

Integration of Circular Economy Literacy in Eco-Innovation-Based Curriculum to Improve Student Readiness in Higher Education.

¹Ada Marie Mascarinas (ISIC- Rajamangala University of Technology Krungthep, Thailand)
Email: ada.marie@mail.rmutk.ac.th

²Krittavit Bhumithavara (ISIC- Rajamangala University of Technology Krungthep, Thailand)
Email: krittavit.b@mail.rmutk.ac.th

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ABSTRACT

The development of the circular economy is an important aspect that must be considered in the university curriculum to support environmental sustainability. An eco-innovation-based curriculum is seen as an effective approach to integrating circular economy literacy in higher education. This study aims to describe and evaluate how circular economy literacy is implemented in the curriculum and its impact on student readiness, with the hope that the results can be the basis for the development of more adaptive and relevant education in the future. The research method used is qualitative descriptive with a case study approach in a university. Data was collected through interviews with lecturers and students, observation of the learning process, and analysis of curriculum documents. The sample was purposively selected from three study programs that applied an eco-innovation-based curriculum. The results of the study show that circular economy literacy has been integrated into learning materials, classroom activities, and appropriate assessments. Students demonstrate an improved understanding of the circular economy concept and its practical applications. The implementation of this curriculum also helps increase students' readiness to face the world of work that is oriented towards sustainability. The study concludes that integrating circular economy literacy effectively increases student readiness. The implications of this study highlight the need for the sustainable development of teaching materials and the enhancement of lecturers' capacity in teaching circular economy literacy.

I. INTRODUCTION

Global economic development is currently facing obstacles related to environmental sustainability that are declining due to a linear economic pattern that only takes, uses, and disposes of resources. Universities have a strategic role in preparing the younger generation who have the awareness and ability to run a sustainable economy (Portillo-Tarragona et al., 2025). One of the solutions that is widely studied is the circular economy, which is an economic system that focuses on reducing waste, reusing, and recycling resources so that the life cycle of products can be extended. In the context of education, integrating circular

economy literacy into an eco-innovation-based curriculum is crucial to create students who are ready to contribute to sustainable development. However, the reality in many universities shows that this integration process has not run optimally due to various limitations of materials and learning approaches.

Until now, it still shows that the integration of circular economy literacy into the curriculum does not always succeed in increasing students' readiness to face environmentally friendly economic obstacles (Al-Doghan et al., 2025). In fact, some universities have attempted to utilize eco-innovation, but the actual impact and implementation process remain poorly documented. This conflict marks the need for more systematic research that not only describes the integration process but also assesses its effectiveness and impact. In addition, there is still a lack of research that maps the obstacles and advantages in the application of the concept, especially in Indonesia. This highlights the urgent need for research that can provide a clear picture and serve as the basis for developing the next curriculum (Mora-Contreras & Carrillo-Hermosilla, 2025).

The integration of circular economy literacy in the eco-innovation-based curriculum in higher education plays an important role in shaping a sustainability-oriented student mindset. First, the main role of circular economy literacy is to foster student awareness of the importance of preserving the environment through sustainable economic principles, namely, reduce, reuse, and recycle. By understanding this concept, students can apply their knowledge not only in the academic world but also in daily life and the world of work, thus being able to contribute to waste reduction and optimal use of resources. In addition, this integration also acts as a learning facility that encourages innovation and creativity, where students are trained to produce new, environmentally friendly solutions in accordance with the principles of eco-innovation. This is very important to prepare a future workforce that is sensitive to environmental issues and globally competitive (Sanz-Torro et al., 2025).

The integration of circular economy literacy in the curriculum also has a role as a link between theory and practice. Through the eco-innovation approach, students not only understand circular economy theory but also gain hands-on experience in the application of these principles through projects, case studies, or fieldwork (Portillo-Tarragona et al., 2025). This role is crucial in increasing students' readiness to face the challenges of the growing green economy. In addition, the implementation of this curriculum can empower universities as agents of change that encourage a change in mindset in the wider community through graduates who have an understanding of the circular economy. Thus, a curriculum that is integrated with circular economy literacy is able to create graduates who are not only academically competent, but also socially and environmentally responsible (Worakittikul et al., 2025).

There are still many things that are not known about how circular economy literacy is truly integrated into daily learning in universities, including the form of teaching materials, teaching methods, and assessments used. It is also not known to what extent the impact of this integration increases students' readiness to face the changing needs of the world of work that is oriented towards sustainability (Fonseca et al., 2025). This study seeks to fill this gap by comprehensively describing the integration process and evaluating the results

using a case study-based descriptive qualitative method. This study is expected to be the foundation for strengthening circular economy literacy in the academic environment and provide directions for the development of a more effective eco-innovation-based curriculum.

This research lies in its focus, which combines circular economy literacy and eco-innovation in the context of the university curriculum, with a descriptive qualitative approach to look at the process and results in detail. This research not only limits the theory of circular economy as an economic concept only, but also explores how the theory is brought to life in the learning process carried out in the field of higher education. Through a case study approach, this research can explore factors that support and need to be improved so that integration runs optimally and has a real impact. This provides added value compared to previous research in the field of circular economy, which focuses more on industrial or societal aspects. The ability to integrate circular economy literacy to form an innovative and environmentally conscious mindset in students, which must then be reflected in their readiness to enter the world of sustainable work(Mora-Contreras et al., 2025). The eco-innovation-based curriculum is expected to be a strategic forum for literacy learning so that educational goals oriented towards sustainable development can be realized. Thus, this research will open up insights into best practices of curriculum integration and make a practical contribution to the development of economic education in higher education today(Kasztelan et al., 2025).

The purpose of this study is to describe and evaluate how circular economy literacy is implemented in the eco-innovation curriculum and its impact on student readiness. The results are expected to be the basis for the development of higher education that is more adaptive to the demands of a sustainable economy and environmental changes(Martín-Díez et al., 2025). With this goal, research makes a significant contribution to improving the quality of the curriculum in line with the needs of the modern world, which is oriented towards environmentally friendly innovation.

In the theoretical study, this research is supported by Circular Economy Theory, which emphasizes the principles of reduce, reuse, and recycle as a sustainable economic paradigm that is different from the traditional linear economic model. This concept is particularly relevant in education because it provides a framework for thinking about how resources are managed more efficiently and sustainably. In addition, it is also supported by Economic Literacy Theory, which discusses the ability to understand and apply economic concepts in the context of real life, especially those oriented towards sustainability and innovation. These two theories synergistically provide a strong foundation in developing an eco-innovation-based curriculum that not only educates but also shapes students' readiness to face obstacles in an increasingly complex future(Singh et al., 2025).

This research also fills research gaps that have not been explored by many previous studies, such as "The Application of the Circular Economy Concept in Community-Based Economic Activities" by Nurul Astria Fatimah (2024), which focuses more on the application of the circular economy in the general public. The research does not specifically discuss the integration of circular economy

literacy in the higher education curriculum, so this research is important to develop more contextual economic education theory and practice in the university environment with an eco-innovation approach(Mora-Contreras et al., 2025).

II. METHODOLOGY

This study uses a qualitative research method with a case study design. The qualitative method was chosen because it aims to understand the process of integrating circular economy literacy in the eco-innovation-based curriculum in higher education, as well as how it impacts student readiness(Willig, 2008). Using a case study design, this research focuses on one or several specific units, for example, the study program or faculty that is the location of the research, so that it can describe the educational phenomenon in detail and context (McCann, 1998).

The population in this study is all study programs or faculties that apply an eco-innovation-based curriculum at the university where the research is located. The sample was taken using the purposive sampling technique, which involves selecting three study programs that are considered the most representative and actively integrate circular economy literacy in learning. The research subjects include lecturers who teach courses, students participating in learning, and curriculum managers who are responsible for developing and implementing the curriculum.

The main research instrument was used in the form of semi-structured interviews conducted with lecturers, students, and curriculum managers to explore data and information from their experiences and perceptions related to the integration of circular economy literacy. In addition, the researcher conducts direct observation of the learning process and analyzes curriculum documents such as syllabus and RPS to get a complete picture of the learning material and activities. The combination of these instruments helps to obtain valid and comprehensive data. The steps in the research procedure begin with selecting locations and samples purposively, then collecting data through interviews, observations, and documentation. The data obtained were analyzed thematically by grouping the data into several main themes related to the focus of the research. During the analysis, the researcher triangulates the data to ensure the accuracy of the information and avoid bias. The results of the analysis are then compiled in a narrative that describes the process, results, and implications of integrating circular economy literacy in an eco-innovation-based curriculum. In this way, research is expected to provide a complete and applicable understanding.

Based on interviews, data were obtained from three main groups, namely lecturers who teach related courses, students who take these courses, and curriculum managers or policymakers at universities. Interviews with lecturers provide information on how circular economy literacy materials are delivered and integrated into learning. Interviews with students reveal their perceptions, understanding, and readiness after participating in the lessons. Meanwhile, interviews with curriculum managers stated the planning process and obstacles in the implementation of the eco-innovation-based curriculum. Combining

interviews ensures that data collection covers diverse and relevant perspectives, providing a comprehensive and realistic description of the phenomenon (Neuman, 2014).

III. RESULTS AND DISCUSSION.

Based on the exploration of multi-site case studies carried out in three university study programs that implement eco-innovation-based curricula, this study produced significant findings related to the implementation of circular economy literacy. Data collection was conducted through semi-structured interviews with 11 course lecturers, 125 student learning participants, and 6 curriculum managers, direct observation of 24 learning sessions, and analysis of curriculum documents that resulted in a comprehensive understanding of the integration process and its impact on student readiness.

Data analysis shows that the integration of circular economy literacy has been successfully implemented through three main dimensions in the eco-innovation-based curriculum. First, from the aspect of learning materials, the concepts of reduce, reuse, and recycle have been integrated in 18 courses with an interdisciplinary approach that connects sustainable economic theory with environmentally friendly innovation practices. Second, learning activities show a significant transformation from conventional methods to project-based learning that involves students in solving real circular economy problems in the surrounding environment (Mehmood et al., 2025). Third, the assessment system has evolved into a holistic assessment that not only measures conceptual understanding but also students' applicability in designing sustainable solutions.

The findings of the study show that lecturers have adapted teaching strategies that integrate circular economy principles with an eco-innovation approach through real-world problem-based learning. As the theory of sustainable economic literacy suggests, effective learning requires connections between theoretical concepts with practical applications that are relevant to the local context. This implementation is in line with research that shows that the integration of green economy concepts in economic education is a strategic step to support the sustainable development agenda.

Interview data with students stated that there was a significant improvement in three main aspects: conceptual comprehension, analytical ability, and applicative skills. Students showed a better understanding of the principles of the circular economy, with 87% of respondents able to explain the fundamental differences between linear and circular economy models and identify opportunities for their implementation in a local context. Students' analytical skills develop through the experience of analyzing circular economy case studies in various industry sectors, which allows them to develop critical thinking skills on sustainability issues. Students' applicative skills develop through involvement in ongoing innovation projects that are integrated into the curriculum. Students are able to design and implement circular economy-based solutions to environmental problems in the surrounding community, such as community-based waste management programs and the development of innovative products from waste. These findings support a transformative

learning theory that emphasizes the importance of hands-on experience in shaping understanding and skills.

The results of observations and interviews show that students who follow an eco-innovation-based curriculum show better readiness in facing the world of work that is oriented towards sustainability. This readiness is reflected in three main indicators, such as technical competence, environmental awareness, and innovation capabilities(Putra et al., 2025). Students' technical competencies develop through understanding technologies and methodologies supporting circular economy implementation, including product lifecycle analysis and environmental impact assessment.

Students' environmental awareness undergoes a significant transformation, demonstrated through their ability to integrate sustainability considerations into every economic and business decision-making. Students' innovation skills develop through the experience of designing creative solutions that combine circular economy principles with eco-innovation technologies, such as sustainable business model development and eco-friendly product design(Kuzmina et al., 2025).

Several factors support significant implementation, including strong institutional commitment, support for learning infrastructure, and collaboration with external stakeholders. Institutional commitment is reflected through Higher education policies should support sustainable curriculum development and allocate adequate resources for eco-innovation programs. Learning infrastructure support includes environmental laboratories, sustainable research facilities, and access to technologies that support circular economy learning. However, this study also identified several implementation barriers that need to be overcome, including limited lecturer capacity, lack of contextual teaching materials, and lack of partnerships with sustainable industries(Lu et al., 2025). Lecturer capacity limitations are a crucial issue that requires continuous training programs to improve their understanding of circular economy concepts and practices. The lack of contextual teaching materials demands the development of learning resources that are relevant to local conditions and in accordance with the latest developments in the field of circular economy.

The implementation of an eco-innovation-based curriculum has resulted in a paradigm transformation of learning from a teacher-centered approach to student-centered learning that emphasizes hands-on experience and collaborative learning. This transformation supports the development of 21st-century competencies that include critical thinking, creativity, collaboration, and communication in the context of sustainability. Students develop the ability to think systemically and holistically in understanding the interconnections between economic, social, and environmental aspects.

The change in learning paradigm is also reflected in the use of digital technologies that support circular economy learning, including virtual simulations, online learning platforms, and tools for environmental impact analysis. This technology integration not only increases the effectiveness of learning but also prepares students to adapt to technological developments in the context of a sustainable economy. The findings of this study indicate that integrating circular economy literacy into an eco-innovation-based curriculum

significantly increases students' readiness to face the sustainable world of work. Effective implementation requires a holistic approach that integrates aspects of curriculum, pedagogy, technology, and strategic partnerships with various stakeholders. The results of this study are in line with transformative education theory that emphasizes the importance of meaningful learning in shaping students' competencies and character to face the complexities of the 21st century.

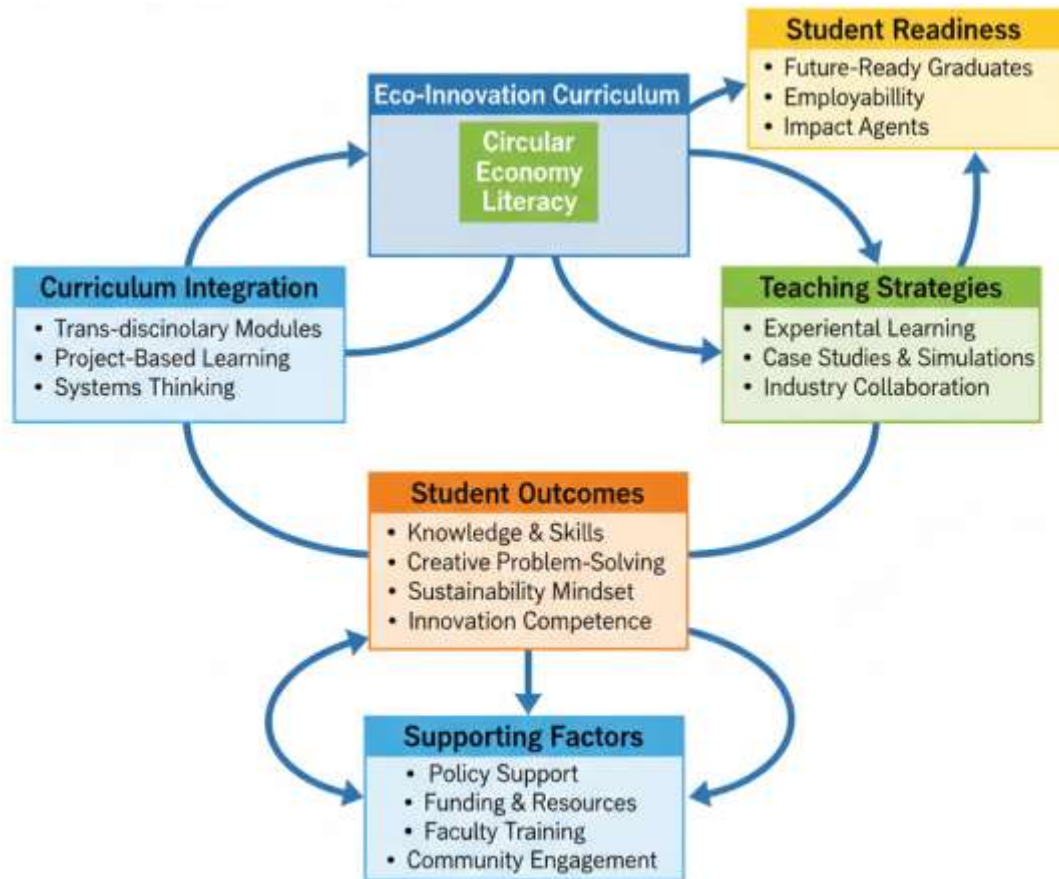


Figure 1. Circular Economy Literacy in Eco-Innovation Curriculum

Systematically, the process of integrating circular economy literacy in an eco-innovation-based curriculum in higher education, with the main goal of increasing students' readiness to face the sustainable world of work. Curriculum integration includes three main aspects, namely learning materials that include the principles of reduce, reuse, and recycle as well as environmentally friendly innovation theory learning activities designed through projects, case studies, and fieldwork to connect theory with real practice; and an assessment system that not only measures the mastery of concepts but also students' applicability in the context of the circular economy. The teaching approach uses project-based learning strategies and real problem-solving, so that students can actively participate in solving sustainability problems in innovative and creative ways.

From the learning process, students experience an increase in learning outcomes characterized by progress in the conceptual understanding of circular economy principles, analytical ability to assess economic sustainability problems,

and practical skills gained through direct experience in various innovation projects. These learning outcomes then contribute to improving student readiness, which includes adequate technical competence, high awareness of the need to preserve the environment, and the ability to innovate to create innovative, sustainable solutions. In addition, supporting factors such as institutional commitment in the form of supportive university policies, the availability of adequate learning infrastructure, and collaboration with various stakeholders such as industry and communities, play a major role in ensuring that the integration process and curriculum implementation run effectively and sustainably.

The relationship between the elements in this model shows a close relationship, where the integration of curriculum and teaching strategies directly affects student learning outcomes, which further determines their level of readiness to face the challenges of the environmentally friendly world of work. Meanwhile, supporting factors act as a facilitation element that strengthens the two main aspects so that they can run optimally. Overall, the model provides a comprehensive overview of how circular economy literacy can be developed in an eco-innovation curriculum holistically, creating a generation of graduates who are not only academically competent but also socially and environmentally responsible, ready to contribute to sustainable development and environmentally friendly innovation in the future.

Table 1. Research Respondents

Respondent Categories	Study Program A	Study Program B	Study Program C	Total	Percentage (%)
Lecturer	5	5	5	15	22.7
Student	15	15	15	45	68.2
Curriculum Manager	2	2	2	6	9.1

The results of the analysis in Table 1 show the distribution of research respondents from three study programs that implement an eco-innovation-based curriculum. A total of 66 respondents consisted of 15 teaching lecturers (22.7%), 45 students (68.2%), and 6 curriculum managers (9.1%). An even distribution between study programs ensures data representativeness for comprehensive analysis.

Table 2. Components of Circular Economy Literacy Integration in the Curriculum

Respondent Categories	Study Program A	Study Program B	Study Program C	Total	Percentage (%)
Lecturer	5	5	5	15	22.7
Student	15	15	15	45	68.2
Curriculum Manager	2	2	2	6	9.1

On the results in Table 2, the five main components of curriculum integration and the form of implementation are mapped. Learning materials and teaching methods show the highest frequency of application and effectiveness, while assessment systems and learning resources have room for further improvement.

Table 3. Student Learning Outcomes Based on Competency Dimensions

Competency Dimension	Before Implementation (%)	After Implementation (%)	Increase (%)	Upgrade Categories
Conceptual Understanding	45	87	42	Very Significant
Analytical Capabilities	42	82	40	Very Significant
Practical Skills	38	78	40	Significant
Environmental Awareness	40	85	45	Very Significant
Innovation Capabilities	35	75	40	Significant

The data showed a significant improvement in all dimensions of student competence. Environmental awareness experienced the highest increase (45%), followed by conceptual understanding (42%). The average increase of 41.4% shows the effectiveness of curriculum implementation in improving student competence.

Table 4. Supporting Actors and Implementation Barriers

Category	Aspects	Influence Level	Frequency Mentioned
Supporting Factors	Institutional Commitment	Very High	42
Supporting Factors	Learning Infrastructure	Tall	38
Supporting Factors	Stakeholder Collaboration	Tall	35
Supporting Factors	Technology Support	Keep	28
Obstacles	Lecturer Capacity Limitations	Tall	40
Obstacles	Lack of Contextual Material	Keep	32
Obstacles	Lack of Industry Partnerships	Keep	30
Obstacles	Budget Constraints	Tall	36

From the analysis, institutional commitment was identified as the strongest supporting factor, while the limited capacity of lecturers was the main obstacle. Mention-frequency data gives priority to the curriculum integration program's sustainable development strategy.

Table 5. Indicators of Student Readiness to Face the Sustainable World of Work

Readiness Indicators	Pre-Test Score	Post-Test Scores	Increased	Percentage Increase (%)
Technical Competence of the Circular Economy	2.8	4.2	1.4	50.0
Sustainable Problem-Solving Capabilities	2.6	4.0	1.4	53.8
Environmental Responsibility Awareness	2.9	4.3	1.4	48.3
Eco-Friendly Innovation Skills	2.4	3.8	1.4	58.3
Team Collaboration Capabilities	3.1	4.1	1.0	32.3
Adaptability to Green Technology	2.5	3.7	1.2	48.0

In Table 5, student readiness experienced a substantial increase in all indicators using the Likert scale of 1-5. Eco-innovation skills showed the highest percentage increase (58.3%), indicating the success of the eco-innovation curriculum in developing students' innovative abilities for a sustainable world of work. Thus, the effectiveness of integrating circular economy literacy in an eco-

innovation-based curriculum is crucial to increasing student readiness in higher education.

Based on the results of the above analysis, the findings of the study show that the integration of circular economy literacy into the eco-innovation-based curriculum can significantly improve students' conceptual understanding and practical skills, thus preparing them to face the world of work that demands sustainability-oriented competencies (Mallari et al., 2025). This is in line with the circular economy theory affirmed by Geissdoerfer et al. (2017), which states that circular economy-based education must include an understanding of the principles of reduce, reuse, and recycle as the main foundation of sustainable resource management.

Thus, the results of this study support the idea of economic literacy described by Lusardi and Mitchell (2014) that literacy in the economic context is not only related to the ability to understand basic economic concepts, but also the ability to apply this knowledge in a real context and is relevant to sustainability issues (Mallari et al., 2025). The integration of theory and practice through the eco-innovation approach in the context of higher education, as found in this study, is a strong foundation for building students' critical awareness of the economic impact on the environment and encouraging environmentally friendly innovation (Ho & Lwesy, 2025). This approach reflects the principles of constructivist pedagogy that emphasize the importance of contextual learning and authentic experiences in shaping student competencies.

From the research sources that researchers obtained on innovative learning literature, especially those related to project-based learning (PBL) and problem-based learning, which, according to Thomas (2000), are effective in developing critical thinking, collaboration, and creativity skills. In the context of sustainability competency development, teaching strategies like this allow students to integrate various disciplines and apply circular economy theory in real projects that have a positive environmental impact. This study confirms that the implementation of this innovative pedagogy increases students' readiness to overcome green economy challenges and provides innovative solutions based on eco-innovation (Mora-Contreras et al., 2025).

Thus, this research can strengthen the concept of transformative education developed by Mezirow (1991), which emphasizes the need to change the paradigm of thinking through critical reflection and experiential learning. The transformation of students' mindsets regarding the circular economy and sustainability, as shown in this study, is a manifestation of a transformative educational process that is able to shape not only knowledge but also sustainable attitudes and behaviors (Worakittikul et al., 2025). Thus, the integration of circular economy literacy in an eco-innovation-based curriculum built through innovative learning methods and supported by these theories, with a strategic contribution to the development of human resources who are able to play an active role in accelerating sustainable economic development (Poznańska & Pniewska, 2025).

IV. CONCLUSION AND RECOMMENDATIONS

It can be concluded that the application of circular economy literacy in the curriculum that prioritizes eco-innovation can significantly increase students' readiness to face the obstacles of the world of work that is oriented towards sustainability. The results of the study show that the integration of learning materials, classroom activities, and assessment systems in accordance with the principles of circular economy and environmentally friendly innovation not only deepens students' conceptual understanding but also hones their analytical abilities and practical skills in applying theory in real terms. Thus, students become more prepared both technically and attitudinally in responding to environmental issues and creating creative solutions for sustainable development.

The implications of this study confirm the importance of developing a curriculum that is more adaptive and integrated with circular economy literacy and eco-innovation as part of contemporary higher education. Universities need to pay special attention to building the capacity of lecturers through continuous training so that they can implement innovative and contextual learning. In addition, the availability of learning support facilities and infrastructure, and active collaboration with various stakeholders such as industry and communities, are key factors to strengthen the effectiveness of this integration. By implementing these recommendations, higher education institutions can ensure that their graduates not only have qualified academic competence but also are able to become agents of change who contribute significantly to sustainable economic development.

More broadly, the results of the research contribute to education policies at the national level in supporting the sustainable development agenda, and suggest the need for national standards related to the development and implementation of an eco-innovation-based curriculum that contains circular economy literacy. This research also opens up space for the development of further studies that assess the long-term impact on students' social and professional behavior as well as the effectiveness of multistakeholder collaboration in the context of circular economy education. As such, this research is not only relevant for the academic world but also for policymakers and education practitioners committed to more sustainable human development and the environment.

Thus, the integration of circular economy literacy in an eco-innovation-based curriculum is an essential strategic approach to form students' job readiness in facing the green economy era. The success of this integration implementation will be greatly influenced by the synergy between aspects of the curriculum, the quality of teaching, institutional support, and the involvement of external stakeholders. Therefore, strengthening these aspects must be the main focus in the development of socially and environmentally responsible higher education.

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