INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 13, Issue 1, (2024) E-ISSN: 2226-6348

Exploring Dominant Approach for Teaching Circular Economy

Norzaharah Ab Hamid, Fathiyah Mohd Kamaruzaman, Mohamad Sattar Rasul

STEM Enculturation Research Centre, Faculty of Education, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

Corresponding Author Email: fathiyah@ukm.edu.my

To Link this Article: http://dx.doi.org/10.6007/IJARPED/v13-i1/20872 DOI:10.6007/IJARPED/v13-i1/20872

Published Online: 12 February 2024

Abstract

The delivery of the circular economy concept requires a specific teaching method to ensure student understanding. A good teaching method can stimulate students' creative and critical thinking towards circular economy. However, there are still many teachers who do not understand effective teaching methods in teaching the circular economy. Therefore, this study aims to explore teaching methods used by teachers all around the world in teaching circular economy. This study uses a comprehensive systematic review on teaching circular economy approaches. In this study, we used the PRISMA approach to find primary data based on several keywords. Based on advanced searching on Scopus, Web of Science and Google Scholar we found n=22 relevant articles for this study. Our findings show project-based learning is the most dominant and widely practiced circular economy teaching method. In the other hand, active based learning, problem-based learning, games and case study are the teaching methods that are always practiced by teachers to teach circular economy.

Keywords: Teaching Method, Learning Approach, Circular Economy, Education

Introduction

The Circular economy is an increasingly important concept in the global landscape, embracing an approach towards resource management and sustainable development. Conventional economic models that are linear have created a negative impact on the environment and resource sustainability. In this context, there is a need to study the dominant teaching approaches in shaping understanding and acceptance of the concept of circular economy. The circular economy involves changing from a "take-make-dispose" economic model to one that emphasizes recycling, efficient use of resources, and waste reduction. These changes demand deep learning and comprehensive understanding to support the transition towards a more sustainable economic model. In the transition to a circular economy, the teaching approach becomes the main focus to achieve positive effects in strengthening the principles of the circular economy. The teaching approach includes methodology, strategies, and methods used to convey the concept of circular economy to students. Through a deeper understanding of these approaches, we can create more efficient teaching guides, promote holistic

understanding, and accelerate the acceptance of the circular economy concept among students.

Literature Review

Circular Economy

Previous studies have focused on the successful application of circular economy (CE) principles in various studies. The commonality across studies lies in their emphasis on the practical implementation of CE principles in an educational context. Forman (2021) outlines the effectiveness of the concept of designing Fashion within the framework of the Circular Economy. This stimulates the transfer of knowledge from theory to practice, emphasizing the practical application of CE principles in an educational context. Graf et al (2022) proposed the e-CirP project (Embedding Circular Economy into Product Design and Optimization) for the transfer of knowledge from theory to practice. Both of these studies focus on the practicality and relevance of CE in the real world.

However, differences emerge in the approach taken by different studies. For example, Leppänen and Kuula (2020) demonstrated a proactive stance through infrastructural CE courses, demonstrating a commitment to integrating CE applications into the educational curriculum. Mansour et al (2020) delved into the design discipline, emphasizing the application of CE principles in textile dyeing using natural waste materials. This difference in focus indicates the various strategies used to integrate CE principles into different educational domains.

Although there are similarities and differences, there are limitations in the circular economy teaching approach. Additionally, ensuring sustainable student engagement and commitment to sustainability, as seen in an evaluation at the University of Agder (O'Born & Heimdal, 2022), represents a potential constraint. In most studies on the circular economy in education, the main focus is on the practical application of CE principles in their specific approach. Thus, this study was done to explore global teaching methods for circular economy, intending to assist educators lacking understanding in effective teaching approaches for this concept.

Teaching Approach

Teaching the circular economy requires a holistic approach to ensure a solid understanding. The Teaching for Robust Understanding introduced by Schoenfeld (2013) provides dimensions such as content engagement, operating within the learner's developmental zone, and supporting core content engagement (Schoenfeld et al., 2020). The transition to virtual teaching and the impact of Covid-19 add challenges, particularly in the understanding of knowledge areas and the use of relevant resources. Recent studies emphasize the importance of using relevant resources and adapting to virtual teaching (Gil-Villa et al., 2020; Phillips et al., 2021). Teaching the circular economy requires an approach that can leverage technology and align itself with student needs.

The teaching approach for the circular economy involves the application of theories and models that support deep understanding and application of concepts in the context of everyday life. Constructivism theory emphasizes active learning, stimulating students' critical thinking and creativity in understanding the principles of the circular economy (Manshoven & Gillabel, 2021; Scalabrino et al., 2022). Situational Learning Theory is needed because it

encourages learning in a practical context (Yeung & Wong, 2022), while Kolb's Teaching Theory ensures that various learning styles are applied (Sandström et al., 2021). The Student Centered Learning Model emphasizes the active role of students in the learning process, particularly in the context of a circular economy that encourages collaborative thinking. Overall, the integration of these theories and models forms a solid foundation for a teaching approach that goes beyond theoretical knowledge, inculcating students' ability to think critically and effective action in achieving circular economy goals.

Realizing the importance of circular economy education, this study explores the main approach in teaching this concept. A deep understanding of the circular economy is important in the era of environmental sustainability, where students need to be prepared with creative and critical thinking in understanding the impact of the circular economy. However, there are still challenges in teaching the circular economy that may not be understood by all teachers. Therefore, this study investigates global teaching methods for teaching the circular economy, providing guidance for educators and stakeholders to improve sustainable and relevant economic education, thereby strengthening conceptual understanding and encouraging future efforts.

Methodology

The search strategy for this study includes three processes of identification, screening, and study qualification (Shaffril et al., 2021). The starting point of this study is the research topic. Several databases were selected as platforms to search for articles, and search criteria for the literature were established. Search inclusion and exclusion criteria are then selected. During the article search process, information was gathered, and potential articles were also evaluated. Research questions have guided a careful evaluation of each data, and conclusions have been drawn. Identification improves search terms used to find material.

Systematic Searching Techniques

Well-known data sources Scopus, Web of Science (WoS) and Google Scholar were searched using sophisticated software. Boolean operators (AND, OR, NOT, or NOT), truncation, phrase searches, wildcards ("*") and field code operations (either using them together or separately) are among the search techniques used. The keywords used for the article search are shown in Table 1.

Table 1
Keywords Used for Article Searching

Database	Keyword
Scopus	TITLE-ABS-KEY ((approach OR method) AND (teach* OR coach OR instruct) AND "circular economy")
WoS	(approach OR method) AND (teach* OR coach OR instruct) AND "circular economy"
Google Scholar	Using specific keywords from Scopus and WoS, together with Boolean operators, phrase searches, and field code functions (either using them together or separately), if necessary.

Source: Owner

Inclusion and exclusion criteria were established in order to guarantee the studies' relevance. Table 2 provides additional data based on researcher criteria, including literature type, language and time period.

Table 2
The Eligibility and Exclusions Criteria

Criterion	Eligibility	Exclusion
Literature type	Journal (Research Articles)	Journals (systematic review), book collections, books, books with chapters, and conference proceedings
Language	English	Non-English
Timeline	2018 - 2023	Before 2018

Source: Owner

A systematic search strategy known as filtering adds or removes items from consideration. Excluded were publications from other databases that replicated the results of this investigation. The researchers have set a time frame for the year of publication, which spans from 2018 to 2023. The selection of a specific time period of this study ensured the relevance and comprehensive analysis of the research, with eligibility review and manual screening of linked papers. One step in the procedure is to read the title and abstract of the article. After being screened and assessed as eligible, only (n=22) of the (n=589) items found in the database were selected for inclusion in this article. A flow chart explaining the process and emphasizing the main steps for article selection is shown in Figure 1. The entire process in each phase is illustrated in this flow chart, which starts with the identification of records, text filtering, deletion of redundant articles and addition of articles that are relevant to the study.

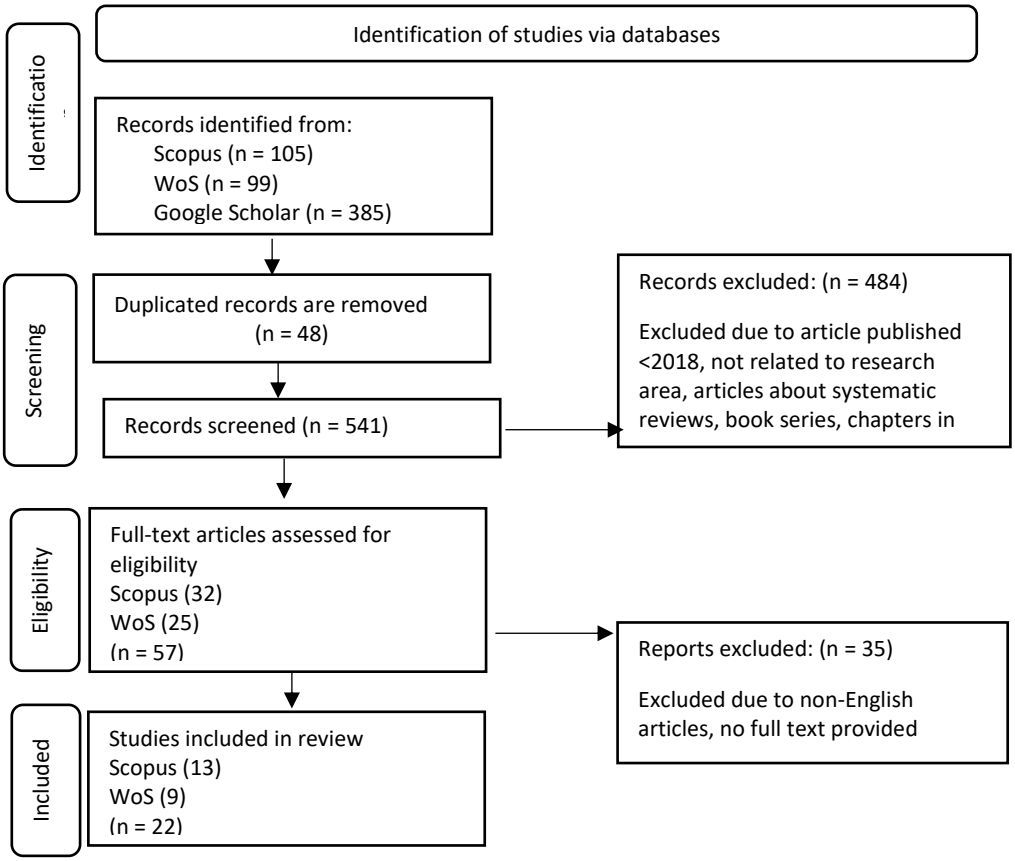

Figure 1: Flowchart of the study selection process
Source: adapted from Moher et al., (2009)

Results and Discussion

In the following section, the findings of the analysis of 22 various articles used in this study are presented. Table 3 details the specifics of the papers that make up this study.

Table 1
Overviews of selected studies

References	Methodology	Teaching Approach
Binde & Freimane, (2022)	Qualitative	Assignment namely "zero-waste fashion design learning-teaching square assignment method" (project based learning).
Bjelobaba et al., (2023)	Qualitative	Collaborative Learning and Student Work Evaluation (CLSW) model, utilizing blockchain technology.
(Bugallo-Rodríguez & Vega-Marcote, 2020)	Qualitative	Set of activities (group work, enquiry-based task, worksheet, project-based) to improve students' attitudes and actions towards reducing their daily impact on campus and promoting the circular economy.
Corral et al., (2023)	Qualitative	Interactive and fun learning, project based learning
de la Torre et al., (2021)	Qualitative	Simulation-based learning and serious games
Gomes et al., (2022)	Qualitative	Teaching life cycle assessment (LCA) and circular design metrics within the design studio atmosphere. A combination of lectures, hands-on design exercises, and the development of tools such as project based.

González-Domínguez et al., (2020)	Quantitative	Collaborative project-based learning
Hoffman et al., (2021)	Qualitative	Active imagination of the future, blended classrooms
Jääskä et al., (2021)	Qualitative	Educational games, active and experiential teaching method.
Keramitsoglou et al., (2023)	Qualitative	Experiential learning
Khoury et al., (2023)	Qualitative	Gamification "NextGen Serious Game" for understanding the Circular Economy for water.
Kioupi et al., (2022)	Mix method	active-learning pedagogies, serious games (such as "In the Loop"), and the Active-Learning ToolKit Sustainable Development.
Kirchherr & Piscicelli, (2019)	Qualitative	Course designed with principles of constructive alignment and problem-based learning.
Liu & Côté, (2021)	Qualitative	Lectures, group discussions, case studies, role-play, oral presentations, evaluation, and student feedback.
Marquez et al., (2023)	Qualitative	Product-based learning methods and the use of GPT (Generative Pre-trained Transformer) artificial intelligence text generation models.
Nguyen, (2023)	Qualitative	Inquiry based learning, real-world problem-solving
Occhioni et al., (2023)	Quantitative	Gamification-based with a focus on geoscience-related themes.
Sierra & Suárez-Collado, (2021)	Mix method	Online simulation that combines three active-learning methodologies: role-play, collaborative-learning, and inquiry-based learning
Spreafico & Landi, (2022)	Quantitative	Project based approach, where data is collected from students' annual projects and MSc Degree thesis based on real industry case studies.
Stacchiotti et al., (2019)	Qualitative	Didactic activity uses geosciences and is implemented through an interdisciplinary approach, with students working in groups following the Inquiry-Based Science Education approach.
Tuzun, (2020)	Qualitative	Student-centered active learning, experiential, cooperative learning environment with communication and feedback.
Whiting et al., (2023)	Qualitative	Rethinking interior design methodology to create a sustainable circular design ecosystem. It emphasizes the need to evaluate designing for a circular economy based on the 10 R's

The analysis of the 22 selected articles as presented in Table 1 above can be shown in a graphic form that is easy to understand. Figure 1 shows the word “projectbased” with the largest size, indicating that it is mentioned the most in most articles. Using tools like https://wordart.com/, these graphics help highlight words that appear frequently in studies. This graphic provides a visual understanding of the words that dominate the discussion in the context of teaching the circular economy. The visual representation offered by Figure 1 simplifies the complexity of the textual data, offering a concise overview of the most prevalent concepts and ideas. This helps in determining the dominant teaching approach used in circular economy teaching.

Figure 1: Word Frequency Visualization
Source: owner creation with https://wordart.com/

This study shows that project-based is the most dominant and often used approach in circular economy teaching (Binde & Freimane, 2022; Bugallo-Rodríguez & Vega-Marcote, 2020; Corral et al., 2023; Gomes et al., 2022; González-Domínguez et al., 2020; Spreafico & Landi, 2022). In addition, teaching methods such as active learning (Hoffman et al., 2021; Kioupi et al., 2022; Sierra & Suárez-Collado, 2021; Tuzun, 2020), problem-based learning (Kirchherr & Piscicelli, 2019b; Nguyen, 2023), games (de la Torre et al., 2021; Jääskä et al., 2021; Khoury et al., 2023b; Kioupi et al., 2022; Occhioni et al., 2023), and case studies (Liu & Côté, 2021; Spreafico & Landi, 2022) are also often practiced by teachers in circular economy teaching.

This detail is important because it offers insight into the most effective approach to conveying circular economy concepts to students. Project-based teaching, which involves students in practical projects that stimulate creative and critical thinking (Sari & Prasetyo, 2021; Sumarni & Kadarwati, 2020), is important because of the complexity of the circular economy concept, requiring deep understanding and creative application in real life. However, for teachers, this approach presents a challenge in providing sufficient resources and support for effective implementation (Antera, 2022). Despite the challenges, the benefits of project-based teaching are proven in improving students' understanding of the circular economy concept through hands-on projects (Gomes et al., 2022).

Active learning methods stimulate critical and creative thinking through direct student involvement (Lombardi et al., 2021). The use of games brings interactive elements and high involvement, increasing the attractiveness and effectiveness of teaching (Zeng et al., 2020). Case studies allow students to relate theory to real situations (Willems et al., 2021), reinforcing the understanding of circular economy concepts. The stated advantages, such as the direct involvement of students, the attractiveness, and the connection of theory with practical application, are in line with the active and practical learning approach that is the main characteristic of circular economy teaching (Forman, 2021; Graf et al., 2022). The consideration for teachers is the need to choose and integrate these teaching methods wisely to ensure effective teaching. Selecting and integrating these methods thoughtfully will

enhance the learning experience and deepen students' understanding of the circular economy.

Conclusion

In conclusion, this study provides important insights into the teaching of the circular economy and identifies the dominant teaching approach. It also underlines the need for further efforts in improving the teaching of circular economy concepts and contributing to sustainable economic development. This study suggests that active teaching approaches (active based learning), problem-based learning, games, and case studies are also teaching methods that are often used by teachers to teach the circular economy. This shows the diversity of approaches used in teaching this concept.

The implication of this study is that there is a need to expand the use of effective teaching approaches in teaching the circular economy. Project-based learning plays an important role in guiding policy makers and stakeholders towards effective circular economy education. The positive effects of project-based learning, along with other teaching methods, emphasize the need for appropriate support and resources. Policy makers should provide training and related resource materials (Rusmiati Aliyyah et al., 2020), and create policies that encourage the integration of project-based learning, active learning, problem-based learning, games and case studies into the circular economy curriculum. Stakeholders need to recognize the importance of this approach in improving the understanding of circular economy concepts and contributing to the development of students' practical skills. Their recognition is essential in fostering collaboration, ensuring ongoing support, and facilitating the successful implementation of these methods in the educational landscape.

In addition, this study reveals gaps in the research landscape, indicating the need for further investigation in this area. Future studies could explore the long-term effects of specific teaching methods on students' understanding and application of circular economy concepts, addressing the gaps identified. Proposed methodologies to explore this gap include longitudinal studies tracking student progress over time, qualitative analyses of teaching practices, and surveys evaluating the effectiveness of different teaching approaches in achieving desired learning outcomes.

References

Antera, S. (2022). Being a Vocational Teacher in Sweden: Navigating the Regime of Competence for Vocational Teachers. *International Journal for Research in Vocational Education and Training*, *9*(2), 269–293. https://doi.org/10.13152/IJRVET.9.2.6

Binde, M., & Freimane, A. (2022). Is There a zero waste in a fashion design? *Proceedings of the 24th International Conference on Engineering and Product Design Education: Disrupt, Innovate, Regenerate and Transform, E and PDE 2022*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85142839157&partnerID=40&md5=3edc70decb4c154673f9e7a4816f4cba

Bjelobaba, G., Savić, A., Tošić, T., Stefanović, I., & Kocić, B. (2023). Collaborative Learning Supported by Blockchain Technology as a Model for Improving the Educational Process. *Sustainability*, *15*(6), 4780. https://doi.org/10.3390/su15064780

Bugallo-Rodríguez, A., & Vega-Marcote, P. (2020). Circular economy, sustainability and teacher training in a higher education institution. *International Journal of Sustainability in Higher Education*, *21*(7), 1351–1366. https://doi.org/10.1108/IJSHE-02-2020-0049

Corral, L. G., Calderón, S. R., Bordehore, L. J., & Mezga, K. (2023). The importance of education on mineral raw materials for more secure and enjoyable tomorrow. *Geologica Macedonica*, *37*(1), 85–92. https://doi.org/10.46763/GEOL23371398086c

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

Forman, G. (2021). Fashion Design Education Towards Transition: Circularity and Biobased Materials. *Lecture Notes in Networks and Systems*, *277*, 26–34. https://doi.org/10.1007/978-3-030-80415-2_4

Gil-Villa, F., Urchaga, J. D., & Sánchez-Fdez, A. (2020). Perceptions and expectations in the university students from adaptation to the virtual teaching triggered by the COVID-19 pandemic. *Revista Latina de Comunicación Social*, *78*, 99–119. https://doi.org/DOI: 10.4185/RLCS-2020-1470| ISSN 1138-5820

Gomes, V., da Silva, M. G., & Kowaltowski, D. C. C. K. (2022). Long-Term Experience of Teaching Life Cycle Assessment and Circular Design to Future Architects: A Learning by Doing Approach in a Design Studio Setting. *Sustainability (Switzerland)*, *14*(12). https://doi.org/10.3390/su14127355

González-Domínguez, J., Sánchez-Barroso, G., Zamora-Polo, F., & García-Sanz-Calcedo, J. (2020). Application of circular economy techniques for design and development of products through collaborative project-based learning for industrial engineer teaching. *Sustainability (Switzerland)*, *12*(11). https://doi.org/10.3390/su12114368

Graf, R., Sandström, N., Nevgi, A., Balkenende, R., Danese, P., Grönman, K., Holopainen, J., Luukkonen, M., Nuorttila-Jokinen, J., & Olsen, S. I. (2022). Education for optimized Life Cycle Management: The Project e-CIRP and its insights into embedding circular economy aspects to product design via teaching. *E3S Web of Conferences*, *349*. https://doi.org/10.1051/e3sconf/202234912003

Hoffman, J., Pelzer, P., Albert, L., Béneker, T., Hajer, M., & Mangnus, A. (2021). A futuring approach to teaching wicked problems. *Journal of Geography in Higher Education*, *45*(4), 576–593. https://doi.org/10.1080/03098265.2020.1869923

Jääskä, E., Aaltonen, K., & Kujala, J. (2021). Game-based learning in project sustainability management education. *Sustainability (Switzerland)*, *13*(15). https://doi.org/10.3390/su13158204

Keramitsoglou, K., Litseselidis, T., & Kardimaki, A. (2023). Raising effective awareness for circular economy and sustainability concepts through students' involvement in a virtual enterprise. *Frontiers in Sustainability*, *4*. https://doi.org/10.3389/frsus.2023.1060860

Khoury, M., Evans, B., Chen, O., Chen, A. S., Vamvakeridou-Lyroudia, L., Savic, D. A., Djordjevic, S., Bouziotas, D., Makropoulos, C., & Mustafee, N. (2023a). NEXTGEN: A serious game showcasing circular economy in the urban water cycle. *Journal of Cleaner Production*, *391*. https://doi.org/10.1016/j.jclepro.2023.136000

Khoury, M., Evans, B., Chen, O., Chen, A. S., Vamvakeridou-Lyroudia, L., Savic, D. A., Djordjevic, S., Bouziotas, D., Makropoulos, C., & Mustafee, N. (2023b). Nextgen: A serious game showcasing circular economy in the urban water cycle. *Journal of Cleaner Production*, *391*. https://doi.org/10.1016/j.jclepro.2023.136000

Kioupi, V., Vakhitova, T. V, & Whalen, K. A. (2022). Active learning as enabler of sustainability learning outcomes: Capturing the perceptions of learners during a materials education workshop. *MRS Energy and Sustainability*, *9*(1), 64–78. https://doi.org/10.1557/s43581-021-00019-3

Kirchherr, J., & Piscicelli, L. (2019a). Towards an Education for the Circular Economy (ECE): Five Teaching Principles and a Case Study. *Resources, Conservation and Recycling*, *150*. https://doi.org/10.1016/j.resconrec.2019.104406

Kirchherr, J., & Piscicelli, L. (2019b). Towards an Education for the Circular Economy (ECE): Five Teaching Principles and a Case Study. *Resources, Conservation & Recycling*, *150*. https://doi.org/10.1016/j.resconrec.2019.104406

Leppänen, M. M., & Kuula, P. H. (2020). Experiences from collaborative online education for degree and further education on circular economy. *SEFI 47th Annual Conference: Varietas Delectat... Complexity Is the New Normality, Proceedings*, 699–709. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85077819533&partnerID=40&md5=c851c4c9c52f344be2839ae0425ae583

Liu, C., & Côté, R. (2021). Teaching industrial ecology to undergraduate students: Lessons learned. *Sustainability (Switzerland)*, *13*(19). https://doi.org/10.3390/su131910491

Lombardi, D., Shipley, T. F., Bailey, J. M., Bretones, P. S., Prather, E. E., Ballen, C. J., Knight, J. K., Smith, M. K., Stowe, R. L., Cooper, M. M., Prince, M., Atit, K., Uttal, D. H., LaDue, N. D., McNeal, P. M., Ryker, K., St. John, K., van der Hoeven Kraft, K. J., & Docktor, J. L. (2021). The Curious Construct of Active Learning. *Psychological Science in the Public Interest*, *22*(1), 8–43. https://doi.org/10.1177/1529100620973974

Manshoven, S., & Gillabel, J. (2021). Learning through play: A serious game as a tool to support circular economy education and business model innovation. *Sustainability (Switzerland)*, *13*(23). https://doi.org/10.3390/su132313277

Mansour, H., Hilal, N., Alhajri, S., Al-Yahyai, F., & Al-Amri, M. (2020). The education of art culture at Sultanate of Oman through the multidisciplinary integration between graphic design and eco-friendly textile printing. Part 1: Standardization of extraction and dyeing with natural wastes products. *Energy Reports*, *6*, 933–939. https://doi.org/10.1016/j.egyr.2019.12.020

Marquez, R., Barrios, N., Vera, R. E., Mendez, M. E., Tolosa, L., Zambrano, F., & Li, Y. (2023). A perspective on the synergistic potential of artificial intelligence and product-based learning strategies in biobased materials education. *Education for Chemical Engineers*, *44*, 164–180. https://doi.org/10.1016/j.ece.2023.05.005

Mohamed Shaffril, H. A., Samsuddin, S. F., & Abu Samah, A. (2021). The ABC of systematic literature review: the basic methodological guidance for beginners. *Quality and Quantity*, *55*(4), 1319–1346. https://doi.org/10.1007/s11135-020-01059-6

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine*, *6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Nguyen, T. P. L. (2023). Integrating circular economy into STEM education: A promising pathway toward circular citizenship development. *Frontiers in Education*, *8*. https://doi.org/10.3389/feduc.2023.1063755

O'Born, R., & Heimdal, A. (2022). Experiences from teaching circular economy concepts to engineering students. *Proceedings of the 24th International Conference on Engineering and Product Design Education: Disrupt, Innovate, Regenerate and Transform, E and PDE*

2022. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85142818333&partnerID=40&md5=95d1b0d6f3cf685bc20d2d158b55d8fe

Occhioni, M., Beccaceci, A., & Paris, E. (2023). Environmental education in distance learning: using Virtual Worlds to link geosciences and sustainability. *Journal of Geoscience Education*, 1–15. https://doi.org/10.1080/10899995.2023.2266863

Phillips, C., Sunderlin, D., & Addy, T. (2021). Adapting to New Modes of Teaching During COVID-19: Developing Instructional Approaches that Empower Learners and Facilitate Virtual Learning Experiences. *Journal of Transformative Learning*, *8*(1), 10–21.

Sandström, N., Nevgi, A., & Betten, T. (2021). *Title Excellence in education requires excellence in collaboration: learning modules in circular economy as platforms for transdisciplinary learning*. https://www.eesd2020.org/,

Sari, D. M. M., & Prasetyo, Y. (2021). Project-based-learning on critical reading course to enhance critical thinking skills. *Studies in English Language and Education*, *8*(2), 442–456. https://doi.org/10.24815/siele.v8i2.18407

Scalabrino, C., Navarrete Salvador, A., & Oliva Martínez, J. M. (2022). A theoretical framework to address education for sustainability for an earlier transition to a just, low carbon and circular economy. *Environmental Education Research*, *28*(5), 735–766. https://doi.org/10.1080/13504622.2022.2031899

Schoenfeld, A. H., Baldinger, E., Disston, J., Donovan, S., Dosalmas, A., Driskill, M., Fink, H., Foster, D., Haumersen, R., Lewis, C., Louie, N., Mertens, A., Murray, E., Narasimhan, L., Ortega, C., Reed, M., Ruiz, S., Sayavedra, A., Sola, T., … Zarkh, A. (2020). Learning with and from TRU. In *International Handbook of Mathematics Teacher Education: Volume 4* (pp. 271–304). BRILL. https://doi.org/10.1163/9789004424210_011

Sierra, J., & Suárez-Collado, Á. (2021). Understanding economic, social, and environmental sustainability challenges in the global south. *Sustainability (Switzerland)*, *13*(13). https://doi.org/10.3390/su13137201

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

Stacchiotti, L., Acqua, A., Pennesi, D., Beccaceci, A., & Paris, E. (2019). Wasteberg: A didactic activity about waste and sustainable use of georesources in relation to the Agenda 2030. *Rendiconti Online Societa Geologica Italiana*, *49*, 127–133. https://doi.org/10.3301/ROL.2019.62

Sumarni, W., & Kadarwati, S. (2020). Ethno-stem project-based learning: Its impact to critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 11–21. https://doi.org/10.15294/jpii.v9i1.21754

Tuzun, U. (2020). Introduction to systems engineering and sustainability PART I: Student-centred learning for chemical and biological engineers. *Education for Chemical Engineers*, *31*, 85–93. https://doi.org/10.1016/j.ece.2020.04.004

Whiting, P., Cullen, V., Adkins, H., & Chatteur, F. (2023). A New Retail Interior Design Education Paradigm for a Circular Economy. *Sustainability (Switzerland)*, *15*(2). https://doi.org/10.3390/su15021487

Willems, P. P., Gonzalez-DeHass, A. R., Powers, J. R., & Musgrove, A. (2021). The role of authentic teaching cases and mastery approach goals in online pre-service teachers' self-regulated learning. *Educational Technology Research and Development*, *69*(2), 1003–1023. https://doi.org/10.1007/s11423-021-09972-9

Yeung, S. M. C., & Wong, F. C.-C. (2022). Green circular economy: An educational model to transform. *Corporate Board Role Duties and Composition*, *18*(3), 15–23. https://doi.org/10.22495/cbv18i3art2

Zeng, J., Parks, S., & Shang, J. (2020). To learn scientifically, effectively, and enjoyably: A review of educational games. In *Human Behavior and Emerging Technologies* (Vol. 2, Issue 2, pp. 186–195). Wiley-Hindawi. https://doi.org/10.1002/hbe2.188