



Transformation of the Economic Education Model through Technology-Based Market Signals to Achieve External Efficiency in the Green Industry Sector

*Baiq Salkiah¹

Universitas Sebelas Maret,
Indonesia

Aniek Hindrayani²

Universitas Sebelas Maret,
Indonesia

Mintasih Indriayu³

Universitas Sebelas Maret,
Indonesia

***Corresponding author:**

Baiq Salkiah, Universitas Sebelas Maret,
Indonesia. ✉ baiqsalkiah@student.uns.ac.id

Article Info:

Article history:

Received: May 05, 2026

Revised: May 23, 2026

Accepted: May 25, 2026

Keywords:

digital transformation, economic education, external efficiency, green industry, market signals.

Abstract

Background: Amid global digital disruption and ecological crises, economic education faces significant challenges regarding the relevance of graduates to the labor market.

Objective: This study aims to construct a transformative model of economic education that is adaptive to technology-based market signals to enhance external efficiency within the green industry sector.

Methods: Employing a mixed-methods approach with an exploratory sequential design, this research integrates Research and Development (R&D) procedures to design a dynamic curriculum framework. Data were collected through big data analytics from digital labor platforms and validated by a panel of experts and circular industry practitioners.

Results: The findings reveal a significant information asymmetry between conventional curricula and the actual green competency requirements in the field. The primary results confirm that the “Adaptive-Green Economic Education” (A-GEE) transformation model, integrated with real-time market-monitoring technology, significantly improves external efficiency. Statistical tests demonstrate a positive correlation between the precision of technological signal capture and the reduction of graduate competency mismatches. These findings indicate that economic education can no longer exist as a static theoretical discipline but must instead function as an adaptive ecosystem responsive to ecological shifts.

Conclusion: This study provides theoretical implications for the expansion of Signaling Theory within the context of the circular economy and offers practical recommendations for higher education institutions to reform their curricular structures so they become more agile and data-driven. This transformation is essential for producing competitive human capital in the era of the global green economy transition.

To cite this article: Salkiah, B., Hindrayani, A., & Indriayu, M. (2026). Transformation of the economic education model through technology-based market signals to achieve external efficiency in the green industry sector. *Journal of Business, Social and Technology*, 7 (2), 546–556. <https://doi.org/10.59261/jbt.v7i2.659>

INTRODUCTION

The global uncertainty triggered by climate change, accelerated digitalization, and shifting labor market structures places economic education at a critical evaluation point (Storonyanska et al., 2025). Economic education can no longer be understood merely as a process of delivering theories about production, consumption, distribution, and market behavior; instead, it must be directed toward a competency-building system capable of addressing the demands of sustainable development. In this context, economic education faces an existential challenge because its learning orientation remains largely rooted in the linear economic paradigm—a perspective emphasizing growth, cost efficiency, and output maximization without consistently considering ecological carrying capacity (Graupe, 2019). Yet, climate change has altered how industries define

productivity (Bijnens et al., 2024).

Productivity is no longer measured solely by profit margins but also by an organization's ability to manage resources efficiently, maintain low emissions, and operate responsibly toward the environment (Ushakov et al., 2021). Therefore, economic education must move from a static learning model toward one that is adaptive to changing market signals and green competency needs (Rosenberg et al., 2018).

This transformation reaffirms the relevance of the thinking of Osiobe (2019), who emphasized that education has a close relationship with economic development through human capital formation. Human capital in the green industry era refers not only to academic ability and basic economic literacy but also to the ability to interpret data, understand the energy transition, analyze sustainable supply chains, and design economic decisions aligned with circular economy principles. Thus, educational investment can no longer be separated from the real needs of industry (Bai et al., 2020). If the education system fails to capture these changes, graduates will experience a competency gap relative to labor market demands. This gap subsequently lowers the external efficiency of education, as graduates take longer to be absorbed into the workforce, experience employment mismatches, or require additional training before being considered work-ready.

In the green industry sector, competency needs develop more rapidly than the conventional curriculum renewal cycle (Dunderfelt et al., 2025). Industries are beginning to require a workforce that understands sustainability accounting, circular economy management, green supply chain management, carbon footprint measurement, environmental impact analysis, and the use of digital technology for resource efficiency (Borazjani & Adeel, 2025; Dwivedi & Paul, 2022; Singh et al., 2025). These competencies demonstrate that the green economy is not merely an environmental issue but also a matter of management, finance, production, policy, and consumer behavior. Economic education holds a strategic position because it can bridge economic knowledge with industrial practice needs (Tu, 2024). However, this strategic position can function effectively only if the economic education curriculum continuously interprets market signals. Without an accurate signal-monitoring mechanism, the curriculum will continue to lag behind, and graduates will tend to possess competencies that are not fully relevant to industry requirements.

External efficiency is a key concept in this article because it directly relates to the education system's ability to produce graduates who are valuable to society and the workforce. Hanushek (2020) affirm that education quality significantly affects economic growth, but this impact does not occur automatically. Education provides economic value only when the competencies developed genuinely align with the needs of the productive sector (Bing & Zhenzhen, 2025; Yudiono, 2017). In the context of economic education, external efficiency can be observed through three main indicators: the relevance of graduate competencies, the speed of labor market absorption, and graduates' contributions to priority sectors. When economic education graduates lack the competencies required by the green industry, inefficiency occurs because educational resources have been utilized without generating optimal benefits for sustainable economic development.

The main problem that arises is an information asymmetry between educational institutions and the industrial sector. Educational institutions often design curricula based on established knowledge structures, academic traditions, and accreditation requirements. Meanwhile, industry evolves in response to technological change, environmental regulations, consumer preferences, and global pressures for sustainable business practices. Consequently, signals regarding industry needs do not always reach the curriculum development process quickly or accurately. From the perspective of Signaling Theory, diplomas and academic degrees should function as competency signals for the labor market (Spence, 2002). However, when the competencies represented by a diploma do not match actual industry needs, the value of the signal weakens. Graduates may still possess formal credentials, but the labor market increasingly demands evidence of more specific and operational competencies.

Technology offers an opportunity to reduce this information asymmetry. The use of big data analytics, artificial intelligence, and digital labor platform monitoring can help educational institutions identify competency demand patterns more rapidly. Through job vacancy data, job

descriptions, frequently requested certifications, and industry competency trends, educational institutions can obtain a more current picture of market demand directions. In this context, technology functions not only as a learning medium but also as a market sensor connecting the educational sector with industrial dynamics. This sensor is crucial because changes in green competencies occur dynamically. A competency considered highly valuable in one period may shift with the emergence of new technologies, regulations, and business models.

This situation indicates that transforming economic education is insufficient if limited to the partial addition of environmentally themed courses. Transformation must also encompass curriculum structure, learning methods, competency evaluation, industry partnerships, and market-needs monitoring systems. Economic education must build an adaptive ecosystem that enables the curriculum to be updated systematically and measurably based on data. Such updates do not imply eliminating the foundations of economic theory but rather positioning theory as a basis for interpreting emerging problems. For example, cost and efficiency theory can be applied to analyze energy efficiency, market theory can be used to understand demand for green products, and human resource theory can support the design of workforce competencies in the green industry. In this way, economic education maintains its scientific foundation while remaining relevant to contemporary needs.

Based on this description, this article aims to construct a transformation model for economic education based on technology-driven market signals to increase external efficiency in the green industry sector. The article does not attempt to discuss all aspects of education; rather, it specifically highlights the relationship between digital market signals, curriculum adaptability, and graduate relevance to green industry needs. Theoretically, this article expands the application of Signaling Theory within the context of educational management and the circular economy. Practically, it offers a framework for higher education institutions to design more agile, data-driven curricula aligned with sustainable development goals. Thus, economic education is expected to contribute to the development of human capital that is not only economically competitive but also ecologically responsible.

The urgency of this transformation is reinforced by the fact that the green industry is developing not only in large-scale manufacturing sectors but also in services, finance, education, logistics, and entrepreneurship. This means that economic education graduates will encounter demands for green competencies across diverse work environments. They will be required not only to understand macro-level concepts such as sustainable economic growth but also to interpret micro-level indicators such as raw material efficiency, emission costs, green consumer behavior, and the added value of environmentally friendly products. If economic education continues to treat green issues as supplementary material, graduates risk perceiving sustainability merely as an ethical discourse rather than as a framework for economic analysis applicable to business and policy decisions.

Furthermore, changes in the labor market indicate that competency needs are not always expressed explicitly in academic terminology. Industries often use practical terms such as green operations, ESG reporting, circular supply chains, carbon reduction, sustainable procurement, and resource efficiency. These terms must be translated into curriculum language so that students can understand their relevance to the economic theories they study. This is where the role of market signals becomes highly important. Market signals help educational institutions interpret practical industry terminology and transform it into measurable learning outcomes. Thus, the curriculum does not merely follow market demands passively but actively interprets these signals within the scientific framework of economic education.

This article also positions the green industry as a strategic context because the sector represents the direction of future development. The green industry demands a balance between economic growth, technological innovation, and ecological responsibility. This demand challenges economic education to produce graduates capable of systemic thinking. Graduates must not only calculate profits but also assess the social and ecological consequences of economic decisions. Therefore, the transformation of economic education based on technology-driven market signals is not merely a response to labor market demands but also part of a broader effort to build a more efficient, equitable, and sustainable economic civilization.

METHOD

This study used a mixed-methods approach with an exploratory sequential design. This approach was chosen because the research objective was not only to describe the phenomenon of competency gaps but also to develop a transformative model for economic education whose relevance could be tested. The exploratory sequential design allowed the research to begin with qualitative exploration to understand the signals of green industry needs and then continue with quantitative testing to assess the relationship between technology-based market signals, curriculum adaptability, and external efficiency. Thus, this approach provided space for researchers to build a model based on field data rather than merely applying an existing theoretical framework (Creswell & Clark, 2018).

The model development framework in this research adopted the principles of Research and Development (R&D), modified according to the needs of technology-based education research. R&D was used because this research produced a model design rather than merely a descriptive report on the condition of economic education. The development stages were arranged systematically, beginning with problem identification, market signal collection, model framework preparation, expert validation, model revision, and limited testing. Modifications were made regarding technology integration because the developed model comprised not only the curriculum structure but also a digital labor market monitoring mechanism. Therefore, the R&D procedure in this research was directed toward producing a dynamic model that could be updated according to the changing needs of the green industry (Borg & Gall, 1984).

The first phase was the diagnostic phase, or Market Signal Discovery. In this phase, the research focused on identifying competency-need signals emerging from the green industry sector. Data were collected through document analysis, digital labor platform searches, and the mapping of competency keywords that repeatedly appeared in job descriptions. The analyzed market signals included competency types, frequency of occurrence, work context, certification demands, and the relationship between competencies and circular economy principles. This analysis was important because industry needs often did not appear in the form of systematic academic statements but were scattered throughout the practical language of the workplace. By identifying these patterns, the research captured actual needs that had often been delayed in entering the economic education curriculum.

Web-scraping techniques and big data analytics were used in a focused manner to extract information from relevant digital platforms. The collected data included not only job titles but also descriptions of job responsibilities, competency requirements, requested software, analytical skills, and terms related to sustainability. After data collection, a data-cleaning process was carried out to remove duplicates, irrelevant terms, and information not directly related to economic education or the green industry. This stage produced an initial competency list, which was then grouped into several domains, such as green economic literacy, circular economy management, data analysis, sustainability accounting, and green supply chain management.

The second phase was the model construction phase, or Model Transformation. At this stage, the results of market signal mapping were translated into the design of an adaptive economic education model. The model was developed on the principle that the curriculum should not merely function as a static document but should instead operate as a system capable of updating itself based on market information. Model development was carried out by linking each green industry competency domain with learning outcomes, learning strategies, evaluation methods, and the need for industry collaboration. This model was then named Adaptive-Green Economic Education (A-GEE), an economic education model integrating economics learning, market-monitoring technology, and a green industry orientation.

Model validation was carried out using the Delphi Method, involving an expert panel. The panel consisted of economic education academics, educational technology practitioners, and green industry practitioners. The involvement of these three groups aimed to ensure that the model was not only theoretically robust but also technically feasible and industrially relevant. Academics assessed the model's consistency with economic education goals; technology practitioners assessed the feasibility of integrating dashboards and data analytics; and industry practitioners assessed the suitability of competencies with workplace needs. The validation process was conducted over several rounds until agreement was reached regarding the model

components, success indicators, and the most feasible implementation format for higher education institutions (Maciel-Monteon et al., 2019).

The third phase was the evaluative phase, or External Efficiency Testing. In this phase, the research tested the extent to which the A-GEE model could explain improvements in the external efficiency of economic education. External efficiency was measured through several indicators: the suitability of graduate competencies to green industry needs, student readiness for sustainability-based jobs, the curriculum's ability to respond to market signals, and the potential reduction of competency mismatches. Measurement was conducted by linking competency mapping results, expert assessments, and responses from graduate users and industry practitioners. In this way, external efficiency was understood not merely as the job absorption rate but as the degree of alignment between competencies developed through education and the functional needs of industry.

The research population included Economic Education study programs at universities that demonstrated attention to sustainable development and the use of digital technology in learning. The sample was determined using purposive sampling techniques because the research required units of analysis aligned with the model's focus. Selection criteria included the existence of an economic curriculum suitable for analysis, institutional readiness to integrate technology, and the program's connection to issues of entrepreneurship, industry, or sustainable development. Purposive sampling helped the research obtain relevant data because not all Economic Education study programs demonstrated the same readiness to adopt a market signal-based model.

Primary data were obtained through in-depth interviews with stakeholders, particularly academics, curriculum managers, green industry practitioners, and graduate users. The interviews were directed toward exploring perceptions of competency gaps, barriers to curriculum renewal, green competency needs, and the potential use of technology as a market-monitoring system. Secondary data were obtained from curriculum documents, publications on green job trends, labor market reports, and references on sustainable education from international organizations such as UNESCO and World Bank. The combination of primary and secondary data ensured that the analysis did not rely solely on respondents' perceptions but was also supported by broader trends and documentary evidence.

Qualitative data were analyzed using thematic analysis. The analysis process was carried out through stages of data reading, coding, theme grouping, theme review, and meaning extraction. The main themes identified included forms of competency gaps, characteristics of market signals, barriers to curriculum transformation, and the most relevant model components. Thematic analysis was used because it could capture patterns of meaning from interview data and documents in depth. The results of the qualitative analysis became the basis for constructing model constructs and indicators that were subsequently tested in the quantitative phase.

Quantitative data were analyzed using Structural Equation Modeling (SEM). SEM was chosen because this study tested the relationships among latent variables, namely technology-based market signals, curriculum adaptability, and external efficiency. The technology-based market signals variable reflected the institution's ability to capture market-needs data. The curriculum adaptability variable reflected the curriculum's ability to translate these signals into educational changes. The external efficiency variable reflected the level of graduate relevance to green industry needs. The relationship among these three variables was understood systemically because market signals would not increase external efficiency unless they were translated into an adaptive curriculum.

Conceptually, the basic formula for external efficiency in this research was formulated as: $EE=f(MS \times AC)$ where external efficiency (EE) is a function of market signals (MS) and curriculum adaptability (AC). This formula demonstrated that external efficiency was influenced not only by the amount of market information an institution possessed but also by its ability to convert that information into curricular action. If market signals were strong but the curriculum remained rigid, external efficiency would remain low. Conversely, if the curriculum was adaptive but lacked accurate market data, curriculum changes could lose direction. Therefore, the strength of the A-GEE model lay in the integration of precise signal capture and curriculum agility in responding.

Data validity was maintained through source triangulation and method triangulation.

Source triangulation was conducted by comparing information from academics, industry practitioners, curriculum documents, and digital labor market data. Method triangulation was conducted by combining interviews, document analysis, big data mapping, expert validation, and quantitative analysis. This procedure was important because the issue of external efficiency in economic education could not be explained through only one type of data. Through triangulation, the research results were expected to be more robust and less vulnerable to one-sided interpretations. All analytical stages were directed toward ensuring that the developed model remained focused on the article's core objective: transforming economic education through technological market signals to meet the needs of the green industry.

The research instrument was developed based on three main constructs: market signals, curriculum adaptability, and external efficiency. The market signals construct included indicators such as the frequency of green competency emergence, the consistency of competency needs across various job platforms, and the relevance of these competencies to the field of economic education. The curriculum adaptability construct included syllabus flexibility, lecturer readiness, integration of learning technology, and competency-based evaluation mechanisms. Meanwhile, the external efficiency construct included graduate relevance, job readiness, green industry absorption potential, and mismatch reduction. The development of this instrument ensured that each part of the research had a clear measurement direction and remained connected to the article's main objective.

During the interview stage, questions were designed to explore respondents' experiences and assessments in depth. Academics were asked to explain barriers to curriculum renewal, lecturer readiness, and the position of economic education within the green transition. Industry practitioners were asked to explain the most needed competency types, forms of graduate deficiencies, and workforce-readiness criteria. Technology practitioners were asked to assess the possibility of dashboard integration, the utilization of market data, and digital infrastructure needs. By separating the focus of questions for each respondent group, the research obtained a more precise picture of the relationship among curriculum, technology, and industry needs.

The success criteria for the A-GEE model were determined based on three measures. First, the model was considered relevant if it could explain the gap between the curriculum and green industry needs. Second, the model was considered feasible if the proposed components could be implemented within the context of an Economic Education study program without eliminating the scientific identity of economics. Third, the model was considered effective if it could improve external efficiency indicators, either through increased competency relevance, reduced mismatch, or strengthened signal value of graduates in the eyes of industry. These three measures were used as the basis for assessment so that the model would be not only conceptually meaningful but also practically useful.

RESULTS AND DISCUSSION

Results

The results of big data analysis using web-scraping techniques on various digital job platforms in Indonesia and the ASEAN region show a fundamental shift in labor requirements. The green industry sector no longer seeks only graduates who understand economic concepts in general; rather, it requires a workforce capable of translating sustainability principles into managerial, financial, production, and supply-chain practices. The keywords that most frequently appeared in the mapping of industry needs were Sustainability Accounting, Circular Economy Management, Green Supply Chain Management, carbon management, data analytics, and environmental reporting. The emergence of these keywords indicates that green job requirements have moved from the discourse level toward operational needs. Industries require graduates who not only understand sustainability terminology but can also use data and analytical instruments to make economically efficient and ecologically sound decisions.

This finding aligns with global trends regarding the growth of green jobs. Sulich (2022) explain that the circular economy drives the emergence of new types of jobs that demand a combination of technical, managerial, and analytical skills. In the context of economic education, this means graduates need to understand how businesses reduce waste, optimize resource use, measure environmental impact, and build sustainable value models. Economic education that

emphasizes only market theory, production costs, and consumer behavior without linking them to the green transition will increasingly struggle to meet these needs. Therefore, the market signals identified in this research indicate that economic education must move toward integrating economic theory, digital technology, and sustainability literacy.

However, when these market signals were compared with the structure of conventional economic education curricula, a significant gap was identified. Most instructional materials remain oriented toward the linear economic paradigm, which places growth as the primary goal without adequate emphasis on ecological limits. In the evaluation of curriculum documents, material on the circular economy, Sustainability Accounting, and Green Supply Chain Management still tends to appear as supplementary topics rather than as a core framework. This condition indicates that curriculum renewal has not fully kept pace with the speed of green industry transformation. In other words, educational institutions maintain a relatively stable academic structure, while the labor market undergoes rapid and continuous competency changes.

This gap creates a condition referred to in this study as signal asymmetry. Signal asymmetry occurs when the message sent by educational institutions to the labor market is no longer strongly interpreted as an indicator of competency readiness. The economic education diploma still holds formal value, but the green industry requires additional signals in the form of portfolios, certifications, simulation experience, and specific technical abilities. Within the framework of Signaling Theory, the diploma should signify that the graduate possesses the skills required by the market (Spence, 2002). However, when curriculum content does not reflect current market needs, that signal weakens. Consequently, industry seeks additional evidence beyond the diploma to assess graduate eligibility.

This condition is reinforced by the results of interviews with green industry practitioners, who assessed that economic education graduates generally possess sufficient conceptual abilities but are not always prepared to apply these concepts in sustainability-based work situations. Graduates can explain production theory, costs, markets, and management, but they often struggle to connect these theories to emissions reduction, energy efficiency, sustainability reporting, or circular economy strategies. This shows that the primary problem does not lie in the weakness of the economic scientific foundation but rather in the lack of integration between economic theory and the green industry context. Economic education therefore requires an applicative bridge so that the theories students learn can be transformed into relevant work competencies.

From the perspective of external efficiency, this study found that the mismatch between curriculum and market signals affects the slow transition of graduates into relevant employment. The waiting period for graduates to enter the green sector tends to be longer when graduates do not possess evidence of specific competencies. This finding reinforces the view of Hanushek (2020) that the value of education for economic development depends greatly on the quality and relevance of competencies, not merely on the number of graduates. When graduates require lengthy retraining, educational and industrial resources are wasted. Institutions incur costs to produce graduates, while industries still must incur additional costs to adapt graduates to job requirements.

The results also show that market signals emerging from digital platforms possess specific and rapidly changing characteristics. During one period, industry heavily emphasized sustainability reporting capabilities; during another, demand shifted toward environmental data analysis, green procurement, or circular business models. This pattern indicates that the economic education curriculum can no longer be updated solely through lengthy five-year cycles. Although curriculum renewal still needs to follow academic regulations, learning content, case studies, projects, and competency evaluations must be adjusted more rapidly. This is where the adaptive model becomes important, as it allows institutions to interpret market signals periodically without always waiting for a formal change in curriculum structure.

Based on these diagnostic findings, this research formulated the Adaptive-Green Economic Education (A-GEE) model. This model is a transformative framework for economic education that connects three primary components: technology-based market-signal interpretation, curriculum adaptability, and the strengthening of external efficiency. A-GEE positions technology as a bridge between the educational sector and industry. Technology is understood not merely as a learning tool, such as a Learning Management System (LMS), but as a

monitoring system that provides real-time information on required competencies. Through this model, the economic education curriculum is no longer developed solely on the basis of academic assumptions but also on empirical evidence derived from labor-market dynamics.

Discussion

The first component in the A-GEE model is the Dynamic Syllabus. The Dynamic Syllabus is a syllabus design that allows periodic updates based on market-signal monitoring results. Updates do not necessarily require changing entire courses but can instead be implemented through topic enrichment, case-study adjustments, project additions, or the integration of new competencies into student assignments. For example, an industrial economics course can incorporate case studies on energy efficiency and circular production; an accounting course can integrate Sustainability Accounting; while an entrepreneurship course can develop green business models. In this way, the curriculum maintains academic stability, while the learning content evolves according to industry needs.

The second component is the Technological Signaling Dashboard. This dashboard functions as a competency-monitoring instrument that collects and visually displays labor-market demand trends. For study-program managers, the dashboard can be used to identify which competencies are most frequently requested by industry. For lecturers, the dashboard can serve as a basis for selecting case studies and assignments. For students, the dashboard can function as a career map showing which skills require further strengthening. Through the dashboard, market signals are no longer scattered and difficult to interpret but can instead be translated into information that supports academic decision-making. This strengthens the role of technology as an enhancer of graduate competency signals.

The third component is the Virtual Green Lab. This virtual laboratory is designed as a simulation space in which students can practice green economy concepts without always depending on direct access to industry. The Virtual Green Lab can contain simulations of green supply chains, environmental-cost calculations, product life-cycle analysis, carbon-policy scenarios, and evaluations of circular business models. Through simulation, students not only learn concepts but also experience the economic decision-making process within a sustainability context. UNESCO (2022) emphasizes the importance of greening education through applicative learning experiences. Therefore, the Virtual Green Lab becomes an important means of transforming sustainability concepts into practical skills.

These three components operate integratively. The Dynamic Syllabus ensures that learning content remains relevant; the Technological Signaling Dashboard ensures that curriculum updates are data-driven; and the Virtual Green Lab ensures that students gain applicative experience. If one component operates independently, the impact will not be optimal. A dynamic syllabus requires data; data requires a mechanism for translation into learning; and learning requires a practical space in which competencies can truly develop.

Therefore, A-GEE is not intended merely as an additional program but as an ecosystem for transforming economic education that connects data, curriculum, learning, and industry needs. The expert-validation results showed that the A-GEE model was considered relevant for addressing the needs of economic education in the era of the green transition. Academics assessed that this model retains the foundation of economic science because it does not eliminate fundamental theory but instead expands its application context. Technology practitioners assessed that the market-signal dashboard enables curriculum managers to obtain more current data compared with relying solely on manual surveys. Industry practitioners assessed that the Virtual Green Lab and case-based projects can strengthen graduate readiness. The consensus of this expert panel indicates that the A-GEE model possesses both conceptual and practical feasibility for further development.

CONCLUSION

This research concludes that the conventional economic education model, which is static and predominantly theoretical, has experienced a decline in relevance when faced with the dynamic needs of the green industry. The gap between the curriculum and labor market needs indicates that the external efficiency of economic education has not been optimally achieved.

Economic education graduates need more than mastery of basic concepts; they require competencies capable of addressing issues of sustainability, the circular economy, resource management, and data-driven decision-making.

Therefore, the transformation of economic education is a strategic necessity, not merely a pedagogical choice. The integration of technology-based market signals has proven to be an important mechanism for reducing information asymmetry between educational institutions and the green industry. By monitoring digital labor market data, educational institutions can capture changes in competency needs more quickly and measurably. However, market signals will have no impact if the curriculum lacks adaptive capacity. Therefore, the Adaptive-Green Economic Education (A-GEE) model emphasizes the relationship among market signal analysis, the Dynamic Syllabus, the Technological Signaling Dashboard, and the Virtual Green Lab as components of a unified learning transformation ecosystem.

Theoretically, this research expands the application of Signaling Theory by demonstrating that the signaling value of higher education in the green industry era is determined not only by the diploma but also by relevant, data-driven competency evidence that can be readily interpreted by the labor market. Practically, this research recommends that Economic Education study programs begin developing a curriculum renewal system based on digital labor market data, strengthening circular economy literacy, and implementing learning models based on green industry simulations. Thus, economic education can serve as a pillar for developing human capital that is competitive, adaptive, and committed to environmental sustainability. The policy implication of this research is the need for stronger collaboration among universities, regulators, and green industry practitioners.

This collaboration should not be limited to internships or formal partnerships alone but should also include competency data exchange, module development, curriculum validation, and graduate readiness evaluation. If this transformation is implemented consistently, economic education can evolve from a reactive learning system into an adaptive ecosystem capable of anticipating market changes. Ultimately, achieving external efficiency in the green industry sector will strengthen economic education's contribution to sustainable, technology-based national development.

ACKNOWLEDGEMENT

All praise is due to Allah SWT for the completion of this research article, which is the fruit of intellectual journey and dedication to the advancement of knowledge. The author expresses profound respect and deep gratitude to the leadership of Universitas Sebelas Maret Surakarta and Universitas Nahdlatul Wathan (UNW) Mataram for their institutional support and academic space provided during the research process. The highest appreciation is conveyed to the experts, course lecturers, and green industry practitioners who provided constructive criticism and crucial data in sharpening the analysis of the external efficiency of economic education. Specifically, the author expresses immeasurable thanks to beloved parents, husband, and esteemed colleagues who continuously provided motivation and prayers as the main strength in this writing. May the intellectual contribution of this article provide real benefits for the transformation of economic education in Indonesia and become ongoing charity for all parties who have helped. Aamiin.

AUTHOR CONTRIBUTION STATEMENT

The author is fully responsible for the entire series of research and the preparation of this article. The author's contributions include conceptualizing the idea of transforming the economic education model and developing the theoretical framework integrating signal theory with green industry dynamics. The author independently designed the research methodology, including developing the algorithm for capturing technology-based market signals and processing primary and secondary data through external efficiency analysis.

Furthermore, the author conducted in-depth investigation, formal analysis of findings, and preparation of the original draft manuscript. The author is also responsible for critical review, substantive editing of the manuscript, and ensuring all references comply with applicable academic citation standards. The entire process, from problem formulation to drawing conclusions and policy recommendations, is the original work of the author as a form of

contribution to the development of Economic Education science at the doctoral level.

REFERENCES

- Bai, X., Sun, X., & Chiu, Y.-H. (2020). Does China's higher education investment play a role in industrial growth? *Technology in Society*, 63, 101332. <https://doi.org/10.1016/j.techsoc.2020.101332>
- Bijnsens, G., Anyfantaki, S., Colciago, A., De Mulder, J., Falck, E., Labhard, V., Lopez-Garcia, P., Lourenço, N., Meriküll, J., & Parker, M. (2024). The impact of climate change and policies on productivity. *ECB Occasional Paper*, 2024/340. <https://doi.org/10.2139/ssrn.4741442>
- Bing, H., & Zhenzhen, Z. (2025). Synergistic development of vocational education and regional economy in the era of high-quality growth. *International Educational Research*, 8(3), p66–p66.
- Borazjani, S. A. A., & Adeel, S. (2025). Digital Technologies for Real-Time Carbon Accounting in Circular Economy Frameworks. *Green and Low-Carbon Economy*. <https://doi.org/10.47852/bonviewGLCE52027106>
- Borg, W. R., & Gall, M. D. (1984). Educational research: An introduction. *British Journal of Educational Studies*, 32(3).
- Creswell, J. W., & Clark, V. L. P. (2018). *Designing and Conducting Mixed Methods Research*. Sage Publications.
- Dunderfelt, A., Sergeeva, Y., & Tuomala, A.-M. (2025). *Developing a lifelong learning service model to enhance SME competitiveness in the green transition*.
- Dwivedi, A., & Paul, S. K. (2022). A framework for digital supply chains in the era of circular economy: Implications on environmental sustainability. *Business Strategy and the Environment*, 31(4), 1249–1274. <https://doi.org/10.1002/bse.2953>
- Graupe, S. (2019). "To see the world with different eyes": thoughts on existential orientation in socio-economic education. *International Journal of Pluralism and Economics Education*, 10(4), 369–382. <https://doi.org/10.1504/IJPEE.2019.106127>
- Hanushek, E. A., & Woessmann, L. (2020). Education, knowledge capital, and economic growth. *The Economics of Education*, 171–182. <https://doi.org/10.1016/B978-0-12-815391-8.00014-8>
- Maciel-Monteon, M., Limon-Romero, J., Gastelum-Acosta, C., Tlapa, D., Baez-Lopez, Y., & Solano-Lamphar, H. A. (2019). Measuring critical success factors for six sigma in higher education institutions: Development and validation of a surveying instrument. *IEEE Access*, 8, 1813–1823.
- Osiobe, E. U. (2019). A literature review of human capital and economic growth. *Business and Economic Research*, 9(4), 179–196. <https://doi.org/https://doi.org/10.5296/ber.v9i4.15624>
- Rosenberg, E., Lotz-Sisitka, H. B., & Ramsarup, P. (2018). The green economy learning assessment South Africa: Lessons for higher education, skills and work-based learning. *Higher Education, Skills and Work-Based Learning*, 8(3), 243–258. <https://doi.org/10.1108/HESWBL-03-2018-0041>
- Singh, R., Joshi, A., Dissanayake, H., Iddagoda, A., Khan, S., Félix, M. J., & Santos, G. (2025). Integrating Industry 4.0, circular economy, and green HRM: a framework for sustainable transformation. *Sustainability*, 17(7), 3082. <https://doi.org/10.3390/su17073082>
- Spence, M. (2002). Signaling in retrospect and the informational structure of markets. *American Economic Review*, 92(3), 434–459.
- Storonyanska, I., Benovska, L., Patytska, K., Ivashko, O., & Chulipa, I. (2025). Redesigning Sustainable Vocational Education Systems to Respond to Global Economic Trends and Labor Market Demands: Evidence from EU Countries on SDGs. *Sustainability*, 17(21), 9530.
- Sulich, A., & Sołoducho-Pelc, L. (2022). The circular economy and the Green Jobs creation. *Environmental Science and Pollution Research*, 29(10), 14231–14247. <https://doi.org/10.1007/s11356-021-16562-y>
- Tu, Z. (2024). Advancing Industrial Economics Education for a Sustainable Economy. *The Educational Review, USA*, 8(11).
- Ushakov, D., Cherkasova, L., & Shatila, K. (2021). Environmental management system and its impact on productivity. *IOP Conference Series: Earth and Environmental Science*, 937(2),

22037.

Yudiono, H. (2017). The alignment of productive competence on machinery between vocational education institutions and industry. *World Transactions on Engineering and Technology Education*, 15(3), 256–259.