JEE Journal of Ecological Engineering

Journal of Ecological Engineering, 2025, 26(11), 454–463
https://doi.org/10.12911/22998993/208368
ISSN 2299–8993, License CC-BY 4.0

Received: 2025.07.02
Accepted: 2025.08.06
Published: 2025.08.15

Circular economy awareness among selected groups of students

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ABSTRACT

The circular economy presents a novel model of production and consumption aimed at minimizing waste by maximizing the reuse of existing resources. This approach closely aligns with the principles of sustainable development and requires urgent and effective implementation. Based on this premise, the aim of the study was to assess the level of awareness of the circular economy among selected students at the University of Rzeszów. The research methodology involved the use of an online survey. The survey respondents demonstrated varying levels of knowledge and awareness regarding the circular economy. The majority (48.3%) reported possessing only basic knowledge of the concept, while just 4.5% indicated an advanced understanding. Additionally, 31.8% responded affirmatively to the question "Do you know what the concept of the circular economy is?". Among the proposed circular economy practices (multiple responses allowed), the most frequently selected were reuse (87.5%), recycling (85.8%), product repair (58.5%), reducing resource consumption (50.0%), and waste disposal (27.8%). Some participants also emphasized the importance of engaging in dialogue and addressing current controversial issues. In response to the open-ended question "In your opinion, what actions should be prioritized to promote the circular economy among students?", the most common answers included "I don't know", "I have no opinion", and "I have no idea". These responses underscore the need for initiatives that strengthen students' sense of agency and promote their active engagement in shaping the conditions of their everyday lives. The findings also indicate the necessity of broader and more effective education in the field of the circular economy. The study further explores educational strategies related to the circular economy, as well as its strengths, weaknesses, opportunities, and threats in the context of production processes and waste management. Emphasis is placed on the importance of a long-term approach to promoting circular economy principles, combining education, inspiration, and practical tools.

Keywords: circular economy, sustainable development, education, questionnaire.

INTRODUCTION

The circular economy (CE) represents a production and consumption model designed to minimize waste by optimizing the use of resources. Adopting circular economy policies provides macro- and microeconomic benefits to businesses and consumers while enhancing environmental conditions. The circular economy, also referred to as a closed-loop economy, is an appealing theoretical concept applicable across various levels of societal organization. It encompasses households, businesses, corporations, and spatial entities such as cities. Its practical implementation can yield environmental and economic advantages while meeting social needs through equitable resource allocation without depleting the planet's regenerative capacity. Consequently, the circular economy is a pivotal step toward sustainable development, a pressing concern in light

of diminishing resource availability, declining biodiversity (Rockström et al., 2009, 2021; Steffen et al., 2015), population growth, and increasing pollution levels (Corona et al., 2019).

The origins of the circular economy date back to the 1970s. Its growing popularity is driven not only by rising awareness of anthropogenic environmental pressures but also by evolving legislation (Winas et al., 2017). The concept builds upon earlier frameworks such as the "cradle-to-cradle" approach (Braungart and McDonough, 2002; Van der Baan, 2008, 2012), industrial ecology – developed post-1973 energy crisis – life cycle assessments, cleaner production, regenerative design, and, more recently, zero-emission and green economy initiatives (Legutko-Kobus, 2020).

The circular economy draws inspiration from natural ecosystems, where no waste exists; everything produced serves a purpose within interconnected life cycles. The European Commission defines the circular economy as a system in which the value and presence of products, materials, and resources are maintained within the economy for as long as possible, and waste generation is minimized (COM 2015.614).

However, achieving this vision remains a long-term goal. The so-called circularity gap, representing wasted potential resources, highlights this challenge. The Circularity Gap Report 2020 (De Vitt et al., 2018) estimates that only 8.6% of the global economy is circular, with a gap of 91.4%. In Poland, 47% of companies report adopting circular economy practices to reduce resource use (Pietrzak, 2024). Despite this progress, Poland's economy is only 10.2% circular. According to the report The Circularity Gap Report: Poland (Keys et al., 2022), this figure could be doubled through closed-loop construction practices, circular food production systems, sustainable transportation, and clean energy adoption. Increasing involvement from Polish businesses across various sectors is encouraging (Bukowski et al., 2021).

The systemic approach of the circular economy, in line with sustainable development principles, integrates economic, social, and environmental dimensions. It promotes reduced consumption of nonrenewable resources and decelerates the depletion of renewable ones. Simultaneously, it ensures profitability for all stakeholders, fostering readiness to transition from linear to circular economic models. Achieving this requires two key conditions: responsible production and consumption. Both producers and consumers must handle natural resources prudently, treating them as renewable whenever possible and viewing waste as raw materials that can and should be reintegrated into the system.

Transforming societal attitudes demands intensified and tailored environmental education, aligned with current needs. Transitioning to a circular economy necessitates long-term, multidimensional, and effective educational initiatives (Figure 1).

Poland has committed to transforming its economy into a circular one, yet it remains at the initial stages of this transition and faces numerous social, technological, legislative, and financial barriers (Jaworski & Grochowska, 2017). To tailor educational methods effectively, it is necessary first to assess the level of environmental awareness in society and identify the areas that require particular focus. As Kowalska et al. (2020) have

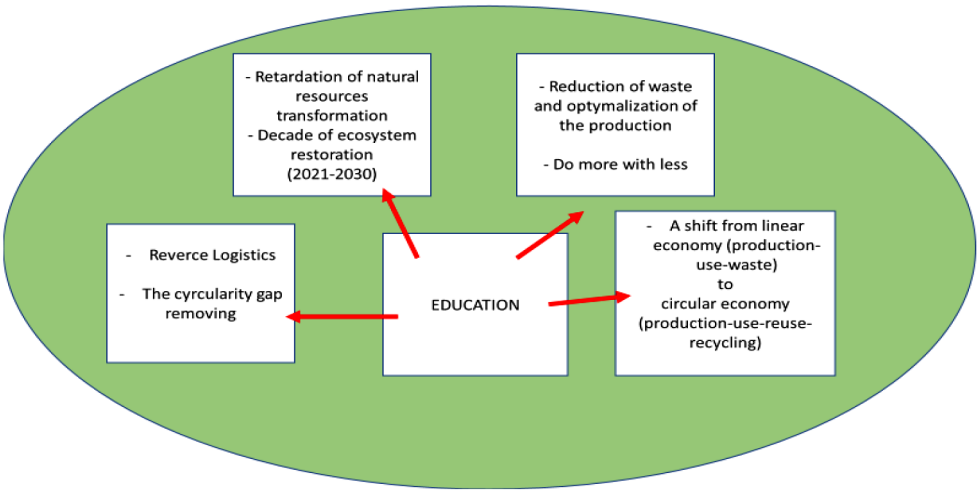

Figure 1. Education as a component of circular economy initiatives

noted, ecological awareness varies significantly across different demographic groups.

The main objective of this study was to analyze the presence of circular economy strategies in the awareness of selected groups of young citizens, using students from various disciplines at the University of Rzeszów as a case study. Additionally, a SWOT analysis was conducted to evaluate the strengths, weaknesses, opportunities, and threats of the circular economy in waste management.

METHODS

The research methods employed in this study included an online survey and a comparative analysis of relevant literature. The survey was conducted among 176 students from the University of Rzeszów, representing four fields of study:

- Logistics in the Agro-Food Industry (4th year) – 14.8%,
- Renewable Energy Sources and Waste Management (2nd year) – 13.1%,
- Renewable Energy Sources and Waste Management (4th year) – 15.3%,
- Tourism and Recreation – 55.7%.

The survey consisted of 19 closed-ended, suggestive questions and one open-ended question (survey link: https://forms.gle/aLDCLA4Ze2FRDa1n7). The questions were designed to test the hypothesis that students are familiar with the concept of the circular economy, understand it, and are able to accurately evaluate and apply CE practices. The results were presented as percentages and illustrated using graphs and tables.

The questions included in the survey may serve as a useful resource for academic instructors seeking to assess students' knowledge both before and after a course, which can help evaluate the effectiveness of the teaching process.

To organize and analyze information related to the circular economy and waste management, the study employed the SWOT (Strengths, Weaknesses, Opportunities, Threats) heuristic analysis technique. The SWOT method is a versatile tool that can be applied in various contexts. It is commonly used in strategic planning, competitive analysis, business decision-making, and even personal development. In this study, the use of SWOT analysis enabled a broader examination of the strengths, weaknesses, opportunities, and threats associated with implementing circular economy practices in waste management.

RESULTS AND DISCUSSION

Of the respondents, 49.4% were women, 46% were men, and 4.5% preferred not to disclose their gender. All respondents were under the age of 30, with 27.3% aged 20 or younger and the remaining 72.7% aged between 21 and 30.

Survey respondents displayed varied levels of knowledge and awareness regarding the circular economy. The majority (48.3%) reported having a basic understanding of the concept, while only 4.5% indicated advanced knowledge (Figure 2). When asked "Do you understand the concept of the circular economy?" only 31.8% answered affirmatively (Figure 3).

Among the proposed (multiple-choice) circular economy practices, the surveyed students most frequently selected reuse (154 answers), recycling (151 answers) product repair (103 answers), reducing of resource consumption (88 answers), and waste disposal (49 answers) (Figure 4).

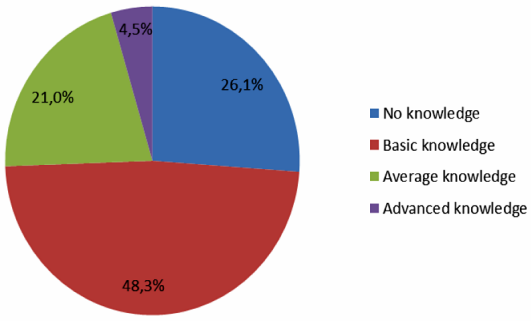

Figure 2. How would you rate your knowledge of the circular economy? [%]

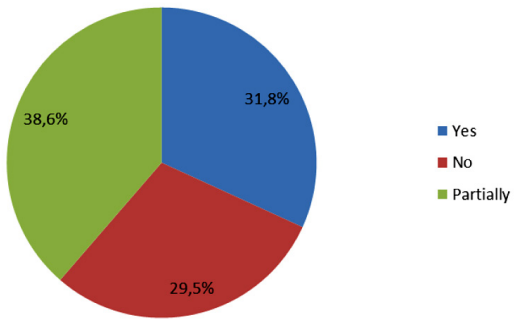

Figure 3. Do you understand the concept of the circular economy? [%]

Approximately 7% of respondents chose waste incineration (without any explicit limitations provided in the survey to justify this response). Although this is a relatively small group, educational efforts should emphasize detailed explanations about the constraints and drawbacks of this practice within the circular economy framework.

The largest group of respondents (51.7%) claimed to be familiar with circular economy policies and strategies in Poland but without knowledge of specific details. A total of 42.6% of the respondents indicated a lack of familiarity with these policies, while only 5.1% answered, "Yes, I am well acquainted with them".

When asked about the transition from a linear economy (production–use–waste) to a circular one (production–use–reuse/recycling), the majority of students considered it important (22.2% rated it "very important" and 52.3% "important"). A minority viewed it as "somewhat unimportant" (9.8%), "not important at all" (2.8%), or had no opinion (13.6%).

The overwhelming majority of students believed that the circular economy could contribute to environmental protection. Half of the respondents (50%) selected "definitely yes", while another 41.5% chose "rather yes". Only 1.7% and 1.1% chose "rather no" and "definitely no", respectively. A small percentage (5.7%) expressed no opinion.

A similar distribution of responses was observed for the question "Is transitioning to a circular economy necessary for sustainable development?". The majority agreed on its necessity, with 29% selecting "definitely yes" and 55.1% "rather yes". A smaller group disagreed, with 6.8% choosing "rather no" and 0.6% "definitely no", while 8.5% expressed no opinion.

The surveyed students in the vast majority assessed the readiness of businesses to implement circular economy principles as moderate, with 69.3% expressing this view (Figure 5).

Subsequent survey questions examined students' contributions to activities promoting circularity at the micro-scale level (Table 1). The table presents detailed percentages of responses broken down by study programs and specific behaviors associated with circular economy practices.

Regarding waste generation, the majority of respondents reported efforts to reduce the amount of waste they produce, with 24.4% stating "always" and 55.1% "sometimes". However, a concerning 20.5% admitted to doing so "rarely", "very rarely", or "never".

When asked "Do you repair products or replace damaged parts before discarding them?" the responses followed a similar distribution (Table 1). Most respondents reported attempting to repair used products, with 17.6% saying "always" and 56.8% "sometimes". However, 25.5% indicated that they do this "rarely", "very rarely", or "never".

A comparable trend is observable in responses to the question, "How often do you choose recycled products or reusable products?". Among all surveyed students, 51.7% reported "always", and 35.2% "sometimes". A total of 13.1% did not engage in such choices, with 4.5% admitting "never".

Over 80% of respondents stated that they segregate waste according to local regulations (Table 1). The respondents also reported efforts to reduce resource consumption, such as energy, water, and materials, with 27.8% stating "always" and 50% "sometimes". Nevertheless, 22.2% admitted that such practices were "rare", "very rare", or nonexistent (Table 1).

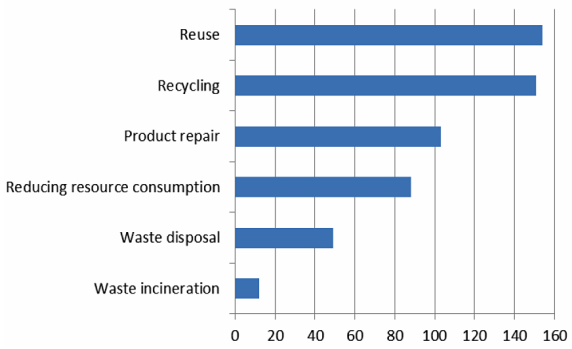

Figure 4. Which of the following practices do you consider part of the circular economy? (You may select more than one answer) [number of answers]

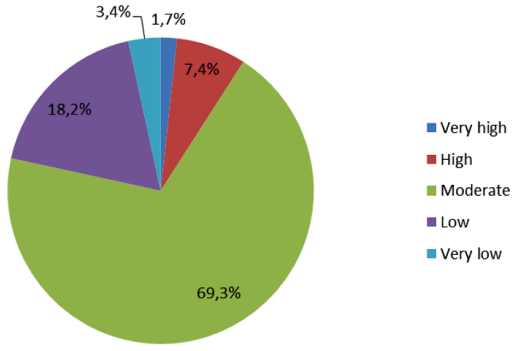

Figure 5. How would you rate the readiness of businesses to adopt circular economy principles? [%]

Table 1. Responses to selected survey questions by study field [%]

Question	Always	Sometimes	Rarely	Very rarely	Never
Do you personally try to reduce the amount of waste you generate?	24.4	55.1	14.8	4.0	1.7
Do you repair products or replace damaged parts before discarding them?	17.6	56.8	17.0	4.0	4.5
How often do you choose recycled or reusable products?	51.7	35.2	6.3	2.3	4.5
Do you separate waste according to local regulations?	40.9	40.3	13.6	4.0	1.1
Do you try to reduce resource consumption, such as energy, water, and materials?	27.8	50.0	14.2	6.3	1.7

The largest group of respondents assessed circular economy policies in Poland as "effective" (55.7%). A significantly smaller proportion rated them as "very effective" (14.2%), while 11.4% considered them "moderately effective", and 17.0% deemed them "ineffective". Only 1.7% of respondents expressed no opinion.

Barriers to implementing a circular economy, according to respondents (who could select multiple answers), were identified in decreasing order of significance as follows: lack of knowledge or awareness, high initial costs, lack of technology, resistance from companies to change, and lack of legal regulations (Figure 6). Additional barriers noted by students included, for example: "Currently, it is unprofitable for companies", and "companies maintain and exploit consumerism among customers".

Low commitment to circularity transformations is reflected in the fact that only 9.1% of respondents would be willing to pay more for products manufactured according to circular economy principles. Conversely, 26.1% answered "no", while the majority (64.8%) indicated that their decision would depend on the specific product (Figure 7).

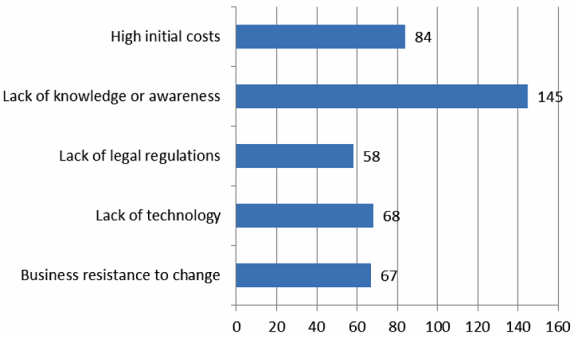

Figure 6. What barriers, in your opinion, hinder the implementation of the circular economy? (You may select more than one answer) [number of answers]

Only 27.8% of respondents expressed a willingness to participate in projects related to the circular economy either at the university or beyond. Almost half of the respondents (47.7%) were unsure about their answer (Figure 8).

Students were also given the opportunity to express their opinions in an open-ended question: "What actions do you think should be prioritized to promote the circular economy among students?". Their engagement and depth of responses varied significantly. The most common replies included: "I don't know", "I have no opinion", or "I have no idea". However, some suggestions included

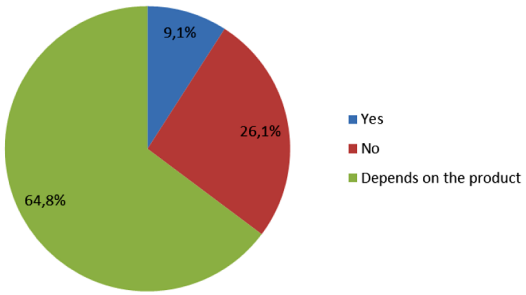

Figure 7. Would you be willing to pay more for products made in accordance with circular economy principles? [%]

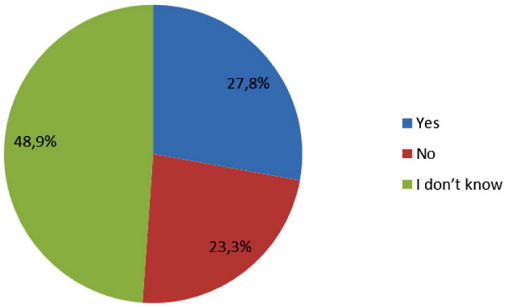

Figure 8. Would you like to engage in projects related to the circular economy at your university or elsewhere? [%]

education, training, conveying knowledge in an engaging way, organizing conferences, and providing opportunities for practical exercises. Additional ideas involved encouraging students to participate in competitions promoting circularity, preparing diverse promotional videos, and hosting meetings with individuals who practice circular economy principles.

In the circular economy system, the emphasis is placed on environmentally sustainable management, encompassing natural resource utilization, waste handling, energy, and water management. Key practices include waste avoidance, minimization, and recycling, energy efficiency, and monitoring water and carbon footprints. These interconnected elements form an integrated whole under the circular economy paradigm, enabling systemic integration across all levels of management.

At the micro level, this approach involves designing eco-friendly household products, promoting waste reduction practices, and utilizing greywater systems to lower individual water consumption. At the meso level, it focuses on the development of eco-industrial parks, which play a crucial intermediary role by facilitating collaboration between enterprises and optimizing resource flows within industrial clusters. At the macro level, it encompasses the planning and implementation of eco-cities, eco-communities, and eco-regions (also referred to as circular cities) (Zero Waste Europe, 2015; Circle Economy, 2016; Johnson, 2023). The circular approach seeks to facilitate economic development while simultaneously reducing resource consumption and minimizing environmental impact (Chenavaz & Dimitrov, 2024).

The prevailing lifestyle model among young people is rooted in the linear economy, which assumes the production of goods, their purchase by consumers, use, and eventual disposal as waste. As living standards improve, people acquire more products, often unnecessary from the outset. Following trends often leads to discarding functional items without considering the socio-environmental-economic consequences of such behavior. This consumer mindset poses a significant challenge. The adult population's awareness is largely shaped by media, which, through extensive advertising, continues to encourage consumerism. These advertisements focus on products designed to simplify life, making their acquisition a central goal for many people. For a significant portion of the population, owning material goods signifies social status.

Mass media lacks balance in presenting product information and the environmental impact of consumerism (Saari et al., 2021). Young people learn about environmental conditions and ecosystem services primarily in school lessons or during occasional eco-friendly events (e.g. "Earth Day", "Clean Up the World", "Soil Day"). However, such ecological education, while valuable, is insufficient to drive change for current and future generations. A broader education for sustainable development is necessary, emphasizing the search for compromise solutions to problems while considering their environmental, social, and economic consequences. This requires an emotional and enduring shift in mindset, necessitating significant educational efforts. Given that waste management is both a fundamental challenge and an opportunity in advancing circularity, educators should focus considerable attention on this domain.

How can waste management problems be addressed for sustainable development? No ideal method for waste management has yet been discovered. However, local solutions should be prioritized, considering the social and economic costs associated with the use of endogenous natural resources. Activities that generate or may generate waste should be planned, designed, and conducted in ways that:

- Prevent waste generation,
- Ensure environmentally safe use of waste if prevention is not possible, and
- Provide environmentally sound disposal methods for waste that cannot be avoided or utilized (KPGO, 2028).

The continuous increase in waste and resource mismanagement stems from economic growth and the ease of discarding less essential items. Competitive pressure to attract customers has also led to the proliferation of visually appealing yet often multi-material packaging, typically intended for single use. This practice contradicts the principles of environmentalism, which emphasize material and energy efficiency and the retardation of natural resource transformation (Kostecka 2010; 2013a; 2013b; 2024). Economically, slowing resource transformation makes sense because waste issues not only increase municipal and household expenses but also impact future resource management opportunities.

Table 2. SWOT analysis of circular economy in waste management

Strengths	Weaknesses
• Incorporation of Circularity Directive into Polish Law: Legal framework supports the implementation of circular economy principles. • Monitoring of Circular Economy Indicators: Numerous research institutions monitor circular economy metrics in waste management. • Corporate Engagement: Increasing numbers of companies are adopting practices to reduce resource usage and preserve ecosystem functions. • Value Recovery from Sorted Waste: Properly segregated waste becomes a valuable resource, eliminating the need for disposal and reducing waste management costs. • Extended Producer Responsibility (EPR) System: Ensures that companies introducing products to the market indirectly take responsibility for managing packaging and its waste.	• Ineffective Educational Efforts: Educational campaigns are superficial, limited in scope, and fail to target diverse groups of producers and consumers. • Media Undervaluation: Mass media often neglects the socio-economic and environmental importance of circularity. • Limited Corporate Buy-In: Few waste management businesses see direct benefits from educating citizens on circularity. • Cost of Eco-Friendly Recovery: Environmentally friendly waste recovery processes are often more expensive than landfill disposal. • System Complexity: Effective system operation is intricate, requiring additional obligations for businesses.
Opportunities	**Threats**
• Adoption of the 7Rs *(Reduce, Reuse, Recycle, Refuse, Repair, Rethink, Redistribute)*: Incorporating these principles into daily life can enhance circularity, reduce waste, and yield individual and societal benefits across environmental, social, and economic dimensions. • Recyclable Waste as a Resource: Segregated waste streams become valuable resources, offering numerous reuse opportunities and aiding ecosystem protection (e.g., *urban mining* in Special Economic Zones). • Economic and Environmental Gains: Circularity practices promote resource efficiency, leading to potential economic and ecological advantages.	• Lack of Unified Educational Strategies: Absence of cohesive strategies across municipalities, regions, and national levels leads to limited support for educators and inadequate funding for transformative circularity efforts. • Resistance to Bearing Costs: End-users, such as households, remain reluctant to bear waste management costs. • Misunderstanding of Circular Economy Concepts: Persistent misunderstanding among stakeholders necessitates extensive, effective, and costly educational initiatives.

A SWOT analysis summarizes the strengths, weaknesses, opportunities, and threats related to circular economy practices in waste management (Table 2). A slightly different approach to analyzing the strengths, weaknesses, opportunities, and threats of the circular economy in waste management is presented in the publication by Wikurendra et al. (2022).

The current social conditions that hinder the implementation of a circular economy necessitate comprehensive educational initiatives. Such initiatives, if widely implemented using effective and continuously evolving methods, have the potential to create a self-sustaining and mutually reinforcing social space that fosters further development.

In this space, mutual understanding of the societal need for a transition toward circularity would emerge, alongside a collective agreement to integrate circular practices into civic actions across various aspects of daily life, including work, leisure, transportation, and other domains.

This, in turn, could naturally lead to increased collaboration and cooperation – both of which are essential for achieving the ultimate goal of transformation and sustainable development (Figure 9).

It is important to emphasize that the circular economy also supports social changes aligned with the Sustainable Development Goals (Mensah, 2019; Gallardo-Vázquez et al. 2024). There are many examples of activities that support the circular use of resources among university students. These include the creation of exchange points for unnecessary items in student dormitories and on student campuses, such as unused electronics, CDs with music, and books. Participating in practical exercises would also be valuable, with a focus on cooperation with companies implementing circular economy practices and educational campaigns highlighting environmental and economic benefits. Promoting the circular economy among students requires initiatives that not only educate but also inspire further action.

It is important to integrate circular economy topics into study programs, especially in fields related to management, engineering, environmental protection, and ecology. A new perspective is also needed on the traits of 21st-century engineers (Kostecka et al. 2023). It is in the public interest to make educational resources on the circular economy (e.g., e-books, reports, case studies) available, promote practical projects and initiatives, create spaces on campuses for reusing items (e.g., book, clothing, and furniture exchanges), and support student projects related to upcycling, waste reduction, or innovations in circular economy practices.

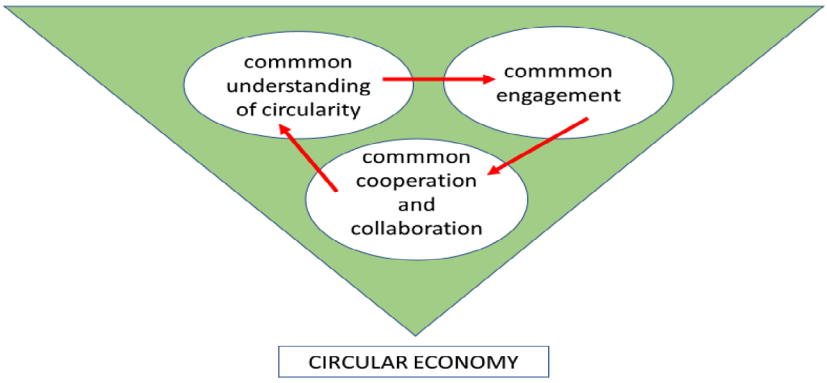

Figure 9. Estimated consequences of educational activities and key success factors in transformation to circularity (after Pietrzak 2024, changed)

Equally important are the organization of hackathons (Kwietniewska, 2023), competitions, and challenges focused on circular solutions; the installation of infrastructure supporting circularity; setting up selective waste collection points on campuses; educating students on proper waste sorting; and promoting the use of reusable products (e.g., bottles, cups, cutlery) during educational conferences (Kostecka et al., 2013). A significant step towards circular economy practices would be the implementation of equipment and tool rental systems instead of purchasing (e.g., electronics or bicycles). Cooperation with external stakeholders, such as companies and entire communities, should also involve inviting them to campuses, conducting student interviews with them, as they can inspire students with their approaches and innovations. The regular repetition of "zero waste" initiatives in dormitories and on campus could also make a significant impact. Students, as future leaders and innovators, have great potential to become ambassadors of this idea.

CONCLUSIONS

Based on the obtained results, the following conclusions were presented:

1. Knowledge of the circular economy and its practical implementation is becoming increasingly essential. Survey respondents demonstrated varying levels of understanding and awareness of the circular economy. A majority (48.3%) reported possessing only basic knowledge of the topic. Just 4.5% indicated an advanced understanding, while 31.8% answered affirmatively to the question "Do you know what the concept of the circular economy is?". This suggests a clear need for broader and more effective education in this area.
2. Among the proposed circular economy practices, students most frequently selected reuse (87.5%), recycling (85.8%), product repair (58.5%), reducing resource consumption (50.0%), and waste disposal (27.8%). Some answers of the respondents emphasized the importance of constant engaging in dialogue with the students and addressing current controversial issues.
3. The study highlights the need for initiatives that foster students' sense of agency and promote active participation in shaping the conditions of their daily lives.
4. The survey presented in this study may serve as a useful tool for academic instructors seeking to assess the need for addressing specific aspects of the circular economy and evaluating the effectiveness of their teaching. Furthermore, the discussion underscores the SWOT associated with implementing circular economy practices in waste management.

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