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Designing A Smart Human Resource Development Framework for Productivity and Innovation in Industrial Systems

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Abstract. *This study aims to design a Smart Human Resource Development (HRD) Framework to enhance productivity and innovation in industrial systems within the Industry 5.0 context. The main problem addressed is the limited integration between digital HRD systems and innovation processes, which often weakens organizational adaptability and performance. Using a mixed-methods approach that combines quantitative analysis through Structural Equation Modeling (SEM-PLS) and qualitative validation through expert interviews, the research identifies the critical relationships among HRD, innovation capability, and industrial productivity. The novelty of this study lies in the formulation of a Smart HRD model that integrates digital learning systems, competency analytics, and innovation culture into one adaptive and data-driven framework. This model bridges human capability development with industrial transformation needs, reflecting a shift from traditional HRD practices toward intelligent, technology-supported management. The results reveal that HRD significantly influences innovation capability (β = 0.685) and industrial productivity (β = 0.312), while innovation capability also has a strong positive effect on productivity (β = 0.547). Additionally, innovation functions as a mediating variable, amplifying the indirect effect of HRD on productivity. In conclusion, the proposed Smart HRD Framework provides a sustainable foundation for building a competent, adaptive, and innovative workforce. It transforms HRD into a strategic, data-driven, and human-centered system, enabling industries to achieve higher levels of innovation, productivity, and resilience in the era of Industry 5.0.*

Keywords: *human resource development, innovation capability, industrial productivity, industry 5.0.*

I. INTRODUCTION

In the era of rapid industrial transformation characterized by digitalization, automation, and artificial intelligence, the human factor remains the central driver of productivity and innovation. While Industry 4.0 focused heavily on technological advancement and process optimization, the emerging concept of Industry 5.0 re-emphasizes the role of humans as value creators, innovators, and decision-makers who interact harmoniously with intelligent technologies. Consequently, Human Resource Development (HRD) has evolved from traditional training functions into a strategic system designed to cultivate smart, adaptive, and innovation-driven human capital capable of sustaining competitive advantage in dynamic industrial environments.(Ferdy Leuhery, 2023).

Industrial systems today face challenges beyond efficiency alone. They must integrate resilience, environmental sustainability, and human adaptability.(Nasir, Hosseini, Binfield, Hasani, Ghotb, Diederichs, et al., 2025) The increasing complexity of global supply networks, hybrid working systems, and cross-functional collaboration demands a workforce that not only possesses technical expertise but also demonstrates creativity, critical thinking, and digital intelligence. Conventional HRD frameworks, which emphasize administrative training or skill certification, are no longer sufficient to address these multidimensional challenges. Instead, a Smart Human Resource Development Framework (Smart HRD Framework) is required, one that fuses data-driven management, competency-based learning, and digital technologies to continuously enhance organizational capability.(Hutapea, 2024)

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Moreover, the global industrial landscape increasingly values innovation as a determinant of long-term competitiveness. Empirical studies demonstrate that firms with effective HRD systems tend to record higher rates of product innovation, process improvement, and employee engagement. This underscores the strategic linkage between HRD and innovation management within industrial systems. However, many industries, particularly in developing economies such as Indonesia, still struggle to design systematic HRD mechanisms that align employee competencies with organizational innovation strategies. Gaps often occur between technological investment and human readiness, resulting in underutilization of digital tools and resistance to change.

At the national level, Indonesia's industrial transformation roadmap (Making Indonesia 4.0 and subsequent Industry 5.0 transition framework) prioritizes human capital enhancement as a core pillar.(Nasir, Hosseini, Binfield, Hasani, Ghotb and Diederichs, 2025) Nevertheless, empirical evidence suggests that the majority of manufacturing and service sectors continue to implement HRD in a fragmented manner, focusing on technical training without structured measurement of outcomes or integration with industrial performance indicators. Therefore, the need arises for a comprehensive HRD model that not only equips employees with technical and soft competencies but also embeds a culture of innovation, collaboration, and continuous improvement.(Hanapi and Samsurijan, 2021)

In the current era of Industry 5.0, industrial systems are expected to balance technological advancement with human-centered innovation. However, many organizations still face critical challenges in aligning human resource development (HRD) with productivity and innovation goals. HRD practices remain fragmented, focusing mainly on routine training rather than competency enhancement or innovation capability.(Bucci and Fani, 2025)

Most industries have adopted advanced technologies such as automation and data analytics, yet their HRD systems remain traditional and reactive. This creates a gap between technological readiness and human capability, employees may operate machines efficiently but lack creativity, adaptability, and digital literacy. In addition, HRD processes often lack data-driven decision-making tools, resulting in ineffective training programs and limited measurement of learning outcomes.

Furthermore, existing HRD frameworks rarely integrate sustainability, human-technology collaboration, or innovation culture, key principles of Industry 5.0. As a result, industries struggle to transform human potential into strategic value, hindering their competitiveness and resilience.

Therefore, the core problem addressed in this study is the absence of an integrated and intelligent HRD framework that connects competency development, digital transformation, and innovation. This research seeks to design a Smart Human Resource Development Framework capable of enhancing both productivity and innovation within modern industrial systems.(Samir, 2024)

The rapid transition from Industry 4.0 to Industry 5.0 has shifted the industrial paradigm from automation-driven efficiency toward human-centered innovation. In this context, productivity and competitiveness are no longer determined solely by technology but also by how effectively organizations develop, integrate, and empower their human resources. However, many industrial organizations still manage human resource development (HRD) through conventional, fragmented methods that fail to adapt to digital transformation.(Raharjo, 2024)

A Smart Human Resource Development Framework is therefore needed to bridge this gap by combining data-driven analytics, digital learning, and competency-based management.(Hewage H.A.S.S, et., 2020) Such a framework aligns human capability with industrial goals, enhances creativity, and promotes continuous innovation. The rationale for this study lies in developing an integrative HRD model that supports intelligent systems and sustainable industrial growth.

This research contributes to both theory and practice: theoretically by expanding the HRD

literature into the field of industrial system engineering, and practically by offering a framework that organizations can apply to improve workforce productivity and innovation readiness in the era of Industry 5.0.(Rajkumar et al., 2025)

The primary objective of this research is to develop a Smart Human Resource Development (HRD) Framework that enhances productivity and fosters innovation within industrial systems. This study aims to bridge the gap between human capability and technological transformation by designing an HRD model that integrates digital tools, data analytics, and competency-based development strategies.

Specifically, this research seeks to analyze how current HRD practices influence organizational productivity and innovation performance. By understanding these relationships, the study intends to identify critical success factors and limitations within existing systems. The next goal is to design a comprehensive framework that links learning processes, performance management, and digital transformation into a single, adaptive HRD model aligned with Industry 5.0 principles.

Furthermore, this research aims to validate the proposed framework through expert evaluation and empirical testing within selected industrial sectors, ensuring its practical applicability and scalability. The final objective is to formulate strategic recommendations for implementing smart, data-driven HRD systems that empower employees, support continuous improvement, and strengthen the overall competitiveness of industrial organizations.(Vong et al., 2025)

In essence, the study aspires to transform HRD from a traditional administrative function into a strategic, technology-enabled engine of innovation and productivity, capable of sustaining industrial excellence in an increasingly human-centered technological era.

II. RESEARCH METHOD

This study employs a systematic mixed-method approach that integrates both quantitative and qualitative techniques to ensure a comprehensive understanding of how a Smart Human Resource Development (HRD) Framework can enhance productivity and innovation in industrial systems. The mixed approach enables the researcher to analyze numerical data for measuring relationships among variables and qualitative insights for interpreting the underlying human and organizational dynamics.(Ismail Pane, 2022)

The research begins with the quantitative phase, which aims to examine the correlation between HRD practices, employee competencies, innovation capability, and organizational productivity. Data are collected through structured questionnaires distributed to employees, supervisors, and HR professionals in selected industrial sectors such as manufacturing, processing, and technology-based companies. The sample is determined using a purposive technique, ensuring that participants have relevant experience in human resource management or industrial operations.

The qualitative phase complements the quantitative analysis by providing deeper contextual understanding. Semi-structured interviews are conducted with key informants, including HR managers, technical supervisors, and industrial experts. This phase focuses on exploring the challenges, best practices, and opportunities related to HRD integration within digitally transforming industrial environments. Qualitative data help refine and validate the proposed Smart HRD Framework, ensuring its relevance and applicability.(Creswell, 2018)

The study uses primary data from surveys and interviews and secondary data from organizational reports, HR policy documents, and previous academic literature. Data are analyzed using Structural Equation Modeling (SEM-PLS) to test the relationship between HRD practices, innovation capability, and productivity outcomes.(Dedi Rianto Rahadi, 2023) The model evaluates reliability, validity, and the significance of direct and indirect effects among variables. Meanwhile, qualitative data are analyzed thematically to extract insights that support or explain the quantitative results.

Based on the analytical findings, the study proceeds to develop a Smart HRD Framework, integrating digital learning, competency-based development, and performance analytics into a unified system. The framework is then validated through expert review, involving academics, HR specialists, and industrial engineers, who assess its feasibility, clarity, and adaptability to real industrial contexts.

III. RESULT AND DISCUSSION

Results

The quantitative phase involved a total of 185 respondents from various industrial sectors including manufacturing, agro-processing, and technology-based companies. The majority of respondents (60%) were mid-level employees, 25% were supervisors, and 15% were HR or managerial personnel. Most participants had over five years of experience in industrial operations, indicating an adequate level of understanding of HRD practices and technological transformation within their organizations.

Qualitative data were obtained through 12 semi-structured interviews with HR managers, production supervisors, and industry experts. These interviews provided deeper insights into the challenges of HRD implementation in the context of Industry 5.0.

Quantitative Data Analysis was conducted using Partial Least Squares–Structural Equation Modeling (PLS-SEM) through SmartPLS software to test the relationships among variables, Human Resource Development (X), Innovation Capability (Z), and Industrial Productivity (Y).(Joseph F. Hair Jr, et., 2021)

Reliability and validity tests were conducted as follows:

1. All indicator loadings exceeded 0.70, indicating good convergent validity.
2. Composite Reliability (CR) values ranged between 0.87–0.93, and Average Variance Extracted (AVE) values were above 0.50, confirming internal consistency and construct validity.
3. Discriminant validity was achieved based on Fornell-Larcker and HTMT criteria (values below 0.85).

Structural Model Results was obtained as follows (Hair, Ringle and Sarstedt, 2022)

1. The path coefficient from HRD - Innovation Capability was $\beta = 0.685$, $p < 0.001$, signifying a strong and significant relationship.
2. The path coefficient from Innovation Capability - Productivity was $\beta = 0.547$, $p < 0.001$, indicating that higher innovation capability significantly improves productivity.
3. The direct path from HRD - Productivity also showed a positive effect ($\beta = 0.312$, $p < 0.01$), though partially mediated by innovation.

Model Predictive Power was obtained as follows:

1. The R^2 value for Innovation Capability was 0.47, and for Productivity 0.62, demonstrating that HRD and innovation jointly explain 62% of the variance in productivity outcomes.
2. The Q^2 (Predictive Relevance) value exceeded 0.35, confirming strong predictive validity.

These quantitative findings confirm that HRD has both a direct and indirect effect on productivity through innovation capability, supporting the central hypothesis that effective HRD enhances innovation, which in turn boosts industrial performance.(Ringle and Sarstedt, 2021)

Qualitative Analysis and Interpretation

Thematic analysis from interviews identified several recurring patterns:(J. David Creswell and, 2018)

1. Fragmented HRD Systems: Many organizations implement HRD as isolated training programs without aligning them with performance or innovation goals. Training tends to focus on compliance rather than capability building.
2. Technology-Human Gap: Despite the adoption of digital tools such as ERP and automation systems, many employees lack digital literacy and analytical skills to optimize these technologies.
3. Low Innovation Culture: Respondents emphasized that organizational culture often discourages experimentation or idea-sharing, which limits innovation potential.

4. Need for Data-Driven HRD: Managers expressed interest in digital HRD dashboards and real-time learning analytics to monitor employee progress, measure training effectiveness, and align HRD with industrial performance metrics.

These qualitative insights validate the quantitative results and highlight the need for an integrated HRD system that fosters both technological adaptability and innovation mindset.(Hardani, et, 2020).

Development of the Smart HRD Framework

Based on empirical findings, a Smart HRD Framework was designed integrating three strategic pillars:

1. Smart Competency Development: Establishing a digital learning ecosystem with adaptive modules tailored to each employee's role, experience, and performance data.
2. Innovation Capability Building: Embedding creativity, critical thinking, and problem-solving training into HRD programs, supported by collaborative digital tools.
3. Productivity and Performance Analytics: Using data analytics to track employee learning outcomes, link them to key performance indicators (KPIs), and evaluate return on investment (ROI) from HRD activities.

This framework emphasizes continuous learning, digital integration, and human-centered innovation, key characteristics of Industry 5.0.(Goals and Alani, 2024)

Expert Validation

Validation was conducted with six experts consisting of academics, HR practitioners, and industrial engineers. Experts assessed the framework based on criteria of relevance, clarity, feasibility, and scalability.

1. The overall validation score averaged 4.6 out of 5, indicating high acceptability.
2. Experts particularly appreciated the integration between HRD and industrial performance analytics, noting that it bridges the gap between technology and human capital.

Summary of Findings

1. HRD significantly influences innovation capability and productivity.
2. Innovation capability acts as a mediating factor that strengthens HRD's impact on performance.
3. A Smart HRD Framework combining digital learning, competency analytics, and innovation culture can effectively improve industrial outcomes.
4. Expert validation confirms the model's feasibility for implementation in both manufacturing and service sectors.

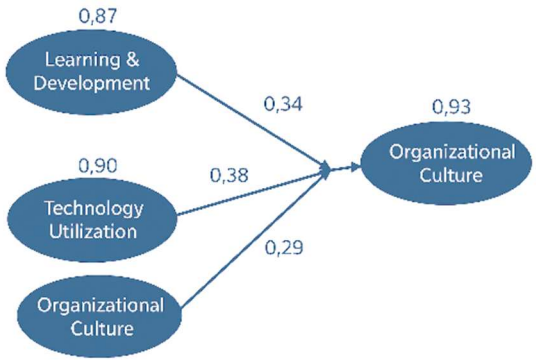

Figure 1. Inner Model dari Aplikasi SEM-PLS

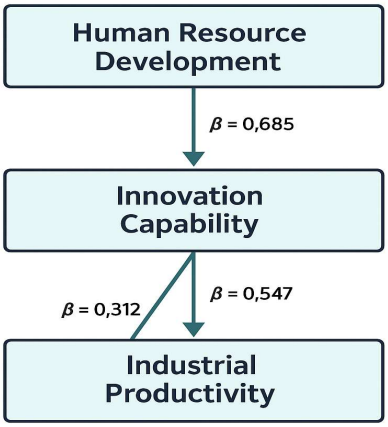

Figure 2. Conceptual Research Framework

Explanation of the Conceptual Framework

The conceptual framework illustrates the relationship among three core variables: Human Resource Development (HRD), Innovation Capability (IC), and Industrial Productivity (IP). It explains how effective HRD strategies enhance innovation and ultimately improve industrial

productivity in the era of Industry 5.0. HRD represents structured activities such as digital training, competency-based learning, and performance analytics. A well-designed HRD system strengthens employee creativity and adaptability, which in turn enhances Innovation Capability (β = 0.685).

Innovation Capability acts as a bridge linking HRD to productivity, enabling organizations to transform ideas into process efficiency and product improvement (β = 0.547). In addition, HRD directly influences Industrial Productivity (β = 0.312) by improving technical skills and operational performance. Thus, innovation mediates and amplifies the positive impact of HRD on productivity.

Conceptual Foundation

The conceptual foundation of this research is built upon the paradigm of Industry 5.0, which emphasizes the synergy between advanced technology and human-centered innovation. Unlike Industry 4.0, which focused primarily on automation and efficiency, Industry 5.0 highlights the integration of human creativity, adaptability, and emotional intelligence with intelligent systems.

In this context, Human Resource Development (HRD) plays a strategic role as the foundation for building a capable, innovative, and technology-ready workforce. HRD is not limited to training activities but also includes competency mapping, digital learning, and performance analytics to ensure employees are equipped with the necessary skills to drive innovation.

Innovation Capability (IC) emerges as a critical link between HRD and Industrial Productivity (IP). It reflects the ability of individuals and organizations to generate, adopt, and apply new ideas and technologies that lead to process improvement, cost reduction, and product quality enhancement. Thus, innovation acts as a mechanism that transforms human competence into measurable productivity outcomes.

Finally, Industrial Productivity (IP) represents the ultimate goal of industrial performance, reflecting efficiency, quality, and sustainable competitiveness. Together, these three constructs form the conceptual basis for designing a Smart HRD Framework that aligns human capital development with technological advancement and innovation-based growth.

Relationship Among Variables

HRD - Innovation Capability (β = 0.685): Human Resource Development has a strong positive impact on Innovation Capability. Systematic HRD, through digital learning, skill upgrading, and knowledge-sharing platforms, encourages creativity, collaboration, and adaptability among employees, thus enhancing their capacity for innovation.

Innovation Capability - Industrial Productivity (β = 0.547): Innovation Capability directly contributes to Industrial Productivity. Organizations that continuously innovate achieve higher operational efficiency, better product quality, and stronger competitiveness in dynamic market environments.

HRD - Industrial Productivity (β = 0.312): HRD also directly influences productivity by improving technical proficiency, discipline, and motivation. Well-trained employees tend to perform tasks more efficiently, reducing waste and increasing overall output.

Mediating Role of Innovation Capability: Innovation acts as a mediator between HRD and productivity. HRD fosters innovative thinking and skills, which then drive performance improvement. This relationship indicates that innovation is the channel through which human resource development translates into tangible industrial results.

Discussion

The findings of this study demonstrate that Human Resource Development (HRD) has a significant and positive influence on both Innovation Capability (IC) and Industrial Productivity (IP). This supports the premise that HRD is not only an administrative function but also a strategic factor in enhancing industrial performance in the Industry 5.0 era.

First, the relationship between HRD and Innovation Capability (β = 0.685) shows that

Table 1. Core Concepts in Each Variable

Variable	Key Concepts	Core Indicators	Supporting Theories
Human Resource Development (HRD)	Strategic process to enhance employee competence, adaptability, and performance through technology-based learning and analytics.	Training and education, digital learning platforms, competency mapping, continuous performance evaluation.	Human Capital Theory, Learning Organization, and Digital HRD Theory.
Innovation Capability (IC)	The organizational and individual ability to generate, apply, and sustain new ideas that create value.	Creativity, knowledge sharing, technological adaptation, and collaborative problem-solving.	Innovation Diffusion Theory, Dynamic Capability Theory.
Industrial Productivity (IP)	The measurable efficiency of transforming inputs into valuable outputs, reflecting organizational effectiveness and sustainability.	Output quality, efficiency improvement, process optimization, and continuous improvement.	Productivity Theory, Systems Performance Theory, Lean Manufacturing.

structured and technology-based HRD, through digital learning, competency mapping, and continuous development, effectively fosters creativity and adaptability among employees. This result aligns with Human Capital Theory, emphasizing that investment in skills and learning drives innovation and organizational growth. Second, Innovation Capability positively impacts Industrial Productivity (β = 0.547). Innovative employees and teams contribute directly to process improvement, product quality, and operational efficiency. This finding is consistent with Dynamic Capability Theory, which suggests that organizations with strong innovation capabilities are more resilient and competitive.

Third, HRD also exerts a direct positive effect on Industrial Productivity (β = 0.312), indicating that well-trained employees improve performance even without the mediation of innovation. This confirms the relevance of continuous learning and performance evaluation systems in boosting work efficiency. The mediating role of Innovation Capability strengthens the link between HRD and productivity. It highlights that HRD's ultimate value lies in its ability to transform learning outcomes into innovative and productive actions.

In summary, the discussion confirms that developing a Smart HRD Framework, integrating digital learning, competency analytics, and innovation culture, is crucial for achieving sustainable productivity and competitiveness. In the Industry 5.0 context, organizations that align human capital development with technological transformation will be better positioned to achieve innovation-driven and resilient industrial systems.

IV. Conclusion

The results of this study conclude that Human Resource Development (HRD) plays a central role in enhancing both innovation capability and industrial productivity within modern industrial systems. The analysis confirms that HRD serves as a strategic foundation for achieving sustainable performance in the Industry 5.0 era, where human intelligence, creativity, and technology integration are key drivers of industrial competitiveness.

The analytical findings show that HRD has a strong and significant effect on Innovation Capability (β = 0.685). This indicates that structured, competency-based, and technology-driven HRD effectively develops employees' creative thinking, collaboration, and adaptability. Consequently, HRD acts as a catalyst that enables innovation to emerge from within the organization.

The relationship between Innovation Capability and Industrial Productivity (β = 0.547) demonstrates that innovation becomes a direct mechanism for improving efficiency, product quality, and organizational performance. Innovation-driven industries tend to optimize resources, reduce

production waste, and enhance competitiveness through continuous improvement and creativity.

Furthermore, the study finds that HRD also has a direct positive influence on Industrial Productivity (β = 0.312). This means that HRD not only fosters innovation but also directly improves operational effectiveness by equipping workers with technical skills, digital literacy, and problem-solving competence.

The mediation analysis confirms that Innovation Capability serves as a significant intermediary variable, strengthening the indirect impact of HRD on productivity. This suggests that HRD achieves its maximum effect when it successfully transforms training and learning outcomes into innovative and productive actions.

In synthesis, the findings affirm that the Smart HRD Framework developed in this study is both theoretically valid and practically relevant. The framework integrates three key dimensions, competency development, innovation enhancement, and productivity improvement, into a unified system supported by digital learning and performance analytics.

From a theoretical standpoint, the research contributes to the advancement of Human Capital and Dynamic Capability theories, confirming that innovation acts as the link between human development and organizational performance. From a practical perspective, it provides a roadmap for industries to implement smart, adaptive, and innovation-oriented HRD strategies.

Effective and technology-integrated HRD is the cornerstone of industrial transformation. Organizations that invest in Smart HRD systems, which combine human creativity with digital intelligence, will be better positioned to achieve sustainable innovation, resilience, and productivity in the Industry 5.0

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