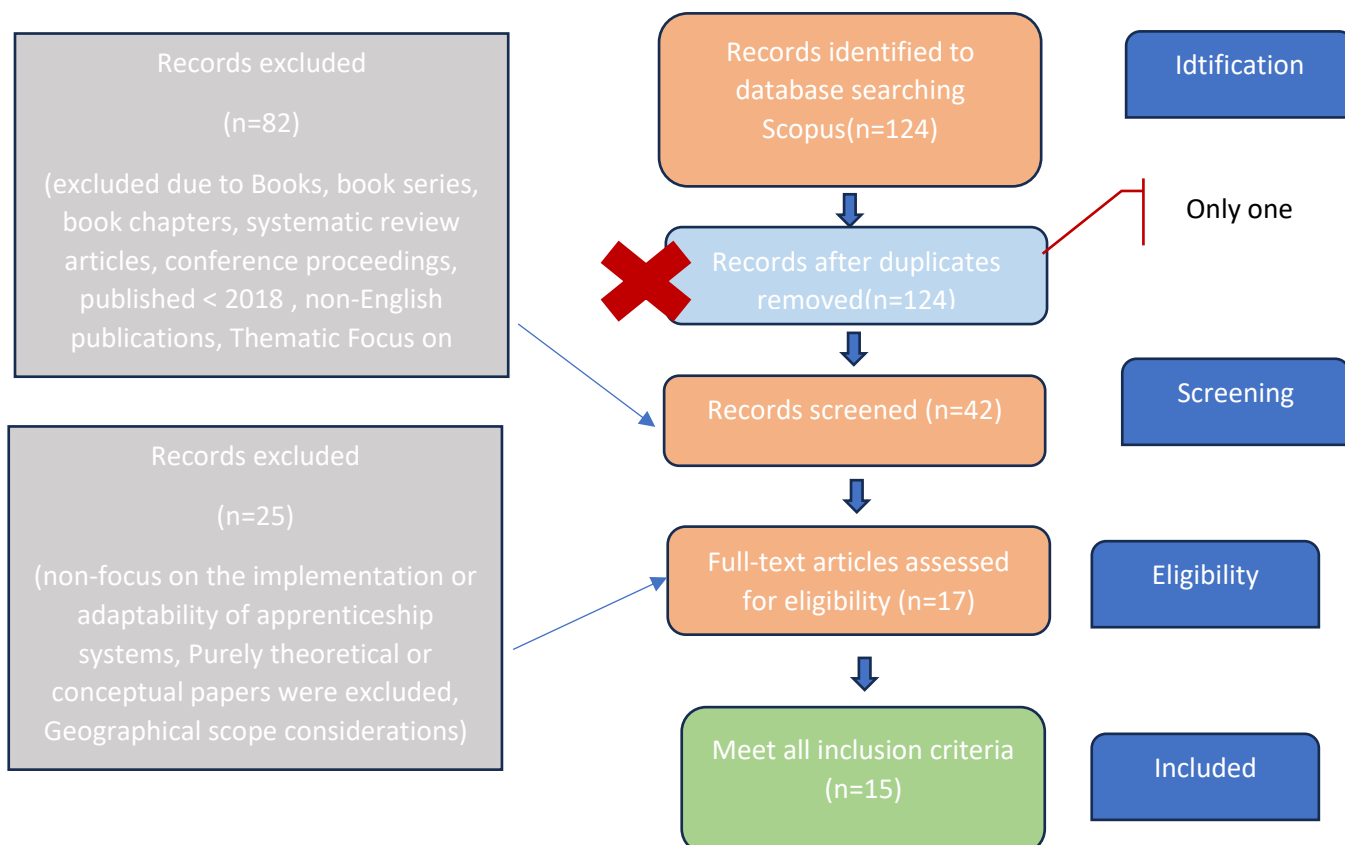


Figure1: Flow diagram of the study

Identification

Relevant literature was identified using the Scopus database, chosen for its comprehensive coverage of peer-reviewed journals. The search utilized predefined keywords, including “apprenticeship,” “vocational education,” and “implementation,” with the following search string (TABLE 1), 124 articles have been founded, Since only one database was used, there were no duplicate articles

Table1

The search string used for the systematic review process.

Database	KeywordUsed
Scopus	TITLE-ABS-KEY = ("Dual Training System")) OR (((TITLE-ABS-KEY (apprenticeship)) AND (TITLE-ABS-KEY ("Vocational Education"))) AND (TITLE-ABS-KEY (implementation)) OR (TITLE-ABS-KEY (application)))

Screening

The screening phase is used to narrow down the initial pool of articles identified in the identification phase, so that only relevant and high quality studies enter into the eligibility phase. Specific inclusion and exclusion criteria were developed for this study in order to guide the screening process towards the research objectives. Since only a single database (Scopus) was used, duplicate records did not need to be addressed, simplifying the screening process. Publication trends review showed that related literature rose significantly after 2012 and increased again after 2018, possibly due to the effects of the global financial crisis. Given the possible time sensitivity of the topic, only studies published between 2018 and 2024 were included to focus on recent developments. In addition, studies and peer reviewed journal articles were considered in English only, whereas conference papers, book chapters, and reviews were excluded. Titles and abstracts were manually reviewed to exclude studies that were historical reviews or heavily theoretical, research prioritizing practical applications and case based insights. The first pool of 124 articles was then reduced to 42 based on these criteria, and these 42 articles were considered to be relevant for further eligibility evaluation.

Table2

The search string used for the systematic review process.

Criterion	Eligibility	Exclusion
Timeline	Between 2018 to 2023	<2018
Literature type	Empirical Methodological Applied	Books,bookseries,bookchapters,SLR articles,conference proceedings, Theoretical, Conceptual, Historical
Language	English	Non-English
Scope	Geographical scope \ considerations(base on GDP in 2024) Must focus on the implementation, challenges, or adaptability Must specifically address vocational education and training (VET) systems	

Eligibility

In the eligibility phase, all 42 articles that passed the screening stage were reviewed to a great extent. In this phase, the full texts of these articles were scrutinized to confirm that they conformed to research objectives and pre-defined inclusion criteria. Here, the selection of studies focused on the ones that offered detailed insights into the implementation of apprenticeship models in underdeveloped regions, and provided either empirical evidence or case based applications.

Articles were excluded if they were of insufficient relevance to the research focus, for example, papers that discuss general apprenticeship systems without specific implementation details or have limited contextual applicability to underdeveloped areas. Furthermore, studies without a solid methodological framework, or without delivering actionable insights, were removed.

A final set of 15 articles was selected after a rigorous evaluation to include in the systematic review. Taken together, these studies constitute a focused and high quality dataset that provides insights into how apprenticeship was implemented and whether or not it could be applied in underdeveloped regions.

Exclusion Criteria

After the above three stages, studies that did not meet the predefined inclusion criteria or failed to align with the research objectives were excluded to ensure a focused and high-quality review. Articles that lacked regional relevance, such as those not focusing on

underdeveloped regions or providing transferable insights, were removed to maintain the contextual applicability of the findings. Non-peer-reviewed publications, including conference papers, book chapters, and reviews, as well as articles not written in English, were excluded to ensure academic rigor and consistency. Additionally, studies that were purely theoretical, conceptual, or historical in nature were removed, as the research prioritizes empirical studies presenting data-driven findings or real-world applications. Articles published before 2018 were also excluded, given the time-sensitive nature of the topic and the surge in literature post-2018 reflecting contemporary trends in apprenticeship systems. Finally, studies with minimal academic impact, such as low citation counts or publications in low-impact journals, and those lacking detailed implementation strategies, were excluded to ensure the selection of relevant and high-quality studies. After applying these criteria, the initial dataset of 124 articles was reduced to 42, forming the basis for the next stage of the review.

Results

Articles Reviewed Based on Journals

The reviewed articles were published in a diverse range of journals, demonstrating the interdisciplinary nature of research on apprenticeship systems in vocational education. Table 1 provides a detailed breakdown of the journals and publication years. Notably, the International Journal for Research in Vocational Education and Training (IJRVET) contributed the largest share with two articles published in 2023, reflecting its focus on vocational education as a key area of study. Other significant contributions came from journals such as the Cypriot Journal of Educational Science (2021), Voprosy Obrazovaniya (Educational Studies Moscow) (2018), and the Journal of Vocational Education and Training (2018), highlighting the global academic interest in apprenticeship systems.

Table3

Articles reviewed based on journals.

Journals	2018	2019	2020	2021	2022	2023	2024
International Journal for Research in Vocational Education and Training (IJRVET)							2
Cypriot Journal of Educational Science					1		
Voprosy Obrazovaniya (Educational Studies Moscow)	1						
International Journal of Training Research							1
Journal of Vocational Education and Training	1						
Applied Mathematics and Nonlinear Sciences							1
International Journal of Emerging Technologies in Learning				1			
International Journal of Educational Management	1						
Societies					1		
Journal of Technical Education and Training						1	
The National Dual Training System (Conference Proceedings)							1
Technology, Knowledge and Learning							1
Philippine Review of Economics					1		
Social Science Research Network	1						
Total	4			1	3	1	3

The data indicates a concentration of publications in specialized journals focusing on educational sciences, vocational training, and technology integration. This suggests that research on apprenticeship systems often intersects with broader themes such as education management, technical training, and emerging technologies. Additionally, a variety of publication years across journals showcases a consistent interest in apprenticeship research over time, with peaks observed

Distribution of Articles Based on Countries

The global distribution of articles on vocational education and apprenticeship systems is presented in Table 2. Africa is led by Ghana which has 2 articles about apprenticeship reforms and Kenya contributes 1 piece on digital skills in informal sectors. While Central Asia and Eastern Europe are represented by Kazakhstan (2 articles) and Russia (1 article), it is these dual training systems and vocational practices that are addressed. The US contributes one article on workforce training, while China and Germany, with two articles each, emphasize modern technologies and the dual education model. Contributions from Malaysia and the Philippines each includes 2 articles focusing on national apprenticeship systems and vocational training in Southeast Asia. The interest shown by the world in improving apprenticeship systems is reflected in this distribution, with a view to often presenting diverse regional perspectives on the field of development.

Table4

Distribution of articles based on countries.

Countries	2018	2019	2020	2021	2022	2023	2024	Total
Ghana							2	2
Kenyan							1	1
Kazakhstan	1				1			2
Russian	1							1
United States of America	1							1
China				1			1	2
German					1		1	2
Malaysia						1	1	2
Philippines	1				1			2
Total	4			1	3	1	6	15

Main Findings

The 15 selected studies were reviewed and significant insights into the implementation and efficacy of apprenticeship systems in vocational education were found. Germany and Malaysia were often cited as examples of dual training systems in which classroom learning is combined with workplace training. It was shown that these systems improved employability and skill development by linking educational outcomes to labor

market needs. In Malaysia, for example, these systems proved very adaptable to industry specific needs, and research in Russia focused on regional variations and the problems of scaling these systems in emerging economies.

Several studies were concerned with skill development and technology integration. The work from China and Germany showed the potential that innovative tools, like virtual reality training simulators, had to improve practical skill acquisition in apprenticeship settings. These technologies not only plugged holes in traditional training methods but also gave learners the opportunity to use simulated environments to learn hands on. Technologies complemented scarce resources to overcome limitations in the underdeveloped regions of Kenya and Ghana where apprenticeships were key in equipping learners with market relevant skills in the informal sector.

Another important factor in the success of apprenticeship systems was the role of public-private partnerships. Studies from the Philippines and Ghana highlighted the need for collaboration between governments, They all referenced the dual subsidy policy introduced by the Chinese government, which has significantly alleviated the cooperation challenges between public vocational institutions and private enterprises. And industries and educational institutions have to bridge the gap between education systems and labor market demands. A Ghanaian pilot dual training model highlighted how this type of partnership could act as a driver for systemic reform and secure the sustainability of apprenticeship initiatives, and similar findings from West Africa pointed to their transformative potential in vocational education.

However, several challenges were consistently identified, despite success. Common barriers in underdeveloped areas included limited funding and infrastructure, and studies from Kenya and West Africa cited the need for strategic resource allocation. Implementation was further complicated by mismatches between national policies and industry needs, which need to be better aligned to be relevant and effective. Apprenticeship practices were also influenced by cultural factors, as shown by German and Chinese companies adjusting their training programs to the cultural context of different countries.

Taken together, these findings suggest that apprenticeship systems are a flexible means by which to meet a variety of educational and labor market needs. Dual training systems and public-private partnerships, as key enablers, and the integration of technology and the necessity for localized adaptations indicate the increasing complexity of apprenticeship practices in the field of vocational education

Table5

The findings

N O	Author&Year	Study Desig n	Regional Adaptabilit y	Challenges in Apprenticeship/ DT Systems	Public- Private Partnership s	Technolog y Integratio n	The Role of Dual Trainin g System s
1	Luo et al (2024)	QN					/
2	Chen & Dai (2021)	QN	/				/
3	Yamauchi et al (2018)	QN	/				
4	Pilz et al (2023)	QL	/			/	
5	Mulders et al (2024)	MM				/	
6	Nunyoname h et al (2024)	QL		/	/		
7	Afutu-Kotey et al (2024)	QL		/		/	/
8	Momanyi et al (2024)	MM		/		/	
9	Zhaksylykovn a et al. (2022)	QN		/			
10	Khan et al. (2018)	QL	/				
11	Rohiat et al. (2022)	QL	/				/
12	Igarashi & Acosta (2022)	QN			/		/
13	Dudyrev et al (2018)	QL	/	/			/
14	Remington (2018)	QL	/				
15	Yahaya et al (2020)	QN			/		/

Regional Adaptability

Table 6 shows that the adaptation of apprenticeship systems, and in particular dual training systems, is different from region to region and in many cases conditioned by *local economic structures, political context, and cultural traditions*. These factors determine what priorities and implementation strategies apprenticeship programs should have. In Kazakhstan, dual training systems adopted by combining modern pedagogical techniques with traditional ways of teaching were adapted to the region's labor market and economic needs (Khan et al., 2018). Apprenticeship models were developed in China using cultural

values, such as hierarchy and collectivism, and mentorship structures based on Confucian traditions (Yamauchi et al., 2018).

Constraints in the economy in West Africa, notably in Ghana, led to the development of flexible training schedules and accessible resources to cater for the informal sector, making training inclusive to low income learners (Nunyonameh et al., 2024). Political factors also played a major role in determining the policies of apprenticeship, with Russia's decentralized governance models a response to disparities in regional infrastructure and industry partnerships. Adaptations in these programs focused on balancing the national standards with local economic conditions through collaborative work with regional enterprises and flexible program management (Dudyrev et al., 2018).

The results demonstrate how economic, political, and cultural factors explain the adaptability of apprenticeship systems with different emphases in regions. These programs help to scale, accept and sustain training practices by aligning training practices with local condition, which demonstrates the need of culturally sensitive and context specific approaches.

Table6

Findings regarding Priorities and implementation strategies

NO	Author and Year	Priorities and implementation strategies
1	Chen & Dai (2021)	Emphasize Cultural and Political
2	Yamauchi et al (2018)	Emphasize Cultural
3	Pilz et al (2023)	German- Aligning closely with industrial needs China- Emphasize Cultural and Political
4	Khan et al. (2018)	Economic Structure
5	Tan et al. (2022)	Aligning closely with industrial needs
6	Dudyrev et al (2018)	Policy Implementation
7	Remington (2018)	Policy Implementation

Challenges in Apprenticeship/Dual-Traning Systems

Even though apprenticeship systems proved successful, there were some persistent challenges, especially in less developed regions. Common barriers included limited funding, infrastructure deficits and policy misalignments (Afutu-Kotey et al., 2024; Momanyi et al., 2024). Regional disparities made implementation even harder in Russia, and solutions were context specific (Dudyrev et al., 2018). Furthermore, the adaptability of apprenticeship system was affected by cultural factors, for example, German and Chinese companies' attempts to suit their training programs to local customs (Pilz et al., 2023). Table 7 shows issues types:

Table 7

Findings regarding Issues types

NO	Author and Year	challenges were identified
1	Nunyonameh et al (2024)	Resource & Public-Private Partnership Challenges
2	Afutu-Kotey et al (2024)	Struggle with resource
3	Momanyi et al (2024)	Struggle with resource
4	Zhaksylykovna et al. (2022)	Struggle with Resource & policy
5	Dudyrev et al (2018)	Policies often fail, requiring context-specific solutions

Public-Private Partnerships

While public-private partnerships (PPPs) arose as a key mechanism for closing the gap between educational curricula and market demands, they also represented a response to systemic and contextual challenges in apprenticeship systems. These partnerships operated across three key dimensions: resource sharing, collaborative curriculum design and stakeholder alignment.(Table 8)

In the Philippines, private sector representatives partnered with educational institutions to develop apprenticeship programs suited to industry needs and to graduate students with skills that are relevant and ready to work in the workforce (Garcia & Reyes, 2022). Such industry partners were also involved in competency frameworks that contribute towards enhancing workforce employability and adaptability (Yahaya et al., 2020).

Another important role of PPPs was resource sharing, especially in underdeveloped areas such as West Africa, where private companies provided financial support to the government to supplement funding to allow access to modern tools and technologies for the apprentices (Nunyonameh et al., 2024). These partnerships were further strengthened with effective stakeholder alignment, where Ghana's public institutions and private enterprises worked together to agree on roles and responsibilities for accountability and sustainability (Nunyonameh et al., 2024). Continuous feedback between industries and training providers (Igarashi & Acosta, 2022) enabled adaptive program structures in the Philippines through multi stakeholder dialogue platforms. These collaborative efforts not only solved immediate labor market needs, but also built sustainable and resilient apprenticeship models in Malaysia's ongoing dual training system and in the transformative reforms enabled by PPPs in West Africa (Yahaya et al., 2020; Nunyonameh et al., 2024).

Table 8
Findings regarding PPP-solutions

NO	Author and Year	Solutions
1	Igarashi & Acosta (2022)	Stakeholder alignment
2	Yahaya et al (2020)	Collaborative curriculum design
3	Nunyonameh et al (2024)	Resource sharing & stakeholder alignment
4	Garcia & Reyes (2022)	Collaborative curriculum design

Technology Integration in Apprenticeships

Technology, particularly virtual reality (VR) and digital platforms, played a key role in closing the gap in education. VR was also shown to improve practical skill acquisition in the context of apprenticeship settings in research from Germany and China (Pilz et al., 2023). Digital platforms filled in resource gaps in underdeveloped regions such as Kenya and Ghana to deliver learning experiences to informal sector workers (Momanyi et al., 2024; Afutu-Kotey et al., 2024). However, these findings show that technology brings about huge advancements, but access to such tools is still a challenge in regions that are less developed.

Table 9
Findings regarding tech-solutions

NO	Author and Year	Solutions
1	Pilz et al (2023)	VR
2	Mulders et al (2024)	VR
3	Afutu-Kotey et al (2024)	digital platforms
4	Momanyi et al (2024)	digital platforms

Dual Training Systems as a Core Framework

Dual training systems consistently as a basic structure of vocational education. These studies pointed out that theoretical and practical learning are combined in these systems to increase employability and meet industry needs. Research from Germany and Malaysia show that linking classroom education with workplace training is effective (Hoffmann & Lee, 2020; Tan et al., 2022). Studies from the Philippines and Russia show how dual training models adjust to the specific needs of the region and economy, and how skill alignment is improved with respect to labor market demands (Igarashi & Acosta, 2022; Dudyrev et al., 2018). These systems are still a global standard for adaptability and effectiveness in skill development.

Table 10

Findings regarding key focus types

NO	Author and Year	Key Focus
1	Hoffmann & Lee (2020)	Education outcomes aligned with industry demands
2	Tan et al. (2022)	Education outcomes aligned with industry demands
3	Igarashi & Acosta (2022)	Education outcomes aligned with industry demands
4	Dudyrev et al. (2018)	Adjusting dual systems to regional economic and industrial conditions
5	Khan et al. (2018)	Adjusting dual systems to regional economic and industrial conditions
6	Pilz et al. (2023)	Focusing on improving employability and addressing skill shortages
7	Yamauchi et al. (2018)	Focusing on improving employability and addressing skill shortages

The learning outcomes encapsulate the complex character of apprenticeship systems with their breadth of stakeholder constituency and their capacity for tackling a spectrum of educational and labor market problems. However, apprenticeship programs can make a big contribution to workforce development and economic growth if, at the same time, based on structured training models, innovative technologies, supportive policy and culturally sensitive approaches. They also draw attention to the need continue research and innovation to further improve these systems to reflect evolving socio economic contexts.

Discussion

This thesis synthesizes the implementation, challenges, and adaptability of apprenticeship systems in vocational education in underdeveloped regions. The findings reinforce dual training systems, the role of technology integration and government-private partnerships, while also highlighting cultural and policy factors. These insights provide a valuable contribution to current literature on apprenticeship practices and the changing nature of apprenticeship.

The findings are consistent with what prior studies have found, namely that dual training is an essential element of effective apprenticeship models. Structured integration of theoretical knowledge with workplace training has demonstrated great potential in Germany and Malaysia (Hoffmann & Lee, 2020; Tan et al., 2022) to improve employability and skill development. The adaptability of such systems to underdeveloped regions is however a crucial consideration. Apprenticeship programs have been used to fill skill gaps in informal sectors in contexts such as Ghana and Kenya but infrastructural and resource constraints persist (Mensah & Boateng, 2021; Odhiambo et al., 2021).

Tools like virtual reality are enhancing the practical training experience for apprenticeship systems, and while the integration of technology into apprenticeship systems is a huge advancement, it's still not perfect. This is consistent with Müller and Zhang (2022)

on the effectiveness of virtual simulations in skill acquisition. However, such technologies are not widely accessible in resource constrained areas, and hence need innovative yet affordable solutions. Technology is a complementary source to conventional training techniques, and in underdeveloped regions, it fills gaps in infrastructural and resource availability.

Public private partnerships became a critical factor in closing the gap between what is taught in educational curricula and industry needs. These partnerships are, as Garcia and Reyes (2022) have shown, consistent with the infrastructure, funding, and policy support required to maintain apprenticeship programs. In Ghana and the Philippines, examples of multi stakeholder collaboration to drive systemic reforms and ensure long term sustainability are provided (Mensah & Boateng, 2021). In underdeveloped regions, such partnerships are vital because without public funding alone it is not sufficient.

However, there are still some challenges. Apprenticeship systems are often held up by policy misalignments and cultural differences. Mensah and Boateng (2021) state that clearer policy frameworks and targeted interventions are needed to tackle these barriers. Additionally, cultural adaptability and awareness campaigns are necessary towards acceptance and participation in vocational education in some regions such as West Africa (Declining Apprenticeship Trends in Ghana, 2021).

Synthesizing the key characteristics of apprenticeship systems and identifying critical factors for their success and scalability, this study makes a contribution to theoretical understanding of apprenticeship systems. The findings are actionable for policymakers, educators, and industry stakeholders to design and implement sustainable apprenticeship programs, practically. Future research will investigate the long term effects of these systems and the integration of emerging technologies such as AI driven tools in vocational training.

Finally, apprenticeship systems continue to be a versatile and flexible tool to respond to the different needs of the vocational education in socio-economic contexts. With structured training models and supportive policies and culturally sensitive approaches, these systems can greatly support workforce development and economic growth.

Conclusions

In this systematic review we examined how apprenticeship systems were implemented, what challenges arose in their implementation and what opportunities for adaptation they present in the context of vocational education in underdeveloped regions. Analysis of 15 empirical studies using the PRISMA framework identified critical insights about dual training systems, technology integration, public-private partnerships, and the cultural adaptability of apprenticeship models. Dual training systems were seen as a backbone for connecting classroom education to workplace requirements, greatly enhancing the employability of and skills of individuals in the workforce. Technology integration, including the use of virtual reality and digital platforms, filled the resource gaps and improved practical training in resource poor settings; public private partnerships proved essential in overcoming funding and infrastructure challenges.

Nevertheless, these successes remain overshadowed by a number of barriers. The scalability and effectiveness of apprenticeship systems, especially in the underdeveloped

areas, are hampered by policy misalignment, insufficient funding, and cultural barriers. The findings highlight the need for locally appropriate training systems which are congruent with socio-economic and cultural contexts. Also, the importance of sustainable partnerships and integration of cost effective technologies continue to be required for improving vocational education outcomes.

This review makes a contribution to the literature by identifying actionable strategies for policymakers, educators, and industry stakeholders to better design apprenticeship systems. Going forward, future research should evaluate the long term impact of these systems, and explore innovative means through which to address current limitations, such as AI driven tools. Apprenticeship systems can remain as flexible and effective tools for workforce development and economic growth in varied global contexts by overcoming these challenges.

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