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Educating Circular Economy and Its Integration with Manufacturing Industry for Sustainable Development: A Systematic Literature Review

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ABSTRACT

BACKGROUND & CONTEXT

The circular economy (CE) has gained significant global attention as a strategic approach to achieving sustainable development across various sectors. However, its academic application that particularly within universities still remains underexplored, in contrast to the extensively studied implementation of CE in the manufacturing industry.

PURPOSE OR GOAL

This study aims to review CE practices in both university and manufacturing contexts.

APPROACH OR METHODOLOGY

A keyword search in the Web of Science (WoS) database yielded 61 studies, of which 48 qualified after screening and eligibility checks, forming the final dataset for CE–sustainability analysis.

OUTCOMES

The results indicate that scholarly publications on university CE have increased substantially, gradually closing the research gap in recent years. Between 2022 and 2024, 28 articles addressed manufacturing CE, while 20 focused on university CE, with the gap narrowing to just one article in 2024. The findings highlight that universities, as centres of knowledge, are increasingly embedding CE principles through sustainable campus operations, academic curricula, and research initiatives.

CONCLUSIONS

This study also proposes a future research direction that advocates for a CE pathway connecting manufacturing practices with university education, fostering cross-sectoral collaboration and equipping future professionals with practical sustainability competencies. In sum, the integration of CE across both domains is crucial for accelerating the transition toward a more circular and resilient economy.

KEYWORDS

Circular Economy, Sustainable Development, University Education.

Introduction

The concept of the Circular Economy (CE), first introduced by Pearce and Turner (1990), has become an essential paradigm in addressing today's sustainability challenges. CE encourages regenerative and restorative industrial systems by closing material loops, extending product utility, and transitioning from ownership to service-oriented models (Rogge & Reichardt, 2016; Gunjan, 2023). It aims to reduce resource input, emissions, and waste through strategies that slow, close, and narrow energy and material cycles (Patwa et al., 2020; Yina et al., 2022).

In light of growing environmental degradation and excessive natural resource consumption (Farooque et al., 2022), there is a pressing need to prepare the next generation of professionals that particularly in fields of Science, Technology, Engineering and Mathematics (STEM) thus to implement CE principles across industries. Furthermore, the engineering education serves as a critical platform to boost circular thinking, systems-based problem-solving, and sustainable innovation (Renfors, 2024). They are future designers, product developers, and process engineers who will directly shape industrial ecosystems, also equipping them with CE knowledge and skills is vital for accelerating the transition toward a sustainable industrial economy (Giurea et al., 2024).

Universities play a foundational role in integrating CE principles into engineering curricula, not only through theoretical courses but also via experiential and project-based learning (Parmawati et al., 2023). Many of the CE-related topics such as life cycle assessment (LCA), sustainable product design, material flow analysis, eco-efficiency, industrial symbiosis, and environmental impact modelling are increasingly embedded into engineering programs (Audretsch & Fiedler, 2024; Kirchherr et al., 2023; Renfors, 2024). Through these programs able to make preparation for student becoming inclusive of problem solvers. Not only that, the engineering faculties also incorporate CE into final-year capstone projects, design studio challenges, green lab certifications, and multidisciplinary innovation competitions that mirror real-world sustainability issues (Audretsch & Fiedler, 2024).

Additionally, partnerships between universities and industries provide engineering students with hands-on exposure to circular strategies, such as remanufacturing, reverse logistics, and waste valorisation (Giorgi et al., 2022; Owojori et al., 2022). Based on Kirchherr et al. (2023), these allow students to apply CE concepts in practical contexts such as supply chain optimization, renewable energy systems, and sustainable manufacturing processes. Universities also act as living laboratories where CE practices like green procurement, waste audits, and closed-loop campus operations are demonstrated, reinforcing student learning through environmental leadership by training courses (Parmawati et al., 2023; Renfors, 2024).

Despite the increasing awareness of CE in higher education, the literature remains limited in examining how CE is systematically taught, internalized, and practiced within engineering programs (Kirchherr et al., 2023). On the other hand, CE has been extensively analyzed in the context of manufacturing operations, particularly regarding resource efficiency, waste minimization, and process redesign (Khan et al., 2023; Nazir et al., 2024). Hence, bridging this academic-practice gap requires research that not only compares CE applications across sectors but also evaluates the pedagogical effectiveness of CE education in engineering.

This paper contributes by reviewing CE adoption in both manufacturing and university contexts, with a focus on how CE is embedded within engineering education. It proposes a future research agenda that advocates for systematic integration of CE competencies in STEM curricula, including curriculum reform, assessment frameworks, and industry-university collaborations. Ultimately, this integration is crucial to empower engineering graduates as agents of circular innovation, enabling sustainable industrial transformation and supporting national and global sustainability goals.

Material Collection

This review focuses on the topic of the circular economy (CE) in relation to the sustainable performance of universities and industry, employing a systematic literature review (SLR) methodology that analyzes published academic literature as the primary source of data. The material collection process followed a structured and transparent procedure to ensure rigor and reproducibility.

To initiate the review, a keyword-based search strategy was developed and applied to the ISI Web of Science (WoS) database, which indexes reputable academic publishers such as Elsevier, IEEE, Springer, and Taylor & Francis. Only peer-reviewed journal articles and conference proceedings published in English were considered to maintain quality and consistency. The search terms were refined to include keywords in article titles such as “sustainable circular economy”, “university circular economy”, “manufacturing circular economy”, and “circular economy practices”. This initial search yielded 61 documents.

In the screening stage, the abstracts of these articles were examined to assess their relevance to the research scope. Nine papers were excluded at this stage because they did not align to specifically address CE practices either university or industry contexts, reducing the pool to 52 relevant papers. Subsequently, a full-text analysis was conducted on the remaining articles to understand CE integration and sustainable performance. An additional four papers were excluded due to insufficient relevance and limited empirical evidences.

Ultimately, 48 articles were retained and incorporated into the final review dataset. These articles represent the inclusion stage of the material collection process and provide the empirical and conceptual basis for the subsequent analysis. By following this systematic process that encompassed identification, screening, eligibility, and inclusion, thus this review ensures a robust and transparent foundation for analyzing the integration of CE in universities and manufacturing industries.

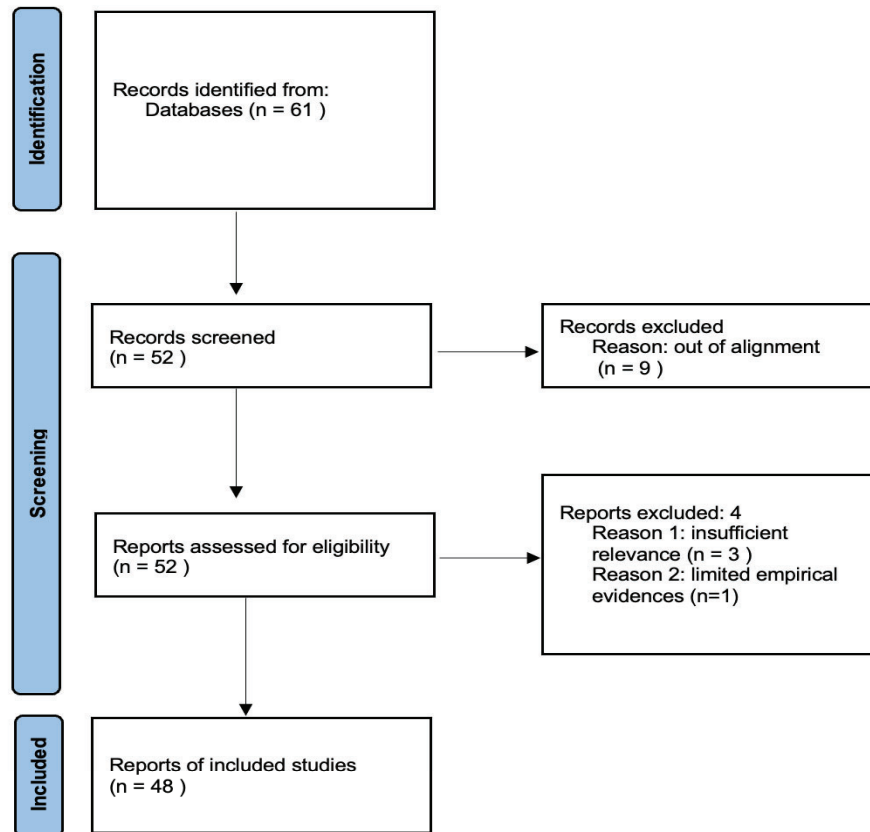


Figure 1: PRISMA flow of material collection

Results and Discussion

Year Wise Publication Details

Based on the literature analysis, both university circular economy (CE) and manufacturing CE have attracted growing scholarly interest, as evidenced by the increasing number of publications from 2022 to 2024. During this period, a total of 20 articles addressed university CE, while 28 articles focused on manufacturing CE, indicating a stronger research emphasis on CE implementation within the manufacturing sector. However, the gap between the two has gradually narrowed. For instance, in 2022, only 3 articles were published on university CE compared to 8 on manufacturing CE. By 2024, university CE publications had risen to 9, while manufacturing CE reached 10—reflecting just a one-article difference. Additionally, the growth in manufacturing CE publications appears to have plateaued, suggesting increasing momentum and interest in university-based CE initiatives. Overall, this trend highlights the emerging potential of university CE in contributing to sustainable development. Therefore, this study aims to provide an in-depth review of university CE, particularly by comparing its development and impact with that of manufacturing CE.

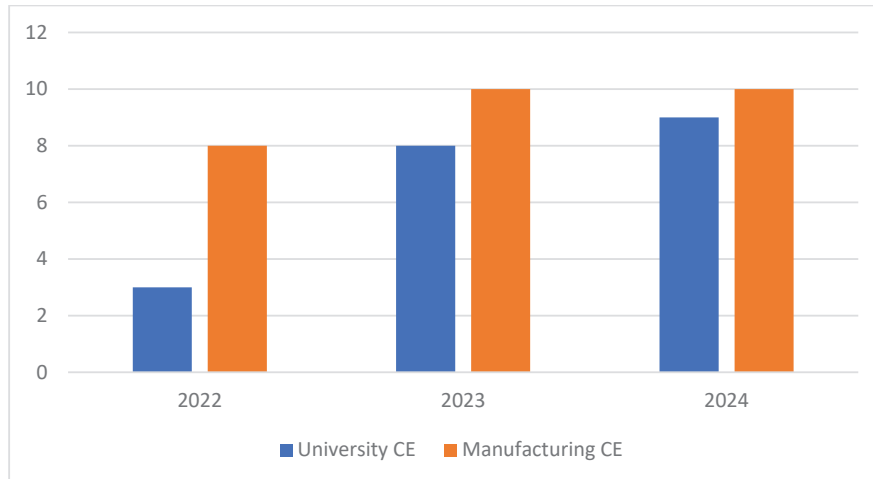


Figure 2: Number of reviewed articles on University CE and Manufacturing CE with respect to publication years

Key Differences between University CE and Manufacturing CE in Aspects of Management System, Eco-Design and Investment Recovery

Circular economy (CE) practices differ significantly between universities and manufacturing industries in terms of focus and implementation. In universities, the management system emphasizes campus-wide sustainability governance, education, and stakeholder engagement (Giurea et al., 2024; Hemidat et al., 2022; Moghayedhi et al., 2024; Owojori et al., 2022; Parmawati et al., 2023; Renfors, 2024), whereas in manufacturing, it is structured around production efficiency and environmental compliance (Agrawal et al., 2023; Calzolari et al., 2022; Coppola et al., 2023; Kafel & Nowicki, 2023; Mallick et al., 2024; Nguyen et al., 2023; Salesa et al., 2023). Consequently, these differing approaches offer potential for mutual reinforcement, where universities shape sustainability mindsets and industries provide real-world application.

Eco-design in universities is applied to infrastructure and learning environments (Bourgeois et al., 2022; Favi & Marconi, 2025; Kirchherr et al., 2023; Renfors, 2024; Spreafico & Landi, 2022), while in manufacturing it is central to product development, focusing on recyclability and lifecycle impact (Geldres-Weiss et al., 2024; Lou et al., 2024; Malhotra, 2023; Spreafico, 2022; Triguero et al., 2023; Zhu et al., 2022). Collaboration in this area can foster innovation in sustainable design practices (Casas et al., 2025), also encourage experimentations like modular product design and biodegradable packaging to ensures that innovations are not only technically feasible but also economically viable in real-world applications (Duan et al., 2024).

Regarding investment recovery, universities prioritize reusing and repurposing assets for educational and environmental benefits, often supported by grants (Gonçalves et al., 2022; Khajuria et al., 2022; M. D. Nguyen et al., 2022; Pinyol Alberich et al., 2023), whereas manufacturers view it as a strategic approach for cost savings, involving the resale or reuse of materials and equipment to enhance profitability (D'Adamo et al., 2024; Dey et al., 2022; Fernando et al., 2023; Gonçalves et al., 2022; Yu et al., 2022). Despite differing goals, partnerships can align research and practice, allowing universities to test circular solutions that industries can scale (Shah & Gillen, 2024; Solling Hamid, 2024). In brief, such integration fosters innovation, practical relevance, and a shared commitment to a circular and sustainable future.

Table 1: Comparison between University CE and Manufacturing CE

Aspects	University CE	Manufacturing CE
Management system	-Focuses on sustainability governance across campus operations and curricula. -Emphasizes behavioural change, education, also willingness and participation	-Structured around production efficiency, supply chain incorporation and organizational compliance. -Driven by environmental certificates such as ISO 14001, and key performance indicators (KPIs) on material usage, waste reduction and profit growth.
Eco-design	-Applied to campus infrastructures and education tools such as designing green buildings and digital study resources. -Purposes to build reuse and recyclable of learning ecosystems	-Central to product development, which involves designing for high durability, repairability and disassembly. -Aims to minimize environmental impacts across the product life cycle.
Investment recovery	-Financial returns are secondary to educational and environmental benefits. -Often driven by university grants or green funding.	-Strongly linked to profitability and industrial waste valorization. -Includes resale of recovered materials and equipment.

Future Research Direction: The Call for a Circular Economy Pathway from Manufacturing to University

Given the increasing investigation in circular economy (CE) practices between manufacturing and higher education, future studies are encouraged to explore an integrated CE pathway that bridges manufacturing operations with academic environment. While manufacturing CE has long focused on resource efficiency, closed-loop systems, and eco-innovation (Farooque et al., 2024; Fernando et al., 2023), universities have recently emerged as influential platforms for cultivating sustainability mindsets, skills, and behaviors (Shahidan et al., 2023). Therefore, future research should investigate how successful CE strategies in manufacturing can be adapted and transferred into university curricula, campus functions, teaching structures and student engagement initiatives. This cross-sectoral approach can foster a new generation of graduates equipped with practical CE knowledge and accelerate the mainstreaming of sustainability principles.

Moreover, collaborative models between industry and academia such as joint CE projects, living labs, learning tools, and knowledge co-creation (de la Torre et al., 2021; Gilmour, 2023; Pudjiarti et al., 2023). Beyond curriculum, research should also investigate about student-led initiatives such as repair cafés, upcycling hubs, or CE-focused innovation clubs to empower learners as sustainability change agents (Renfors, 2024). Finally, future studies should move beyond publication trend analysis and pursue thematic syntheses across areas such as digitalization, green skills development, and CE entrepreneurship, thereby fostering a holistic framework that aligns industrial innovation with educational transformation and prepares graduates to accelerate sustainability transitions. It deserves deeper investigation to move toward a more circular and sustainable ecosystem in universities.

Conclusion

In conclusion, the manufacturing and university contexts play vital roles in advancing circular economy (CE) practices. This study analysed both of practices that based on year of publication and key differences from aspects of management system, eco-design, and investment recovery. Findings indicate an upward trend in publications for both practices from

2022 to 2024, with slightly more studies on manufacturing CE than university CE. While manufacturing CE has traditionally led in implementation and research, the growing academic focus on university CE highlights its emerging importance in shaping sustainable mindsets and institutional practices. Therefore, fostering a circular economy pathway from manufacturing to university education represents the useful direction for future research and policy, aiming to integrate practical industry insights with academic innovation for long-term sustainable development.

References

- Agrawal, N., Rabiee, M., & Jabbari, M. (2023). Contextual relationships in Juran's quality principles for business sustainable growth under circular economy perspective: a decision support system approach. *Annals of Operations Research*. <https://doi.org/10.1007/s10479-023-05737-0>
- Audretsch, D. B., & Fiedler, A. (2024). Bringing the knowledge spillover theory of entrepreneurship to circular economies: Knowledge and values in entrepreneurial ecosystems. *International Small Business Journal: Researching Entrepreneurship*, 42(4), 480–505. <https://doi.org/10.1177/02662426231218357>
- Bourgeois, I., Queirós, A., Oliveira, J., Rodrigues, H., Vicente, R., & Ferreira, V. M. (2022). Development of an Eco-Design Tool for a Circular Approach to Building Renovation Projects. *Sustainability (Switzerland)*, 14(14). <https://doi.org/10.3390/su14148969>
- Calzolari, T., Genovese, A., & Brint, A. (2022). Circular Economy indicators for supply chains: A systematic literature review. *Environmental and Sustainability Indicators*, 13. <https://doi.org/10.1016/j.indic.2021.100160>
- Casas, C. R., Rubia, M. D. La, Aguilar-Peña, J. D., Gilabert-Torres, C., & Hontoria, L. (2025). From Classroom to Business Ideas: Fostering Eco-innovation through Engineering Entrepreneurship Education. In *New Perspectives in Science Education-International Conference*.
- Coppola, C., Vollero, A., & Siano, A. (2023). Developing dynamic capabilities for the circular economy in the textile and clothing industry in Italy: A natural-resource-based view. *Business Strategy and the Environment*, 32(7), 4798–4820. <https://doi.org/10.1002/bse.3394>
- D'Adamo, I., Favari, D., Gastaldi, M., & Kirchherr, J. (2024). Towards circular economy indicators: Evidence from the European Union. *Waste Management and Research*. <https://doi.org/10.1177/0734242X241237171>
- de la Torre, R., Onggo, B. S., Corlu, C. G., Nogal, M., & Juan, A. A. (2021). The role of simulation and serious games in teaching concepts on circular economy and sustainable energy. *Energies*, 14(4). <https://doi.org/10.3390/en14041138>
- Dey, P. K., Malesios, C., Chowdhury, S., Saha, K., Budhwar, P., & De, D. (2022). Adoption of circular economy practices in small and medium-sized enterprises: Evidence from Europe. *International Journal of Production Economics*, 248. <https://doi.org/10.1016/j.ijpe.2022.108496>
- Duan, H., Song, G., Zou, Q., Mao, R., & Liu, X. (2024). Characterizing the packaging waste generation patterns and carbon emissions of university delivery service. *Circular Economy*, 3(3). <https://doi.org/10.1016/j.cec.2024.100103>
- Farooque, M., Zhang, A., Choi, T. M., Hartley, J. L., & Liu, Y. (2024). Antecedents and performance outcomes of circular procurement: An empirical study in China. *Journal of Purchasing and Supply Management*, 30(4). <https://doi.org/10.1016/j.pursup.2023.100882>
- Favi, C., & Marconi, M. (2025). Product Eco-Design in the Era of the Circular Economy. In *Sustainability (Switzerland)* (Vol. 17, Issue 1). Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/su17010213>
- Fernando, Y., Shaharudin, M. S., & Abideen, A. Z. (2023). Circular economy-based reverse logistics: dynamic interplay between sustainable resource commitment and financial performance. *European Journal of Management and Business Economics*, 32(1), 91–112. <https://doi.org/10.1108/EJMBE-08-2020-0254>
- Geldres-Weiss, V. V., Nicolas, C., & Massa, N. P. (2024). Toward a sustainable research agenda on food eco-labelling in the business and management research domain. *European Journal of Management and Business Economics*. <https://doi.org/10.1108/EJMBE-08-2023-0246>
- Gilmour, P. M. (2023). Enhancing research collaboration within a large university department. *Innovations in Education and Teaching International*. <https://doi.org/10.1080/14703297.2023.2209064>
- Giorgi, S., Lavagna, M., Wang, K., Osmani, M., Liu, G., & Campioli, A. (2022). Drivers and barriers towards circular economy in the building sector: Stakeholder interviews and analysis of five european

- countries policies and practices. *Journal of Cleaner Production*, 336. <https://doi.org/10.1016/j.jclepro.2022.130395>
- Giurea, R., Carnevale Miino, M., Torretta, V., & Rada, E. C. (2024). Approaching sustainability and circularity along waste management systems in universities: an overview and proposal of good practices. *Frontiers in Environmental Science*, 12. <https://doi.org/10.3389/fenvs.2024.1363024>
- Gonçalves, B. de S. M., de Carvalho, F. L., & Fiorini, P. de C. (2022). Circular Economy and Financial Aspects: A Systematic Review of the Literature. *Sustainability (Switzerland)*, 14(5). <https://doi.org/10.3390/su14053023>
- Hamid, R. (2024). Behavioural accounting: Evaluating policy and academic support impact on sustainable green mining practices. *Jurnal Kajian Akuntansi* |, 8(1), 94–114. <https://doi.org/10.33603/jka>
- Hemidat, S., Achouri, O., Fels, L. El, Elagroudy, S., Hafidi, M., Chaouki, B., Ahmed, M., Hodgkinson, I., & Guo, J. (2022). Solid Waste Management in the Context of a Circular Economy in the MENA Region. *Sustainability (Switzerland)*, 14(1). <https://doi.org/10.3390/su14010480>
- Kafel, P., & Nowicki, P. (2023). Circular Economy Implementation Based on ISO 14001 within SME Organization: How to Do It Best? *Sustainability (Switzerland)*, 15(1). <https://doi.org/10.3390/su15010496>
- Khajuria, A., Atienza, V. A., Chavanich, S., Henning, W., Islam, I., Kral, U., Liu, M., Liu, X., Murthy, I. K., Oyedotun, T. D. T., Verma, P., Xu, G., Zeng, X., & Li, J. (2022). Accelerating circular economy solutions to achieve the 2030 agenda for sustainable development goals. In *Circular Economy* (Vol. 1, Issue 1). Elsevier B.V. <https://doi.org/10.1016/j.cec.2022.100001>
- Khan, M., Ajmal, M. M., Jabeen, F., Talwar, S., & Dhir, A. (2023). Green supply chain management in manufacturing firms: A resource-based viewpoint. *Business Strategy and the Environment*, 32(4), 1603–1618. <https://doi.org/10.1002/bse.3207>
- Kirchherr, J., Urbinati, A., & Hartley, K. (2023). Circular economy: A new research field? *Journal of Industrial Ecology*, 27(5), 1239–1251. <https://doi.org/10.1111/jiec.13426>
- Lou, G., Zhang, Y., Ma, H., Tu, X., & Wei, Y. M. (2024). Eco-label strategy selection for green product development in supply chain. *Sustainable Operations and Computers*, 5, 51–59. <https://doi.org/10.1016/j.susoc.2023.12.003>
- Malhotra, G. (2023). Impact of circular economy practices on supply chain capability, flexibility and sustainable supply chain performance. *International Journal of Logistics Management*. <https://doi.org/10.1108/IJLM-01-2023-0019>
- Mallick, P. K., Salling, K. B., Pigosso, D. C. A., & McAloone, T. C. (2024). Towards a circular economy: Development of a support tool for designing reverse logistics systems. *Journal of Environmental Management*, 351. <https://doi.org/10.1016/j.jenvman.2023.119819>
- Moghayedi, A., Michell, K., Hübner, D., Le Jeune, K., & Massyn, M. (2024). Examine the impact of green methods and technologies on the environmental sustainability of supportive education buildings, perspectives of circular economy and net-zero carbon operation. *Facilities*, 42(3–4), 201–222. <https://doi.org/10.1108/F-12-2022-0161>
- Nazir, S., Zhaolei, L., Mehmood, S., & Nazir, Z. (2024). Impact of Green Supply Chain Management Practices on the Environmental Performance of Manufacturing Firms Considering Institutional Pressure as a Moderator. *Sustainability*, 16(6), 2278. <https://doi.org/10.3390/su16062278>
- Nguyen, K., Akbari, M., Quang, H. T., McDonald, S., Hoang, T.-H., Yap, T. L., & George, M. (2023). Navigating Environmental Challenges through Supply Chain Quality Management 4.0 in Circular Economy: A Comprehensive Review. *Sustainability*, 15(24), 16720. <https://doi.org/10.3390/su152416720>
- Nguyen, M. D., Thomas, M., Surapaneni, A., Moon, E. M., & Milne, N. A. (2022). Beneficial reuse of water treatment sludge in the context of circular economy. In *Environmental Technology and Innovation* (Vol. 28). Elsevier B.V. <https://doi.org/10.1016/j.eti.2022.102651>
- Owojori, O. M., Mulaudzi, R., & Edokpayi, J. N. (2022). Student's Knowledge, Attitude, and Perception (KAP) to Solid Waste Management: A Survey towards a More Circular Economy from a Rural-Based Tertiary Institution in South Africa. *Sustainability (Switzerland)*, 14(3). <https://doi.org/10.3390/su14031310>
- Parmawati, R., Mulyadi, F., Rosyani, Suaedi, & Yunikewaty. (2023). The Role of Environmental Education and Green Supply Chain Practices in Achieving Sustainable Development: Evidence from Indonesia. *International Journal of Energy Economics and Policy*, 13(1), 421–430. <https://doi.org/10.32479/ijee.14030>
- Pinyol Alberich, J., Pansera, M., & Hartley, S. (2023). Understanding the EU's circular economy policies through futures of circularity. *Journal of Cleaner Production*, 385. <https://doi.org/10.1016/j.jclepro.2022.135723>

- Pudjarti, E. S., Lisdiyono, E., & Werdiningsih, R. (2023). The Correlation among University-Industry Collaboration (Uic) Predictors: The Results of Innovation Collaboration and University Performance. *Journal of Namibian Studies*, 33, 2128–2146.
- Renfors, S. M. (2024a). Education for the circular economy in higher education: an overview of the current state. In *International Journal of Sustainability in Higher Education* (Vol. 25, Issue 9, pp. 111–127). Emerald Publishing. <https://doi.org/10.1108/IJSHE-07-2023-0270>
- Renfors, S. M. (2024b). Education for the circular economy in higher education: an overview of the current state. In *International Journal of Sustainability in Higher Education* (Vol. 25, Issue 9, pp. 111–127). Emerald Publishing. <https://doi.org/10.1108/IJSHE-07-2023-0270>
- Salesa, A., León, R., & Moneva, J. M. (2023). Airlines practices to incorporate circular economy principles into the waste management system. *Corporate Social Responsibility and Environmental Management*, 30(1), 443–458. <https://doi.org/10.1002/csr.2365>
- Shah, R., & Gillen, A. L. (2024). A systematic literature review of university-industry partnerships in engineering education. *European Journal of Engineering Education*, 49(3), 577–603. <https://doi.org/10.1080/03043797.2023.2253741>
- Shahidan, N. H., Abdul Latiff, A. S., & Abdul Wahab, S. (2023). Sustainable technology development during intellectual property rights commercialisation by university startups. *Asia Pacific Journal of Innovation and Entrepreneurship*, 17(3/4), 176–194. <https://doi.org/10.1108/apjie-07-2023-0142>
- Spreafico, C. (2022). An analysis of design strategies for circular economy through life cycle assessment. *Environmental Monitoring and Assessment*, 194(3). <https://doi.org/10.1007/s10661-022-09803-1>
- Spreafico, C., & Landi, D. (2022). Using Product Design Strategies to Implement Circular Economy: Differences between Students and Professional Designers. *Sustainability (Switzerland)*, 14(3). <https://doi.org/10.3390/su14031122>
- Triguero, Á., Moreno-Mondéjar, L., & Sáez-Martínez, F. J. (2023). Circular economy and firm performance: The influence of product life cycle analysis, upcycling, and redesign. *Sustainable Development*, 31(4), 2318–2331. <https://doi.org/10.1002/sd.2509>
- Yu, Y., Xu, J., Zhang, J. Z., Wu, Y., & Liao, Z. (2022). Do circular economy practices matter for financial growth? An empirical study in China. *Journal of Cleaner Production*, 370. <https://doi.org/10.1016/j.jclepro.2022.133255>
- Zhu, Z., Liu, W., Ye, S., & Batista, L. (2022). Packaging design for the circular economy: A systematic review. In *Sustainable Production and Consumption* (Vol. 32, pp. 817–832). Elsevier B.V. <https://doi.org/10.1016/j.spc.2022.06.005>

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