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New Productive Forces in the Digital Era and the Requirements for High-Quality Human Resource Development in Vietnam

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Abstract

In the context of the Fourth Industrial Revolution and the rapid expansion of digital transformation, new productive forces are increasingly emerging, characterized by the development of advanced technologies such as artificial intelligence, big data, and the Internet of Things. These transformations not only reshape production methods but also create urgent demands for the development of high-quality human resources. This paper analyzes the theoretical foundations of new productive forces, clarifies global development trends, and examines the current situation in Vietnam within the digital transformation process. Based on this analysis, the study evaluates the status of human resources, identifying key limitations and challenges in education and training, particularly in science, technology, engineering, and mathematics (STEM) fields. Finally, the paper proposes several orientations and policy solutions to improve the quality of human resource training, thereby meeting the requirements of new productive forces and contributing to economic growth and sustainable development in Vietnam in the digital era.

Keywords: New productive forces, Digital transformation, High-quality human resources,

Digital economy, Science and technology, STEM, Vietnam

1. Introduction

In the context of the Fourth Industrial Revolution, rapid advancements in digital technologies such as artificial intelligence (AI), big data, and the Internet of Things (IoT) are fundamentally transforming the nature of production and economic organization worldwide (Schwab, 2016; Brynjolfsson & McAfee, 2014). These technological breakthroughs are not only reshaping traditional production methods but also giving rise to what is increasingly referred to as "new productive forces." This transformation reflects a shift from conventional production systems toward knowledge-based, technology-driven, and innovation-oriented economic structures (Castells, 2010).

From the perspective of classical political economy, productive forces constitute the material foundation of social development, encompassing labor, means of production, and the level of scientific and technological application in production processes. As emphasized in Marxist theory, the development of productive forces plays a decisive role in shaping production relations and broader socio-economic structures. In contemporary contexts, the concept of new productive forces has been extended to include advanced technologies, new materials, and modern industries associated with the digital economy, as well as a workforce equipped with new knowledge and skills required to operate within these systems.

Globally, the development of new productive forces has become a dominant trend, driven by technological innovation and digital transformation. Countries are increasingly investing in emerging sectors such as AI, high-tech manufacturing, renewable energy, and digital infrastructure to enhance productivity, competitiveness, and sustainable development. The experience of several economies, particularly those prioritizing technological advancement and innovation, demonstrates that the transition toward new productive forces is essential for maintaining long-term economic growth and adapting to global changes (Schwab, 2016; World Economic Forum, 2023; United Nations, 2024).

The transformation of production systems is closely associated with changes in labor markets, where automation and artificial intelligence increasingly influence employment structures and skill requirements (Autor, 2015; Acemoglu & Restrepo, 2018). These changes highlight the growing importance of high-quality human resources capable of adapting to rapidly evolving technological environments.

In Vietnam, digital transformation has been strongly promoted through national strategies and policies, including the National Digital Transformation Program and initiatives to develop science, technology, and innovation. The rapid expansion of the digital economy, the growth of technology enterprises, and the increasing application of digital technologies across sectors have created favorable conditions for the formation and development of new productive forces. However, these developments also pose significant challenges, particularly in terms of human resource capacity, as the demand for highly skilled labor continues to increase (Prime Minister of Vietnam, 2020; OECD, 2021).

Despite these advancements, Vietnam's human resources still face several limitations,

including structural imbalances, relatively low levels of technical expertise, and insufficient capacity in science, technology, engineering, and mathematics (STEM) fields. These constraints hinder the effective development and utilization of new productive forces, thereby affecting the country's ability to fully leverage opportunities arising from digital transformation.

However, despite the growing body of research on digital transformation and human resource development, existing studies have not sufficiently examined the concept of new productive forces in an integrated manner, particularly in the context of emerging economies such as Vietnam. Moreover, limited attention has been given to the linkage between technological transformation and human resource requirements within a unified analytical framework.

This study contributes to the existing literature in three main aspects. First, it systematizes and clarifies the concept of new productive forces in the digital era from both classical and contemporary perspectives. Second, it provides an integrated analysis linking global trends with the Vietnamese context of digital transformation. Third, it offers policy-oriented insights into human resource development, particularly in STEM fields, to support the formation and development of new productive forces.

Against this backdrop, this study aims to clarify the theoretical foundations of new productive forces, analyze global trends and the current situation in Vietnam, and assess the status of human resources in the context of digital transformation. Based on this analysis, the paper proposes policy-oriented solutions to improve the quality of human resource training, thereby meeting the requirements of new productive forces and contributing to sustainable economic development in Vietnam.

As illustrated in Figure 1, new productive forces are formed through the interaction between advanced technologies, digital production tools, and economic outcomes, which generate increasing demand for high-quality human resources.

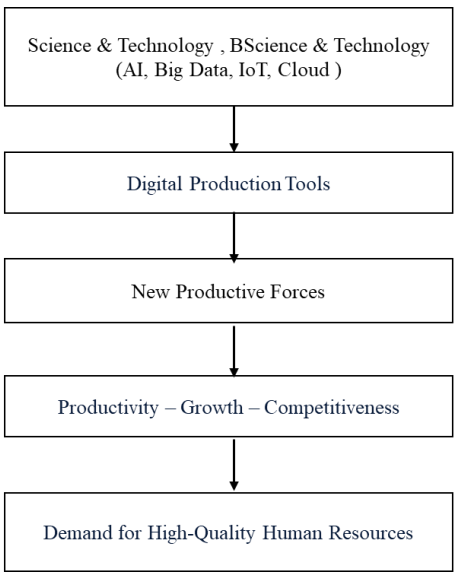

Figure 1. Conceptual framework of new productive forces

Source: Authors' compilation.

2. Literature Review

2.1 The Concept of Productive Forces in Classical Political Economy

In classical political economy, productive forces are understood as a comprehensive concept encompassing labor and the means of production. The means of production include both instruments of labor (such as tools and machinery) and objects of labor. The level of development of productive forces depends on several interrelated factors, including the technological level of production tools, the application of scientific and technical knowledge, and the capabilities of the workforce in terms of skills, experience, knowledge, organization, and management.

Productive forces are considered the material foundation of social existence and development, reflecting the capacity of human beings to transform nature in accordance with their objectives. As societies evolve, accumulated knowledge and practical experience enable continuous improvements in production tools and processes, gradually transforming knowledge itself into a direct and decisive productive force. This perspective highlights the dynamic and cumulative nature of productive forces in shaping socio-economic development.

This perspective is consistent with the human capital theory, which emphasizes the role of knowledge, skills, and education as key determinants of productivity and economic growth (Becker, 1993).

2.2 The Emergence of New Productive Forces

The concept of "new productive forces" was first introduced to emphasize the close relationship between productive forces and social relations. According to classical theoretical perspectives, the emergence of new productive forces leads to fundamental changes in modes of production, which in turn reshape broader social relations. Historical development can thus be understood as a continuous process in which each generation builds upon and transforms the productive forces inherited from previous ones.

In the latter half of the twentieth century, the concept of new productive forces was further developed to refer to new components within the system of productive forces, including emerging energy sources (such as nuclear, solar, wind, and geothermal energy), new materials, and high-technology industries. These developments marked a transition toward more advanced and diversified production systems, driven by scientific and technological innovation.

2.3 New Productive Forces in the Digital Economy

In the context of the Fourth Industrial Revolution, the concept of new productive forces has been increasingly associated with the rapid advancement of digital technologies and innovation systems. Unlike traditional productive forces, which primarily rely on labor, capital, and conventional technologies, new productive forces are fundamentally driven by knowledge, digital technologies, and innovation capacity.

In the digital era, these forces are characterized by the integration of advanced technologies

such as artificial intelligence, big data, cloud computing, and the Internet of Things into production processes. This integration has fundamentally transformed production systems, making them more intelligent, automated, and data-driven, thereby significantly enhancing efficiency, productivity, and overall economic performance (OECD, 2019; World Bank, 2019). As a result, production is increasingly organized around digital platforms, data flows, and network-based interactions, which enable more flexible and responsive economic activities.

Moreover, digital transformation has accelerated the emergence of new economic structures characterized by knowledge intensity, technological innovation, and high value-added activities. These developments have reshaped value creation processes, shifting the focus from resource-based and labor-intensive production toward innovation-driven and knowledge-based development models (UNCTAD, 2021).

From a conceptual perspective, new productive forces can be understood as a synergistic system comprising advanced technologies, modern industries, and a workforce equipped with digital competencies and specialized knowledge. The interaction among these components generates new forms of economic activity, particularly within the digital economy, while simultaneously enhancing competitiveness and facilitating structural transformation. Consequently, the development of new productive forces reflects a fundamental transition in the mode of production, in which knowledge, technology, and human capital become the primary drivers of economic growth and development.

Figure 2 presents the structural components of new productive forces, highlighting the interrelationship among technology, human resources, and institutional factors.

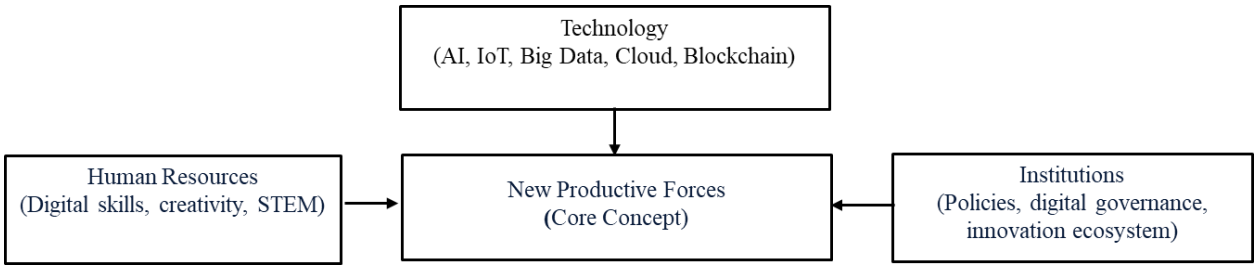

Figure 2. Structure of new productive forces.

Source: Authors' compilation.

2.4 Global Trends in the Development of New Productive Forces

The development of new productive forces has become a dominant global trend, as countries increasingly prioritize technological innovation, digital transformation, and knowledge-based development (Schwab, 2016; OECD, 2023). In recent years, economies across both developed and developing regions have actively promoted high-technology industries, renewable energy sectors, and advanced manufacturing systems to enhance productivity, competitiveness, and resilience in the face of global uncertainties.

Empirical evidence suggests that digital transformation has accelerated significantly, particularly following the COVID-19 pandemic, which acted as a catalyst for the expansion of digital economies worldwide. The rapid growth of digital platforms, data flows, and online services has fundamentally reshaped economic and social interactions, reinforcing the role of digital technologies as core drivers of economic transformation (World Bank, 2021; UNCTAD, 2023). In this context, new productive forces are not only a technological phenomenon but also a structural driver of economic modernization and sustainable development.

At the global level, leading economies have increasingly emphasized the integration of artificial intelligence, automation, and digital infrastructure into production systems. These efforts have contributed to the emergence of new forms of economic organization based on digital ecosystems, platform economies, and global value chains driven by data and innovation. As a result, the competition among nations is increasingly centered on technological capabilities, innovation capacity, and the quality of human resources.

However, despite these advances, the development of new productive forces remains uneven across countries and regions. Differences in institutional capacity, technological readiness, and human capital development create significant disparities in the ability to adopt and benefit from digital transformation. This challenge is particularly evident in emerging economies, where the transition toward new productive forces requires not only technological investment but also comprehensive reforms in education, governance, and innovation systems.

Therefore, understanding global trends in the development of new productive forces provides an essential foundation for analyzing national contexts and identifying appropriate policy responses, particularly for countries such as Vietnam that are undergoing rapid digital transformation.

3. Methodology

This study adopts a qualitative research approach, combining theoretical analysis and empirical observation to examine the development of new productive forces and the requirements for high-quality human resource training in Vietnam. The research design is primarily based on the analysis-synthesis method, which allows for the systematic integration of theoretical perspectives and practical evidence.

First, the study employs a theoretical analysis of classical political economy concepts related to productive forces, with particular emphasis on their evolution into the notion of new productive forces in the digital era. This approach enables the clarification of key conceptual foundations and the identification of the core characteristics of new productive forces, especially in relation to technological advancement and digital transformation.

Second, the study utilizes a descriptive and comparative analysis of global trends in the development of new productive forces. This includes examining the role of emerging technologies, digital economies, and innovation-driven growth models across different countries. By synthesizing international experiences, the study highlights common patterns

and strategic directions that shape the transformation of productive systems in the contemporary context.

Third, the research analyzes the situation in Vietnam through the examination of secondary data obtained from official reports, national statistics, and policy documents. These sources provide insights into the current status of human resources, including educational attainment, technical skills, and workforce structure, as well as the development of science, technology, and digital transformation initiatives. The analysis focuses on identifying key challenges, such as structural imbalances, limitations in skill levels, and gaps in STEM-related human resources.

Finally, based on the integration of theoretical and empirical findings, the study applies a policy-oriented analytical approach to propose strategic directions and solutions for improving the quality of human resource training. This approach emphasizes the alignment between technological development, institutional frameworks, and human resource capacity in order to meet the requirements of new productive forces in the digital era.

This approach is widely used in socio-economic research to integrate theoretical and empirical insights (Castells, 2010).

4. Results

4.1 Global Development of New Productive Forces in the Digital Era

The development of new productive forces has been strongly accelerated by the Fourth Industrial Revolution and the rapid expansion of digital technologies worldwide. Advanced technologies such as artificial intelligence, big data, and the Internet of Things have become central components of modern production systems, enabling higher levels of automation, efficiency, and innovation (Schwab, 2016; Brynjolfsson et al., 2023).

The COVID-19 pandemic further intensified this transformation by acting as a catalyst for digitalization across both economic and social activities. Global data traffic has increased significantly, with monthly data flows projected to rise from approximately 230 exabytes in 2020 to 780 exabytes by 2026. Similarly, the global Internet of Things market has experienced rapid growth, expanding from hundreds of billions of USD in 2020 to a projected scale of nearly 1.85 trillion USD by 2028, with strong annual growth rates (World Bank, 2024; United Nations, 2024).

At the regional level, Southeast Asia has emerged as a dynamic hub of digital economic growth. The Internet economy in the region is expected to reach 1 trillion USD by 2030, driven by a substantial increase in the number of internet users and the expansion of digital services such as e-commerce and online delivery platforms. These developments demonstrate that digital transformation has become a key driver of new productive forces at both global and regional scales.

These developments are consistent with global evidence indicating that digital technologies and automation play a central role in driving productivity growth and economic restructuring (Muro et al., 2019; Bessen, 2019). The expansion of digital platforms and data-driven

production systems further reinforces the importance of new productive forces in shaping modern economies.

4.2 Digital Transformation and the Emergence of New Productive Forces in Vietnam

In Vietnam, digital transformation has been actively promoted through national strategies and policy frameworks. The National Digital Transformation Program and related initiatives aim to build a digital government, digital economy, and digital society, while fostering the development of domestic digital technology enterprises (Prime Minister of Vietnam, 2020; Ministry of Information and Communications of Vietnam, 2021).

The expansion of the digital economy has created favorable conditions for the development of new productive forces. Digital technologies have been increasingly applied across various sectors, including production, business operations, and public services. Activities such as e-commerce, remote work, online education, and digital services have become more widespread, reflecting significant changes in both economic and social practices.

The growth of the information and communication technology (ICT) sector further illustrates this transformation. The number of digital technology enterprises has increased substantially, while the industry's revenue has continued to expand. Domestic enterprises have gradually moved beyond assembly and outsourcing toward developing and mastering digital technologies, contributing to the formation of a more autonomous and innovative production system.

Empirical evidence demonstrates the economic significance of this transformation. Vietnam's digital economy contributed approximately 14.3% to GDP in 2023, generating roughly USD 43 billion in value, with projections reaching 20% of GDP and USD 100 billion by 2025 (World Bank, 2024). The ICT sector alone employed approximately 1.4 million workers in 2023, representing 3.2% of total employment, with an average annual growth rate of 12.5% in value-added output (Ministry of Information and Communications of Vietnam, 2021). These figures indicate that digital transformation has begun to generate substantial economic impacts, though the full potential remains constrained by human capital limitations.

At the same time, Vietnam has set ambitious targets for digital development, including increasing the share of the digital economy in GDP, improving labor productivity, and enhancing the country's position in global innovation and competitiveness rankings. These efforts highlight the strategic importance of developing new productive forces as a foundation for sustainable economic growth.

4.3 Current Status of Human Resources in Vietnam

Despite significant progress in digital transformation, Vietnam's human resources still face several limitations. The overall quality of the workforce remains relatively low, and structural imbalances persist across regions and sectors (OECD, 2021; World Bank, 2021).

Statistical data indicate that approximately 40% of the population aged 15 and above have completed upper secondary education or higher. Meanwhile, only 26.4% of the population possess technical or professional qualifications, with considerable disparities between urban

and rural areas. The proportion of individuals with university-level education or higher remains limited, accounting for approximately 11.6% of the workforce.

The skill shortage in technological sectors represents a quantifiable constraint on economic development. Industry surveys indicate that approximately 65% of technology enterprises report difficulty recruiting qualified personnel, particularly in AI, data science, and cybersecurity (OECD, 2021). Vietnam currently produces approximately 50,000 ICT graduates annually, while industry demand is estimated at 120,000-150,000 per year, creating an annual deficit of 70,000-100,000 qualified workers. This gap is more pronounced in advanced specializations: AI specialists (current supply ~2,000/year vs. demand ~8,000/year) and data scientists (supply ~3,500/year vs. demand ~12,000/year). If unaddressed, these constraints could reduce potential digital economy growth by an estimated 2.5-3.5 percentage points annually through 2030.

Table 1 summarizes the current status of human resources in Vietnam, reflecting key indicators of educational attainment and workforce qualifications.

Table 1. Human resource status in Vietnam

Indicator	Value
Population with high school or above	~40%
Skilled labor	26.4%
University degree or higher	11.6%
R&D personnel	~167,000

Source: Authors' calculation based on national statistics

In the field of science and technology, the number of personnel engaged in research and development is still relatively modest compared to development needs. Although Vietnam has made progress in expanding its scientific workforce, the distribution of human resources remains uneven, with a concentration in the public sector and a shortage of highly qualified experts in key technological fields such as artificial intelligence, biotechnology, and advanced materials.

Furthermore, the quality of human resources is constrained by several factors, including limited practical skills, insufficient collaboration capacity, and a lack of leading experts. The number of patents and high-level scientific outputs remains low, reflecting challenges in research and innovation capacity.

4.4 Challenges in Human Resource Development for New Productive Forces

The rapid development of new productive forces has created increasing demand for highly skilled labor, particularly in digital and technology-related fields. However, the current education and training system in Vietnam has not yet fully met these demands.

There is a significant shortage of information technology and digital workforce, with projections indicating a substantial gap between labor supply and market demand in the coming years. Universities and training institutions are only able to meet a limited proportion

of this demand, and the quality of graduates often falls short of industry requirements.

In addition, investment in science and technology remains relatively low compared to international standards, limiting the capacity for research and innovation. The structure of human resources is also characterized by imbalances, with a high proportion of indirect personnel and insufficient participation from the private sector.

These challenges highlight the urgent need to improve the quality, structure, and effectiveness of human resource development in order to support the formation and growth of new productive forces in Vietnam.

5. Discussion

The findings of this study are consistent with a growing body of literature emphasizing the transformative impact of digital technologies on production systems and labor markets (Brynjolfsson & McAfee, 2014; Autor, 2015). The increasing role of artificial intelligence and automation further confirms that knowledge, innovation, and human capital are becoming central components of modern productive forces (Acemoglu & Restrepo, 2018; Brynjolfsson et al., 2023).

From a theoretical perspective, the evolution of productive forces toward their “new” form reinforces the argument that knowledge and technology are increasingly becoming direct productive forces. This transformation reflects a shift in the mode of production, in which intangible assets—such as data, skills, and innovation capacity—play a more decisive role than traditional factors of production. In this context, human capital is not merely a supporting element but a fundamental driver of economic development.

The empirical analysis of Vietnam indicates that, despite notable progress in digital transformation and technological development, the current human resource system has not yet fully adapted to the requirements of the digital economy. Structural imbalances, limitations in skill levels, and shortages of highly qualified personnel in key technological sectors continue to constrain the effective development and utilization of new productive forces. These findings are consistent with international evidence highlighting the challenges faced by emerging economies in aligning human resource development with technological change (OECD, 2023; International Labour Organization, 2023).

The results also underscore the critical role of policy intervention in facilitating this transition. The development of high-quality human resources requires a comprehensive and coordinated approach, encompassing education reform, investment in science and technology, institutional improvement, and international cooperation. In particular, strengthening STEM education, promoting innovation ecosystems, and enhancing collaboration between universities and enterprises are essential for improving the relevance and effectiveness of training systems.

Furthermore, the role of the state remains central in guiding and coordinating the development of new productive forces. The state is responsible for creating enabling institutional conditions, mobilizing resources, and ensuring strategic alignment between

technological development and human resource capacity. At the same time, the active participation of the private sector and international partners is crucial for fostering innovation, transferring technology, and enhancing workforce skills.

Overall, the findings suggest that the successful development of new productive forces depends on the establishment of a dynamic and adaptive human resource system that is closely aligned with technological progress and global trends. This requires not only quantitative expansion but also qualitative transformation in education and training systems, as well as stronger linkages between education, research, and industry.

6. Conclusion and Recommendations

This study has examined the emergence and development of new productive forces in the context of the digital era, highlighting their critical role in transforming production systems and driving economic growth. The findings confirm that the advancement of science and technology, particularly digital technologies, has become a decisive factor in shaping modern productive forces. In this process, high-quality human resources play a central role, serving as both a driving force and a prerequisite for the effective development of new productive forces.

The analysis of the Vietnamese context indicates that, although significant progress has been made in digital transformation and technological development, the current human resource system still faces substantial limitations. These include structural imbalances, insufficient skill levels, and a shortage of highly qualified personnel in key technological sectors. Such constraints hinder the country's ability to fully exploit the opportunities offered by the digital economy and to effectively develop new productive forces.

In response to these challenges, the study emphasizes that the development of high-quality human resources must be considered a strategic priority, requiring comprehensive and coordinated policy interventions. Based on the findings, several key recommendations can be proposed.

Table 2 presents the key targets for STEM human resource development in Vietnam toward 2030.

Table 2. STEM training targets in Vietnam

Indicator	2030 Target
STEM students	35%
ICT graduates	80,000/year
AI specialists	8,000/year
PhD ratio	≥1%

Source: Authors' proposal based on policy targets.

First, it is essential to strengthen investment policies for STEM education and provide financial support for learners in science and technology fields. This includes expanding scholarship programs, improving career orientation, and creating favorable conditions for

students to pursue advanced training in priority sectors.

Second, specific mechanisms should be developed to attract and retain high-quality academic staff and experts. Policies that promote autonomy in higher education institutions, enhance academic leadership, and encourage the participation of international experts are crucial for improving training quality.

Third, it is necessary to diversify and mobilize investment resources to upgrade infrastructure and technological facilities in higher education institutions. Priority should be given to the development of modern laboratories, digital platforms, and research environments that support advanced training and innovation.

Fourth, strengthening both domestic and international cooperation in education and research is vital. This includes promoting collaboration between universities and enterprises, expanding partnerships with technologically advanced countries, and integrating training programs with research and development activities.

Preliminary cost estimates suggest that closing the identified skill gap requires approximately USD 3.2-4.5 billion in cumulative investment over 2025-2030. This includes infrastructure upgrades (USD 1.2-1.8 billion), faculty development and recruitment (USD 800 million-1.2 billion), student support programs (USD 600-900 million), and R&D facilities (USD 600-800 million). These estimates represent roughly 0.8-1.1% of projected annual GDP during this period. The feasibility is supported by three factors: first, Vietnam's education expenditure currently stands at 4.1% of GDP, below the regional average of 4.8%, providing fiscal space for expansion; second, international development partners have expressed willingness to co-finance STEM programs; and third, the expected economic returns are substantial—conservative estimates suggest that addressing the skill gap could add 2.5-3.5 percentage points to annual GDP growth, yielding a benefit-cost ratio of approximately 4:1 over a 10-year horizon. This makes the investment both feasible and economically justified, though successful implementation requires coordinated action across government, educational institutions, and industry stakeholders.

Figure 3 illustrates the policy framework for high-quality human resource development, focusing on key pillars such as STEM education, talent policies, infrastructure investment, and international cooperation.

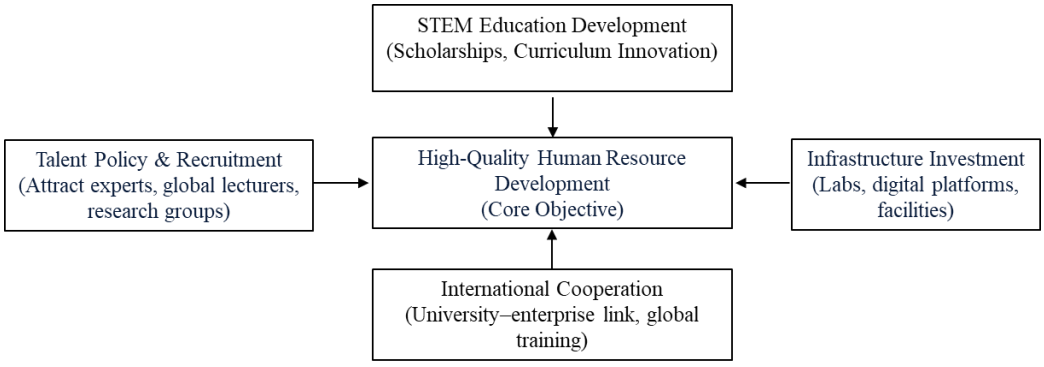

Figure 3. Policy framework for human resource development

Source: Authors' compilation.

Overall, the development of high-quality human resources for new productive forces requires a long-term and systematic approach, combining institutional reform, investment, and innovation in education and training. The state plays a central role in coordinating and facilitating this process, while the active participation of enterprises and international partners is essential to ensure its effectiveness. By aligning human resource development with technological progress and global trends, Vietnam can enhance its competitiveness and achieve sustainable development in the digital era.

These findings are consistent with recent global reports emphasizing the critical role of digital transformation and human capital in achieving sustainable economic development (World Bank, 2024; United Nations, 2024).

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Authors contributions

Duong Quoc Quan was responsible for the research design, conceptual framework, and manuscript writing. Pham Thi Xinh contributed to data collection and analysis. Nguyen Thi Thu Hien assisted in revising and editing the manuscript. All authors have read and approved the final version of the manuscript.

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Competing interests

The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Not applicable.

Ethics approval

Not applicable.

Provenance and peer review

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Data sharing statement

No additional data are available.

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