

ENHANCING WORKERS' DIGITAL CAPABILITIES AND SKILLS FOR GREEN TRANSITION IN VIETNAM'S ELECTRONICS MANUFACTURING INDUSTRY

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Abstract:

Vietnam's electronics manufacturing industry is undergoing a twin transition that integrates digital transformation with green transformation to strengthen global competitiveness, comply with Environmental, Social and Governance (ESG) standards, achieve Net Zero commitments, and satisfy increasingly stringent global supply chain requirements. Within this context, workers' digital competence and digital skills have become strategic determinants of technological adaptation, smart manufacturing, resource efficiency, energy optimization, and carbon emission reduction. Nevertheless, a substantial gap remains between emerging competency requirements and the actual capabilities of the workforce, particularly across enterprises with different levels of automation and digital maturity.

This study investigates the theoretical and practical foundations of digital competency development for workers in the context of green transformation, identifies the major factors influencing digital skill enhancement in Vietnam's electronics manufacturing sector, and proposes an integrated competency framework that aligns workforce development with sustainable industrial transformation. The research adopts a multidisciplinary approach based on an extensive review of international literature, policy analysis, comparative analysis, and systematic synthesis to establish an analytical framework suitable for the Vietnamese context.

The findings indicate that digital competency development should be implemented through four mutually reinforcing dimensions: (i) digital technology and data competence; (ii) green operational skills for smart manufacturing; (iii) innovation capability and lifelong learning; and (iv) adaptive governance competence within digitally enabled production systems. Building upon these findings, the study proposes the Integrated Green Digital Competency Framework (IGDCF), which emphasizes collaborative governance among government agencies, manufacturing enterprises, higher education institutions, vocational training providers, professional organizations, and employees to establish a sustainable talent ecosystem for the electronics industry. The proposed framework contributes to the theoretical understanding of the interaction between digital competence and green transition while offering practical policy implications for workforce upskilling, industrial sustainability, and resilient human capital development in Vietnam's electronics manufacturing sector toward 2035.

Keywords: Digital competence; Digital skills; Green transition; Electronics manufacturing industry; High-quality human resources; Smart manufacturing; Sustainable development.

1. Introduction

Digital transformation and green transformation are becoming two strategic trends, reshaping the growth models of nations and economic sectors in the context of the ongoing Fourth Industrial Revolution globally. Digital technology helps to form many models such as smart manufacturing, smart energy, and smart cities. For the manufacturing industry, especially the electronics component manufacturing sector – a key sector in the global supply chain – the need for a harmonious combination of digitalized production and sustainable development is becoming increasingly urgent. Environmental, social, and governance (ESG) standards, commitments to reduce carbon emissions, and requirements for transparency in production data are posing new challenges for businesses and the workforce.

In this context, the development goal is to minimize human involvement and prioritize automation. In many fields, humans are competing with machines in certain jobs. However, the effectiveness of digital technology depends heavily on the capacity of workers to access, operate, and utilize new technological systems. Therefore, the digital competence and skills of workers are not only a prerequisite for digital transformation, but also a crucial foundation for promoting green transformation in manufacturing enterprises.

Globally, many international organizations such as the OECD, ILO, and World Economic Forum emphasize the role of developing digital skills linked to green skills in sustainable human resource development strategies. However, in Vietnam, current research mainly approaches digital transformation and green transformation as two parallel processes, failing to fully analyze the reciprocal relationship between workers' digital competence and the requirements of green transformation, especially in the electronics component manufacturing industry – a sector that employs a large number of skilled workers and consumes a large amount of energy.

Based on that practical context, this paper aims to systematize the theoretical basis of digital competence of workers and green transformation in the electronics industry; analyze the context and policy requirements for developing digital competence to serve green transformation; and from there, propose some policy implications to enhance digital competence and digital skills for workers in electronic component manufacturing enterprises in Vietnam. The contribution of this paper is not only in the theoretical aspect, but also provides a scientific basis for policy planning to develop human resources in the electronics industry towards green and sustainable development.

2. Theoretical Basis and Research Overview

2.1. Concept and Content of Digital Competence of Workers

Digital competence and digital skills are concepts approached from many different angles. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO) (2023), digital skills are defined as the ability to use digital devices, media applications, and the Internet to access and manage information. They enable people to create and share digital content, communicate and collaborate, and solve problems effectively and creatively in their lives, studies, work, and social activities in general. At a basic level, digital skills are demonstrated through the ability to use digital devices and online applications. At an advanced level, digital skills are the ability to leverage digital technology to enhance competence and adaptability in professional fields such as information and communication technology. Technologies such as artificial intelligence (AI), machine learning, big data analytics, and blockchain are changing skill requirements, thereby impacting the capacity building and development of digital skills for the workforce in the digital economy (UNESCO, 2023).

According to the World Bank, digital skills are the ability to access, manage, understand, integrate, communicate, evaluate, and create information safely and appropriately. Accordingly, the digital skills framework for the workforce in general is defined as comprising seven competencies: software and equipment operation; data and information literacy; communication and collaboration; digital content creation; security; problem-solving; and occupational competencies at four proficiency levels (basic, intermediate, advanced, and highly specialized) (World Bank, 2020; World Bank, 2023).

Digital skills are crucial for personal and professional development; they enable people to communicate, collaborate, learn, and work more effectively. To develop the digital skills of the workforce, it is important to clearly identify the different competencies relevant to different target groups (World Bank, 2025).

According to the OECD (2020), digital skills are the appropriate use of digital technologies and communication tools to access, manage, integrate, and evaluate information, build new knowledge, and communicate with others in order to participate effectively in society (OECD, 2020).

Digital skills are the foundation for workers to master technology, leverage digital tools in their work, thereby improving efficiency and productivity. Digital skills help people participate in and excel in the labor market, enabling workers to interact

and work with people in different countries. The use of digital technologies makes communication and work easier, thus increasing globalization in the workplace. Digital skills are key to improving employment prospects for workers; to take advantage of this, people need skills in the digital environment (PwC, 2021a).

In the "Digital Transformation Handbook" of the Ministry of Information and Communications (formerly), basic digital knowledge and skills are one of the nine constituent elements of digital citizenship. October 4th is designated as Vietnam Labor Skills Day according to Decision No. 1486/QĐ-TTg dated October 1, 2020, of the Prime Minister.

In the context of Industry 4.0, the digital competence of workers in manufacturing enterprises is understood as the sum of the knowledge, skills, and attitudes necessary to operate, exploit, and innovate digitized production systems. Many studies have proposed classifying digital competence into groups: (i) Basic digital skills; (ii) Specialized digital skills serving production; (iii) Advanced digital skills related to data, artificial intelligence, and the Internet of Things; (iv) Digital safety, security and ethics skills (Ester van Laar et al, 2017) (OECD-2019, 2019).

For electronic component manufacturing businesses, the digital competence of workers is also closely linked to the ability to operate automated production lines, use production management software (MES, ERP), analyze quality data, and monitor environmental indicators during the production process.

2.2. Green transformation in the electronic component manufacturing industry

According to the 2020 Industrial Development Report – Industrialization in the Digital Age of UNIDO (2020), green transformation is understood as the process of shifting the development model towards minimizing negative impacts on the environment, using resources efficiently and aiming for sustainable development (UNIDO-IDR2020, 2020). In the manufacturing industry in general, and in the electronics component manufacturing industry in particular, green transformation has its own unique characteristics due to the industry's high energy consumption, use of scarce materials, and generation of large amounts of electronic waste.

The core elements of green transformation in the electronics manufacturing industry include: cleaner production, energy saving, reduction of green house gas emissions, management and recycling of electronic waste, as well as the application of international environmental standards. Digital

technology plays a key role in monitoring and optimizing these activities through sensor systems, big data analytics, and process automation (IEA, 2021).

2.3. The Relationship Between Digital Capabilities, Digital Skills, and Green Transformation

The relationship between digital capabilities, digital skills, and green transformation can be explained through several underlying theories. According to human capital theory (Becker, G.S, 1993), investing in the skills and capabilities of workers helps improve the productivity and operational efficiency of businesses. Enterprise-Based Resource (RBV) theory argues that human capabilities are a strategic resource, creating a sustainable competitive advantage (Ina Ehnert, 2009). Meanwhile, the theory of sustainable development, presented in the book "Cannibals with Forks: Three Pillars of Sustainable Business in the 21st Century" by Elkington (1997), emphasizes the balance between economic growth, environmental protection, and social progress (Elkington, 1997).

From this perspective, the digital capabilities of workers are a necessary condition for businesses to effectively implement green production solutions. Highly digitally capable workers will help businesses operate energy-saving technologies, analyze environmental data, and detect and minimize waste in production. Conversely, green transformation also motivates businesses to invest more heavily in developing digital capabilities for their employees.

2.4. Overview of Related Studies

Recent international studies have focused heavily on the link between digital skills and green jobs, emphasizing the need for retraining and upskilling of the workforce during the green transformation (ILO, 2019) and (WEF, 2023). However, most of these studies are general in nature and do not delve deeply into the specifics of each industry.

In Vietnam, research on human resources in the electronics manufacturing sector mainly focuses on the quality of human resources, factors affecting the quality of human resources for electronics manufacturing enterprises, research in industrial parks in a specific locality, technical training, and digital transformation in manufacturing enterprises. Research on digital capabilities serving green transformation is limited, especially lacking policy-oriented analyses. This is the gap that this paper aims to fill.

3. Research Methodology

This paper uses a qualitative research approach,

based on theoretical and policy analysis. The research data is mainly secondary data, including reports from international organizations (OECD, ILO, WEF, UNIDO, WORLD BANK), policy documents of the Prime Minister, as well as published scientific research works both domestically and internationally.

Content analysis methods are used to systematize concepts, theoretical frameworks, and policy orientations related to digital capabilities and green transformation. Simultaneously, comparative methods are applied to compare international experiences with the Vietnamese context, thereby drawing appropriate policy implications.

4. Context and Policy Requirements for Digital Competence for Green Transformation

4.1. International Policy Trends

Currently, many countries and regions around the world have issued strategies integrating digital skills development with green transformation. The European Union (EU) adopted the European Green Deal and the Digital Competency Framework (DigComp) to standardize digital skills for the workforce. The OECD also emphasizes skills development as a crucial pillar in the post-pandemic green recovery strategy. The current digital environment is closely intertwined with daily life, work, study, and social participation. Individuals need digital competence to take advantage of the capabilities that digital technology offers as well as to face the challenges they may create. We need digital competence for many activities – objectively searching, collecting, and analyzing online information; creating, editing, and sharing digital content; Managing privacy, safety, and health in the digital environment; using digital platforms and services; seizing employment and learning opportunities; connecting socially and participating in civic life through digital technology... However, in 2023, only 56% of adults in the EU had digital skills above the basic level; 43% of high school students in the EU did not achieve basic digital skills. In the period 2024-2025, 92% of EU workers said they needed digital skills to work and 30% used AI systems in their work (EU Science Hub, 2025).

4.2. Context and Policies in Vietnam

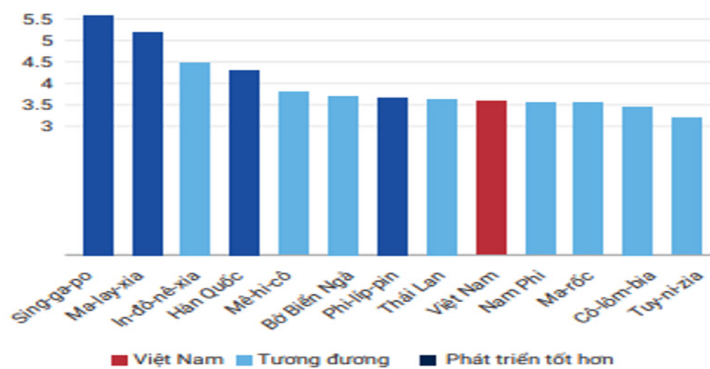
In Vietnam, the National Digital Transformation Strategy and the Green Growth Strategy for the period 2021-2030 have identified human resource development as one of the key tasks. The documents of the 13th National Congress of the Communist Party of Vietnam affirm: “Strongly promote national digital transformation, develop the digital economy and digital society to create breakthroughs in improving productivity, quality,

efficiency, and competitiveness of the economy” and the need to “Train people in the direction of having ethics, discipline, order, a sense of civic and social responsibility; having life skills, work skills, foreign languages, information technology, digital technology, creative thinking and international integration (global citizens) and digital skills need to be included in the general education curriculum” (Communist Party of Vietnam, 2021).

The National Strategy for the Development of the Digital Economy and Digital Society to 2025, with orientation to 2030, identifies the development of digital human resources as one of the three important pillars to achieve the set goals. Digital human resources, including experts, digital technology personnel, and citizens equipped with digital skills, play a key role in promoting the development of the digital economy and digital society (Prime Minister, 2022). Decision No.146/QĐ-TTg dated January 28, 2022, of the Prime Minister approving the Project “Raising awareness, popularizing skills and developing human resources for national digital transformation until 2025, with orientation to 2030” identifies: popularizing digital skills is key to enabling people to access digital knowledge and skills to participate in the digital transformation process, opening up opportunities to access digital services equally, helping to build an inclusive and comprehensive digital society (Prime Minister, 2022). According to PwC survey data (2021), 84% of Vietnamese people surveyed believe that they need a skills framework to guide the development of Industry 4.0 capabilities (PwC, 2021).

According to the World Bank report “Digital Vietnam: The Path to the Future” (2021), Vietnam has two major shortcomings in policy and policy implementation that limit the effectiveness of state management in Vietnam: (1) Lack of a unified legal framework on digital technology leading to the issuance of fragmented regulations; (2) The institutional framework serving digital transformation in Vietnam is still too cumbersome. The above data shows that the adaptability of the legal framework to digital business models in Vietnam is quite low compared to Southeast Asian countries such as Singapore, Malaysia, Indonesia, the Philippines, and Thailand. However, current policies still lack specific linkages between developing the digital capabilities of workers and the requirements of green transformation in each industry, especially the electronics industry. The low level of digital technology innovation in the private sector is explained by the limited needs of businesses, the lack of government support, and the underdeveloped state of “digital” businesses: The limited needs of businesses stem from uncertainty about the return on investment in technology,

Figure 1. Adaptability of the legal framework to digital business models

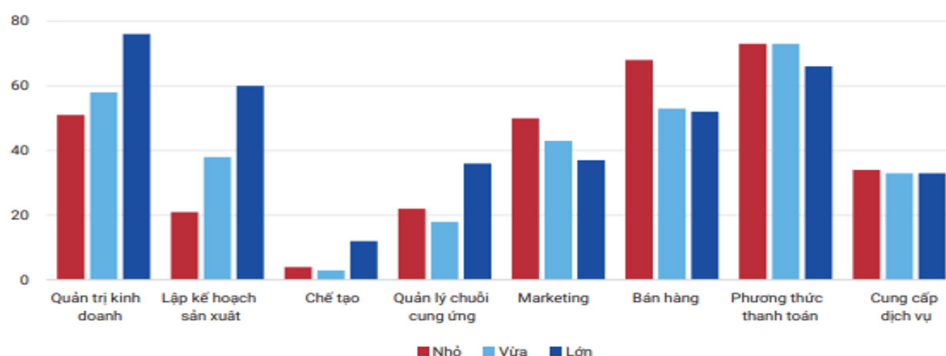


Source: (World Bank, 2021)

weak internal technology usage capacity, limited finances, and legal obstacles. Over 75% of small and medium-sized enterprises (SMEs) and about 63% of large enterprises are currently unclear about the return on investment in technology and whether such investment is suitable for their needs. Less than 60% of small and medium-sized enterprises (SMEs) reported either a lack of information about existing technologies or a lack of skills to use them. Furthermore, Vietnamese businesses also indicated limited access to foreign financing. Public sector support remains focused on research

and development rather than technology upgrading and commercialization, including the adoption and dissemination of existing technologies. The growth rate of digital businesses is still low, a factor that acts as a catalyst for digital transformation in the private sector. Digital businesses are those based on platforms and data, providing digital services or content, digital payment methods, or digital solutions to other businesses, especially startups or small businesses that lack the internal capacity to build these capabilities themselves.

Figure 2. The use of new digital platforms mainly focuses on simple functions and operations



Source: (World Bank, 2021)

Digital platforms are primarily used to streamline simple business functions such as business administration, sales, and payment methods. Only large enterprises with sufficient financial and human resources demonstrate the ability to utilize digital tools in production planning, supply chain management, and manufacturing operations. The World Bank's 2020 survey of businesses on technology adoption shows that the application

of new technologies is still in its early stages in Vietnam. Only 6% of businesses in Vietnam use cloud computing for business tasks, and less than 2% use big data or AI for marketing. More broadly, only about 6% of manufacturing businesses use additive manufacturing (AM) or other advanced techniques, and less than 2% use robotics (World Bank, 2021).

4.3. Challenges to be faced

Vietnam's digital skills ranking is still quite low compared to other countries in the region, ranking 97th out of 141 (WEF, 2019). This index assesses a country's ability to develop, attract, and retain talent. The 97th ranking shows that Vietnam still has much work to do to improve the digital skills of its workforce and people (Hue, N.T, 2024).

The report “Digitalization in Vietnam: A Path to the Future,” published by the World Bank in 2021, recommended a roadmap for realizing digitalization by enhancing the digital skills of workers to leverage the strengths of digital technology, as uneven skill distribution can increase inequality (World Bank, 2021).

Workers in electronic component manufacturing businesses still have limitations in advanced digital skills, data analysis capabilities, and the operation of environmental monitoring systems. Training remains short-term and has not kept pace with the speed of technological innovation and the requirements of sustainable development.

5. Discussion and Policy Implications

The analysis results show that the digital competence and digital skills of workers play a central role in realizing the green transformation goals of the electronics industry. Compared to international experience, Vietnam needs a more integrated policy framework that closely connects digital transformation, green transformation, and human resource development. Regarding macroeconomic policies, the State needs to develop a digital-green competency framework for industrial workers, serving as a basis for training and skills assessment; perfect the legal framework on digital transformation, review, propose, and amend existing legal documents on digital transformation. Simultaneously, it is necessary to promote cooperation between businesses, training institutions, and research organizations to develop training programs that meet practical needs. A program to support industrial production towards the application of Industry 4.0 and to develop smart factories through digital transformation should be issued by 2030. Furthermore, continued support should be provided to businesses in training their technical staff on digital transformation to raise awareness of digital transformation within enterprises. The government and private sector partners should develop a program that combines skills development for the digital economy with

funding and mentoring for digital technology entrepreneurs (World Bank, 2021).

For local agencies, organizations, departments, and industrial parks, it is necessary to minimize administrative procedures and remove legal bottlenecks so that businesses can access digital transformation and smart factories more quickly. For industry associations, they will act as a bridge between businesses to raise awareness about digital transformation and the application of smart factory management models in production and management processes to serving the green growth strategy in the coming years (World Bank, 2021).

For businesses, investing in the digital capabilities of the workforce should be considered a long-term strategy, linked to ESG goals and sustainable development. Building a digital learning culture and encouraging innovation will help businesses enhance their adaptability in the context of green transformation.

Therefore, to enhance the digital skills of workers in electronic component manufacturing enterprises to meet the green transformation requirements of the electronics industry, support from the Government, local management agencies, along with the determined investment of enterprises and the efforts of the leadership and workers are needed.

6. Conclusion

This paper has systematized the theoretical basis of digital competence, digital skills of workers and green transformation in electronic component manufacturing enterprises; analyzed the context and policy requirements; and proposed policy implications to enhance the digital competence of workers to meet the sustainable development requirements of the electronics manufacturing industry. The research contributes to filling the theoretical gap on the relationship between digital competence, digital skills and green transformation, and provides scientific arguments for human resource policy planning in the electronics manufacturing industry in general and electronic component manufacturing enterprises in industrial parks in particular in Vietnam.

A limitation of this study is the lack of empirical surveys. Further research could develop a quantitative model to measure the impact of digital capabilities on the effectiveness of green transformation in businesses.

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NÂNG CAO NĂNG LỰC VÀ KỸ NĂNG SỐ CỦA NGƯỜI LAO ĐỘNG ĐÁP ỨNG CHUYỂN ĐỔI XANH TRONG NGÀNH SẢN XUẤT ĐIỆN TỬ VIỆT NAM

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Lịch sử bài báo

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IPC Green Inventory: Y02P; Y02B; H01L; H05K

Tóm tắt:

Ngành sản xuất điện tử Việt Nam đang đứng trước yêu cầu chuyển đổi kép (Twin Transition), kết hợp giữa chuyển đổi số và chuyển đổi xanh nhằm nâng cao năng lực cạnh tranh, đáp ứng các tiêu chuẩn ESG, cam kết phát thải ròng bằng "0" (Net Zero) và các yêu cầu ngày càng khắt khe của chuỗi cung ứng toàn cầu. Trong bối cảnh đó, năng lực và kỹ năng số của người lao động trở thành yếu tố quyết định đối với khả năng thích ứng công nghệ, tối ưu hóa quy trình sản xuất thông minh, sử dụng hiệu quả tài nguyên và giảm phát thải Carbon. Tuy nhiên, khoảng cách giữa yêu cầu kỹ năng mới và năng lực thực tế của lực lượng lao động vẫn còn đáng kể, đặc biệt tại các doanh nghiệp sản xuất điện tử có mức độ tự động hóa và số hóa khác nhau.

Bài báo nhằm phân tích cơ sở lý luận và thực tiễn về phát triển năng lực số của người lao động trong bối cảnh chuyển đổi xanh; đánh giá các yếu tố ảnh hưởng đến quá trình hình thành và nâng cao kỹ năng số trong ngành sản xuất điện tử Việt Nam; đồng thời đề xuất mô hình tích hợp phát triển năng lực số gắn với chuyển đổi xanh và sản xuất bền vững. Nghiên cứu được thực hiện trên cơ sở tổng quan tài liệu quốc tế, kết hợp phương pháp phân tích chính sách, phân tích so sánh, tổng hợp hệ thống và tiếp cận đa ngành nhằm xây dựng khung phân tích phù hợp với điều kiện Việt Nam.

Kết quả nghiên cứu cho thấy việc phát triển năng lực số cần được triển khai đồng bộ trên bốn phương diện: (i) năng lực công nghệ số và dữ liệu; (ii) kỹ năng xanh trong vận hành sản xuất thông minh; (iii) năng lực đổi mới sáng tạo và học tập suốt đời; và (iv) năng lực quản trị thích ứng trong môi trường sản xuất số hóa. Trên cơ sở đó, bài báo đề xuất Mô hình tích hợp phát triển năng lực số phục vụ chuyển đổi xanh (Integrated Green Digital Competency Framework – IGDCF), nhấn mạnh sự liên kết giữa Nhà nước, doanh nghiệp, cơ sở giáo dục, tổ chức nghề nghiệp và người lao động nhằm hình thành hệ sinh thái phát triển nguồn nhân lực chất lượng cao cho ngành điện tử. Nghiên cứu đóng góp bổ sung cơ sở lý luận về mối quan hệ giữa năng lực số và chuyển đổi xanh, đồng thời cung cấp các hàm ý chính sách phục vụ phát triển nguồn nhân lực bền vững trong ngành sản xuất điện tử Việt Nam giai đoạn hiện nay đến năm 2035.

Từ khóa: Năng lực số; Kỹ năng số; Chuyển đổi xanh; Ngành sản xuất điện tử; Nguồn nhân lực chất lượng cao; Sản xuất thông minh; Phát triển bền vững.