# INTEGRATION OF A DIGITAL INNOVATION SYSTEM MODEL IN VOCATIONAL HIGH SCHOOL EDUCATION (SMK) TO SUPPORT THE DEVELOPMENT OF DIGITAL ECONOMY COMPETENCIES

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**Abstract**

The rapid expansion of the digital economy has significantly transformed workforce demands, requiring vocational education institutions, particularly Vocational High Schools (Sekolah Menengah Kejuruan/SMK), to adapt learning systems that are responsive to technological innovation and industry needs. However, many SMKs still face challenges in aligning graduate competencies with the requirements of the digital economy, including limited integration of digital innovation systems in learning, curriculum, and institutional management. This study aims to analyze and synthesize concepts, theories, and research findings related to digital innovation systems within the context of vocational education, with a specific focus on SMK.

This article employs a conceptual review approach through a structured literature study. Data sources include national and international scholarly journals, education policy documents, and institutional reports published from 2020 onwards, focusing on digital economy, innovation systems, vocational education, and digital transformation in education. Literature was collected through systematic searches using academic databases such as Google Scholar, Scopus, DOAJ, and Garuda, followed by selection based on relevance, publication year, and source quality. Data analysis was conducted using descriptive analysis and conceptual synthesis to identify key themes, interrelationships among concepts, and their implications for SMK.

The findings indicate that digital innovation systems in SMK involve the interaction of key actors, including schools, productive teachers, students, industry partners, and government, supported by adequate digital infrastructure and ecosystem readiness. The study identifies essential competencies for SMK graduates in the digital economy, encompassing digital literacy, applied technological skills, entrepreneurial capabilities, and soft skills such as problem solving, collaboration, and technological adaptability. Furthermore, the integration of digital innovation systems in SMK learning can be strengthened through project-based and problem-based learning supported by digital platforms, e-modules, business simulations, gamification, and industry-oriented learning practices. At the institutional level, curriculum alignment with digital economy competencies, the implementation of Teaching Factory (TEFA), link and match with digital industries, and strong policy and leadership support are critical factors for successful implementation.

In conclusion, digital innovation systems provide a strategic framework for strengthening vocational education in SMK to enhance graduate work readiness and competitiveness in the digital economy. This study contributes a conceptual foundation for the development of digitally oriented vocational education models and offers practical implications for policymakers, school leaders, and educators. Future research is encouraged to empirically examine the implementation and effectiveness of digital innovation systems in SMK contexts.

Keywords: digital innovation systems, vocational education, SMK, digital economy, education transformation

## 1. INTRODUCTION

The rapid expansion of the digital economy has fundamentally transformed the structure of labor markets, production systems, and skill requirements across industries. Advances in digital technologies such as artificial intelligence, big data, cloud computing, e-commerce platforms, and financial technology have reshaped how

economic activities are conducted and how value is created. As a result, the demand for labor is increasingly oriented toward workers who possess not only technical expertise but also a combination of digital skills, critical thinking, adaptability, and problem-solving abilities aligned with the needs of the twenty-first century workforce (OECD, 2020; World Economic Forum, 2023). This transformation places strong pressure on education systems, particularly vocational education, to ensure that graduates are adequately prepared to participate in and contribute to the digital economy.

In the context of workforce development, vocational education institutions such as *Sekolah Menengah Kejuruan* (SMK) play a strategic role in bridging education and industry. SMK is designed to produce graduates who are job-ready and responsive to labor market demands. However, the acceleration of digital transformation has altered occupational profiles and competency standards more rapidly than traditional education systems can adapt. Many emerging jobs now require digital literacy, data-driven decision-making, and the ability to work with digital tools and platforms, competencies that were previously considered supplementary but are now essential (ILO, 2021; World Bank, 2022). Consequently, vocational education faces increasing challenges in maintaining relevance and alignment with the evolving digital economy. One of the major challenges in education today is preparing adaptive human resources capable of responding to continuous technological change. Educational institutions are required not only to update curricula but also to transform learning processes, pedagogical approaches, and institutional ecosystems. Reports from UNESCO (2021) and OECD (2021) emphasize that education systems must move beyond content transmission toward fostering higher-order thinking skills, lifelong learning orientations, and digital competencies. For vocational education, this challenge is more complex due to the need to integrate industry practices, technological innovation, and competency-based learning within formal schooling structures.

Despite various policy initiatives and digitalization efforts, a significant gap persists between the competencies developed in education and those required by the labor market. Several studies indicate that students' digital economy competencies such as digital literacy, entrepreneurial skills, and technology-based problem-solving remain uneven and often insufficient, particularly in vocational education settings (Suryadi et al., 2022; Nugroho & Negara, 2021). This gap is reflected in limited readiness for digital workplaces, low confidence in using digital tools for economic activities, and a mismatch between school-based learning outcomes and industry expectations. In the Indonesian SMK context, this misalignment is frequently associated with constrained infrastructure, limited teacher digital competence, and fragmented collaboration with industry actors (Fitriani et al., 2023).

Addressing these challenges requires more than incremental improvements; it necessitates systemic innovation within education. The concept of digital innovation systems offers a comprehensive framework for understanding how technology, institutions, human resources, and policy interact to support learning and competency development. Digital innovation systems emphasize the integration of digital technologies, learning platforms, industry partnerships, and supportive governance structures to create sustainable and adaptive educational ecosystems (Edquist, 2021; Lundvall & Johnson, 2020). In vocational education, such systems can facilitate the alignment of curricula with digital industry needs, enhance experiential learning

through simulations and digital projects, and strengthen linkages between schools and the digital economy.

The integration of digital technologies through e-learning, digital modules, learning management systems, and industry-based digital practices has been shown to enhance learning flexibility, student engagement, and skill relevance when implemented systematically (Bond et al., 2020; Al-Fraihat et al., 2020). However, without a coherent innovation framework, digital initiatives risk remaining fragmented and ineffective. Therefore, adopting a digital innovation system perspective is crucial for ensuring that technological integration in SMK contributes meaningfully to the development of digital economy competencies rather than functioning as isolated interventions.

Based on these considerations, this article aims to analyze the integration of a digital innovation system model in vocational education, particularly SMK, as a strategic approach to supporting the development of students' digital economy competencies. The novelty of this study lies in its synthesis of digital innovation system theory with the specific context of vocational education and digital economy skill development. The article contributes theoretically by extending the application of innovation system perspectives to education, and practically by offering insights for educators, school leaders, and policymakers on designing more coherent and industry-relevant digital learning ecosystems in SMK. Through this contribution, the article seeks to support the transformation of vocational education in responding effectively to the demands of the digital economy.

## 2. METHODOLOGY

This article employs a conceptual review approach combined with a structured literature study to analyze and synthesize theoretical perspectives, empirical findings, and policy directions related to digital innovation systems in vocational education, particularly in the context of developing digital economy competencies in *Sekolah Menengah Kejuruan* (SMK). The methodological framework is designed to ensure analytical rigor, transparency, and conceptual coherence in addressing the research objectives.

### 2.1 Type of Study

This study is categorized as a conceptual review or literature-based study. The primary purpose of this approach is to examine, compare, and integrate concepts, theories, and research findings related to digital innovation systems, digital economy competencies, and vocational education. Rather than generating new empirical data, the study focuses on developing a comprehensive understanding of how digital innovation systems can be integrated into vocational education to support the development of digital economy competencies. This type of study is appropriate for identifying conceptual gaps, synthesizing fragmented knowledge, and proposing a coherent framework relevant to SMK and vocational education contexts.

### 2.2 Data Sources

The data sources for this study consist of secondary data derived from credible and authoritative publications. These include peer-reviewed national and international journals in the fields of vocational education, digital economy, educational technology, e-commerce, and innovation systems. In addition, policy documents and official reports related to vocational education reform, *link and match* strategies, and digital

transformation in education are included to provide contextual and regulatory perspectives. Reports published by international organizations such as UNESCO, OECD, and the World Bank, as well as official publications from the Indonesian Ministry of Education, are also utilized. To ensure the relevance and novelty of the analysis, the literature selected for this study is limited to publications from 2020 onwards.

### 2.3 Data Collection Technique

Data collection was conducted through a structured literature search process. The process began with the identification of relevant keywords, including *digital economy*, *digital innovation systems*, *vocational education*, *SMK*, *e-commerce in education*, and *digital skills*. These keywords were used to search academic databases such as Google Scholar, Scopus, DOAJ, and Garuda. The retrieved literature was then screened based on predefined inclusion and exclusion criteria. The inclusion criteria comprised topical relevance to digital innovation systems, vocational education, and digital economy competencies; publication year of 2020 or later; and publication in reputable journals or official institutional reports. Literature that did not align with the focus of vocational education or lacked academic credibility was excluded from the analysis.

### 2.4 Data Analysis Technique

The data analysis employed descriptive analysis and conceptual synthesis techniques. Initially, the selected literature was organized into major thematic categories, such as digital economy competencies, innovation systems in education, digital transformation in vocational education, and industry–education linkages. Subsequently, key concepts, patterns, and relationships among the identified themes were analyzed to identify convergences and divergences across studies. The findings were then synthesized within the context of SMK and vocational education to construct an integrated understanding of how digital innovation systems can support digital economy competency development. Based on this synthesis, a conceptual framework was formulated to illustrate the interaction between digital technologies, educational practices, institutional support, and industry collaboration in vocational education settings.

## 3. FINDINGS AND DISCUSSION

### 3.1 Digital Innovation Systems in the Context of Vocational Education (SMK)

Digital innovation systems in vocational education refer to an integrated framework that connects technological infrastructure, human resources, institutional governance, and external stakeholders to support continuous innovation in learning and skill development. In the context of *Sekolah Menengah Kejuruan* (SMK), digital innovation systems are essential to align educational practices with the dynamic demands of the digital economy. Such systems emphasize not only the adoption of digital technologies but also the coordination of actors, processes, and policies that enable sustainable competency development.

Within vocational education, the implementation of digital innovation systems involves multiple key actors. Schools function as institutional hubs that facilitate curriculum design, learning management, and collaboration with external partners. Productive teachers play a central role as learning designers and facilitators who translate industry needs into meaningful learning experiences. Students act as active learners who engage with digital tools to develop vocational and economic

competencies. Industry partners contribute through curriculum alignment, real-world projects, and technology transfer, while government institutions provide policy direction, regulatory frameworks, and resource support. The effectiveness of a digital innovation system in SMK depends on the synergy among these actors rather than the performance of individual components in isolation.

Infrastructure and digital ecosystems also constitute critical elements of digital innovation systems in SMK. Adequate access to hardware, software, internet connectivity, and learning platforms enables the integration of digital technologies into vocational learning. Beyond physical infrastructure, digital ecosystems encompass learning management systems, digital content, industry platforms, and collaborative networks that support experiential and technology-enhanced learning. When these components are coherently integrated, SMK can create learning environments that reflect the realities of digital workplaces and economic activities.

### 3.1.1 Digital Economy Competency Needs of SMK Graduates

The digital economy requires vocational graduates to possess a combination of technical, entrepreneurial, and transversal competencies. Digital literacy and applied technological skills represent foundational competencies for SMK graduates. These include the ability to use digital tools, understand digital systems, manage data, and operate technology-based applications relevant to vocational fields. Such competencies enable students to adapt to technology-intensive work environments and engage effectively in digital production and services.

In addition to technical skills, entrepreneurship and digital economy competencies are increasingly important for SMK graduates. The growth of e-commerce, digital services, and online business models creates opportunities for vocational graduates to participate not only as workers but also as digital entrepreneurs. Competencies related to digital marketing, online transactions, business model innovation, and customer engagement are therefore essential to enhance graduates' economic participation and employability in the digital era.

Soft skills remain a crucial dimension of digital economy competencies. Problem-solving, collaboration, communication, and adaptability to technological change are widely recognized as key skills for success in digital work environments. In vocational education, these skills support students in navigating complex tasks, working in interdisciplinary teams, and continuously updating their competencies in response to evolving technologies. The integration of soft skills with technical and entrepreneurial competencies strengthens the overall readiness of SMK graduates for the digital labor market.

### 3.1.2 Integration of Digital Innovation Systems in SMK Learning

The integration of digital innovation systems in SMK learning is reflected in the adoption of pedagogical approaches that emphasize active, contextual, and technology-supported learning. Project-Based Learning (PjBL) and Problem-Based Learning (PBL) are widely regarded as effective approaches for vocational education, as they allow students to engage with real-world problems and industry-relevant projects. When integrated with digital technologies, these approaches enable students to develop technical competencies, digital skills, and higher-order thinking simultaneously.

Digital platforms, e-modules, and digital business simulations further support the implementation of innovation-oriented learning in SMK. Learning management systems facilitate flexible access to learning resources, assessment, and feedback,

while e-modules enable self-paced and personalized learning. Digital simulations, particularly those related to business and economic activities, provide students with experiential learning opportunities that mirror real digital economy practices without the constraints of physical environments.

Gamification and industry-based learning also contribute to strengthening digital innovation systems in SMK. Gamified learning elements, such as points, levels, and challenges, can increase student motivation and engagement when aligned with learning objectives. Industry-based learning, including virtual internships and digital collaboration with industry partners, allows students to experience authentic work processes and technologies. Together, these approaches enhance the relevance and effectiveness of vocational learning in preparing students for the digital economy.

### 3.1.3 Integration into Curriculum and SMK Management

The integration of digital innovation systems extends beyond classroom practices to curriculum design and school management. A curriculum oriented toward digital economy competencies emphasizes competency-based outcomes, flexibility, and alignment with industry needs. Such curricula incorporate digital skills, entrepreneurship, and transversal competencies across vocational subjects rather than treating them as standalone components.

Teaching Factory (TEFA) initiatives and *link and match* programs represent strategic mechanisms for integrating digital innovation systems into SMK management. Through TEFA, schools simulate industry environments and production processes, enabling students to apply digital technologies in authentic vocational contexts. Collaboration with digital industries strengthens curriculum relevance, provides access to current technologies, and supports the continuous updating of competency standards.

School leadership and policy support play a critical role in sustaining digital innovation systems. Effective leadership fosters a culture of innovation, supports teacher professional development, and ensures strategic investment in digital infrastructure. Policy alignment at the institutional and governmental levels further reinforces the implementation of digital innovation systems by providing regulatory clarity, funding mechanisms, and quality assurance frameworks.

### 3.1.4 Impacts and Challenges of Implementation in SMK

The implementation of digital innovation systems in SMK has significant implications for graduates' work readiness and competitiveness. By integrating digital technologies, industry collaboration, and competency-based learning, SMK can enhance students' employability, entrepreneurial capacity, and adaptability to digital work environments. Graduates equipped with digital economy competencies are better positioned to respond to labor market demands and pursue diverse career pathways.

Despite these benefits, several challenges constrain the effective implementation of digital innovation systems in SMK. Infrastructure limitations, including unequal access to digital devices and internet connectivity, remain a major barrier. Variations in teachers' digital competence also affect the quality of technology integration in learning. Additionally, digital divides among students can exacerbate inequality in learning outcomes and access to digital opportunities.

To address these challenges, strategic efforts are required to strengthen digital innovation systems in vocational education. These include targeted investment in infrastructure, continuous professional development for teachers, and strengthened

collaboration with industry partners. Policy support and institutional leadership are also essential to ensure coherence, sustainability, and scalability of digital innovation initiatives. Through these strategies, SMK can more effectively leverage digital innovation systems to support the development of digital economy competencies.

## 4. CONCLUSION

This article has examined the integration of digital innovation systems in vocational education, particularly *Sekolah Menengah Kejuruan* (SMK), as a strategic response to the growing demands of the digital economy. Through a conceptual review and structured literature analysis, the study synthesizes current theories, empirical findings, and policy perspectives related to digital economy competencies, vocational learning, and systemic educational innovation.

The findings indicate that the development of digital economy competencies among SMK students requires a systemic and integrated approach rather than isolated technological interventions. Digital innovation systems provide a comprehensive framework that connects key actors schools, productive teachers, students, industry partners, and government institutions within a coherent digital ecosystem. When supported by adequate infrastructure, aligned curricula, and effective governance, such systems enable vocational education to respond more adaptively to technological change and labor market dynamics.

Furthermore, the analysis highlights that digital economy competencies in vocational education extend beyond technical digital skills to include entrepreneurial capabilities and transversal skills such as problem-solving, collaboration, and adaptability. The integration of innovation-oriented pedagogical approaches, including project-based and problem-based learning supported by digital platforms, e-modules, simulations, and gamification, enhances the relevance and effectiveness of learning in preparing students for digital workplaces. At the institutional level, curriculum alignment, Teaching Factory (TEFA) implementation, and *link and match* partnerships with digital industries emerge as critical mechanisms for embedding digital innovation systems within SMK management.

Despite these potentials, the study also identifies persistent challenges in implementing digital innovation systems in SMK, particularly related to infrastructure disparities, variations in teacher digital competence, and digital divides among students. These challenges underscore the need for sustained policy support, strategic leadership, and continuous capacity building to ensure equitable and effective integration of digital innovation in vocational education.

In conclusion, this article contributes theoretically by extending the application of digital innovation system perspectives to the context of vocational education and digital economy competency development. Practically, it offers insights for educators, school leaders, and policymakers on designing coherent and sustainable digital learning ecosystems in SMK. Future studies are encouraged to empirically examine the implementation and impact of digital innovation systems in vocational education settings to further validate and refine the conceptual framework proposed in this study.

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