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Concept of circular economy in technical and vocational education: a systematic literature review

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ABSTRACT

Circular economy emphasizes the principles of reduce, reuse, and recycle. By adopting circular economy concepts in the food system, we can ensure a more resilient and sustainable food supply. Aligned with this, technical and vocational education (TVET) plays an important role in bridging environmental education and the circular economy. Within the realm of TVET, students receive comprehensive training and skill development encompassing subjects related to food preparation and production. Additionally, TVET extends its purview to cover essential areas, including sustainable resource management, renewable energy technology, waste management, and the implementation of environmentally friendly production processes. However, the lack of clear understanding of the circular economy in the education sector requires this to be explored more deeply. Therefore, this study was conducted to identify the nature of published scientific literature on this topic and what are the emerging themes of circular economy of food system in TVET education. A systematic literature review (SLR) was conducted using Scopus, Web of Science (WoS), Education Resources Information Center (ERIC) and Dimensions databases. The result from this analysis revealed that four themes emerged: i) skills and competency; ii) implementation in food system; iii) economy, social, and environmental (ESE) impact; and iv) delivery of content. Based on the derived theme, the concept of circular economy is discussed consisting of four pillars in order to provide a clear understanding about the relation of circular economy in TVET education. The findings of this study expand knowledge and the literature on the circular economy within the context of TVET.

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1. INTRODUCTION

Food waste poses a significant threat to the world, as the population is expected to reach 9 billion by 2050 [1]–[3]. A third of the total food produced is wasted or lost annually, and 820 million people lack enough food [4]. Inefficient waste management leads to greater food losses and affects natural resources [5]–[7]. The circular economy concept promotes efficient resource use, reduces waste, and encourages reuse and recycling [8]–[10]. Education plays a crucial role in introducing this concept, minimizing environmental impact, increasing food efficiency, and achieving sustainable food security [11]. Circular economy is applied through environmental education which is taught indirectly through other subjects [12]. This means that by adopting circular economy concepts in the food system we can ensure a more resilient and sustainable food

supply [13]. Aligned with this, technical and vocational education (TVET) plays an important role in bridging environmental education and the circular economy. Within the realm of TVET, students receive comprehensive training and skill development encompassing subjects related to food preparation and production. Additionally, TVET extends its purview to cover essential areas, including sustainable resource management, renewable energy technology, waste management, and the implementation of environmentally friendly production processes.

By integrating these principles into TVET programs, individuals are equipped with the knowledge and skills needed to implement sustainable practices [14], contribute to economic development [15], and foster innovation in various industries. TVET empowers teachers and students to be catalysts for sustainable change [16]–[18]. Vocational skills need to be taught to prepare students to work and be independent [19], [20]. However, studies on the circular economy of food waste are still lacking due to lack of understanding about the concept of circular economy [21]–[23]. Thus, this study was conducted to identify the nature of published scientific literature on this topic and what are the emerging themes of circular economy of food system in TVET education. The lack of clear understanding of the circular economy in the community in the education sector and the absence of specific guidelines on food waste management cause this matter to be studied in more depth. Additionally, this study will make a valuable contribution to the literature on TVET.

2. RESEARCH METHOD

A systematic literature review (SLR) was used as its methodology. The method of SLR can be used to solve issues involving the lack of methodological references [24]. This study uses four stages namely identification, screening, eligibility, and admission to articles extracted from Scopus, Web of Science (WoS), Education Resources Information Center (ERIC), and Dimension databases.

2.1. Identification

Identification in a SLR involves the process of identifying relevant sources by using a systematic search strategy. This study utilized advanced and manual searching techniques, truncation, wildcard ("*"), phrase searching, and Boolean operators (OR and AND) to link keywords in systematic searches, resulting in detailed search results and eligibility criteria. Table 1 lists the search terms for articles while Table 2 displays the eligibility and exclusion criteria in this research.

Table 1. Search terms for articles

Database	Keywords	Identified	Included
Scopus	TITLE-ABS-KEY (((*circular* OR *"zero waste"*) *economy*) AND *food* AND (*organization** OR *institution**))	222	6
WoS	ALL=(((circular OR "zero waste") economy) AND food AND (organization* OR institution*))	332	4
ERIC	Using precise keywords from Scopus and WoS, as well as Boolean operators, phrase searches, and field code functions (either collectively or individually) as necessary	18	0
Dimensions	(((circular OR "zero waste") economy) AND food AND (organization OR institution))	175	3
Publication earned		747	13

Table 2. Eligibility and exclusion criteria

Criterion	Eligibility	Exclusion
Type of literature	Research article	Book, book series, chapter in book, systematic review articles, conference proceeding
Language	English	Non-English
Year	2019 to 2023	2018 and earlier
Country	World	-
Subject area	Education, environmental sciences, social sciences	Food science technology, material science, computer science, psychology, medicine

2.2. Screening

Screening is the second process in the systematic search strategy. During screening, the researcher defines some criteria to select the articles to review. The screening process in a SLR is important because it helps to narrow down the range of sources that will be included in the study analysis.

2.3. Eligibility

Eligibility refers to the process of determining whether the literature sources that have been screened are suitable and meet the inclusion criteria set for the study. Eligibility assessment involved the selection of 85 quality and relevant papers for systematic literature analysis. Thus, ensuring accurate and reliable research conclusions and findings.

2.4. Quality evaluation of articles

Quality assessment verifies literature sources' credibility by assessing design, methodology, sample size, data analysis, and reproducibility, thereby reinforcing strong evidence and high-quality contributions in articles on circular economy, food, and institutions. The study extracts data from selected articles, including methodology, sample, findings, and institutional views, to understand patterns, differences, and conclusions related to the circular economy, food, and institutions. It compares literature sources and explores relationships and trends. Based on the search results using the method, a total of 747 items were found. Of those, 42 were screened out for overlap. Then, 620 papers were disqualified based on subject, language, and review type. After careful scrutiny, another 72 papers were removed because they were not related to the aim of the study. Finally, only 13 papers met the study goals and were selected for analysis. Figure 1 displays the flowchart of the study selection process.

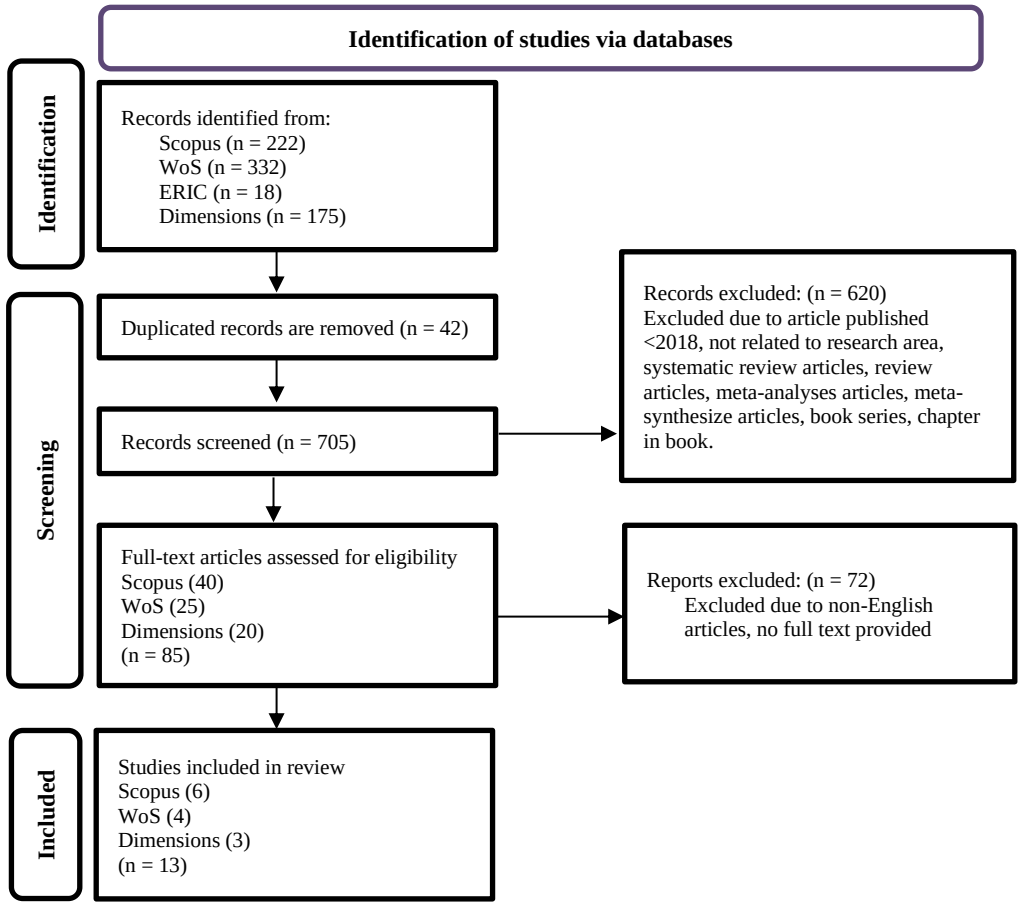

Figure 1. Flowchart of the study selection process

3. RESULTS AND DISCUSSION

Table 3 lists the 13 publications of recent research that were selected for the SLR based on the aforementioned criteria. Table 3 describes publications, key findings, and themes of selected articles. The concept of circular economy in TVET context is discussed based on derived themes acting as the pillar. The themes are: i) skills and competency; ii) implementation in food system; iii) economy, social, and environmental (ESE) impact; and iv) delivery of content.

3.1. Theme 1: skills and competency

Skills and competency are crucial for waste reduction in the food system, as they enable a skilled workforce to manage waste reduction initiatives and conserve resources [25]. TVET education plays a significant role in preparing students for the circular economy, enabling them to contribute to sustainable food waste management and undergo transformations related to academic work and social networks [26], [27].

3.2. Theme 2: implementation in food system

This theme discusses the importance of food supply chain implementation in developing countries such as India, and the importance of sustainable food development and the implementation of TVET education in the circular economy. This theme identifies barriers, correlates, and reasons why implementation is needed and shows how a circular food supply chain can reduce waste [28]. Sustainable urban development that promotes the food system, with the support of the circular economy in the sustainable use of resources can reduce food waste. This study also explains the importance of education and demographic factors in overcoming waste problems and promoting sustainability, which has direct implications for the concept of circular economy, sustainable food systems, and education that focuses on environmental sustainability [29], [30]. Implementation is important in developing circular economy in TVET education to foster awareness of food system.

Table 3. The results

Publication	Key findings	Themes
[25]	This study links the circular economy, food, and education by demonstrating the importance of systems thinking, modelling, and scientific understanding in the context of reducing waste in the food industry.	Skills and competency
[28]	This article examines food supply chain circular economy integration in developing nations like India. This study identifies barriers, correlates, and defines reasons. This study shows how circular food supply chains can minimize waste and improve sustainability.	Implementation in food system
[31]	This study explores US food waste disposal and usage in the circular economy. It explores food waste-to-fuel and product technologies. Examine profitability. This study informs business, local authorities, and government decision-makers and promotes food waste sustainability research.	ESE impact
[32]	This article examines how a circular food supply chain reduces domestic food waste. It assesses consumers' preparedness to participate in circular business models and suggests merchants test new models by planning with consumers and implementing circular practices at the regional or social group level. This study addresses the circular economy, food waste, and policy institutions.	ESE impact
[33]	This study connects the circular economy, food, and education by showing the importance of systems thinking, modelling, and scientific understanding in the context of reducing waste in the food industry.	ESE impact
[34]	Ecological innovation reduces food production and consumption's environmental impact. This study highlights the limitations of implementing circular economy techniques in the food business and the need for innovations that combine agriculture and biotechnology to produce high potential bioproducts.	ESE impact
[35]	This project investigates black soldier fly larvae to treat canteen and oil separator food waste. Canteen garbage was larvae's best diet, reducing waste and increasing utilization index compared to chicken feed. The study's findings could lead to decentralized waste management sites that use larvae to digest food waste, following circular economy concepts.	Delivery of content
[36]	This study balances food distribution with sustainable waste reduction and social cohesiveness. The study examined food safety, natural resource utilization, biodiversity conservation, and environmental sustainability.	ESE impact
[29]	A sustainable food city promotes food habits and systems. The circular economy of sustainable resource use and waste reduction supports this study's sustainability goal. This project emphasizes stakeholder collaboration and capacity building for sustainable development and improved food systems education.	Implementation in food system
[37]	Challenge-based and flipped classrooms are used to teach circular economy. A novel learning method boosted student passion, sustainability, and circular economy competencies in two unique educational programs.	Delivery of content
[38]	This study recommends food waste composting to manage organic waste and fertilize farmland cheaply. Circular economies eliminate waste and increase resource use. The report suggests trash separation, improved disposal facilities, and waste management education for students and employees. Circular economy principles can reduce TVET campus trash and improve resource efficiency.	ESE impact
[30]	This study explains the importance of education and demographic factors in overcoming the problem of waste reduction and promoting sustainability, which has direct implications on the concept of circular economy, sustainable food system, and education that focuses on environmental sustainability.	Implementation in food system
[39]	This NYC hospital kitchen waste reduction study links food, institutions, and the circular economy. Studies show hospital kitchens generate much of landfill garbage. Recycling and composting could cut landfill trash by 55% and greenhouse gas emissions by 64% at the hospital.	ESE impact

3.3. Theme 3: economy, social, and environmental impact

The theme of ESE impact refers to an important aspect in developing the circular economy in TVET education. Several researches [31], [33] emphasized the importance of systems thinking, modeling, and scientific understanding in reducing waste in the food industry. Not only that, other studies [32], [38] discussed the reduction of food waste and the need for consumer involvement and group practices in a circular business model. Similarly, the study [34], [36] emphasize ecological innovation in reducing environmental impact and preserving the diversity of natural resources. This theme is important in TVET education as it combines economic, social, and environmental aspects. By focusing on ESE impact, students learn to reduce waste, maintain resource sustainability, and engage in meaningful activities. This approach develops skills for facing challenges in these fields, fostering a quality workforce focused on resource sustainability and social well-being [40].

3.4. Theme 4: delivery of content

The delivery of circular economy content in TVET education significantly influences students' understanding and application of concepts. Effective content delivery can increase students' interest and competence in the circular economy. For instance, a study on black bat caterpillars for food waste processing can lead to a decentralized waste management site [35]. Challenge-based and flipped classrooms methods can also enhance student interest, sustainability, and competence in the circular economy [37]. The theme of delivery of content is important because the way content is delivered about the circular economy can effectively influence students' motivation, understanding, and application in the context of circular economy development in TVET education.

3.5. Circular economy concept in food system of technical and vocational education sector

The European Union is promoting the circular economy, an alternative economic system designed for regeneration [41]. This system aims to improve industrial systems to resemble nature, addressing climate change and global warming [42]. The circular economy redefines the 3R system to 4R, 6R, and 9R principles, ensuring resource regeneration and future generations' survival [43]. Food is a strategic field for implementing the circular economy, as it represents the mutual relationship between humans and the environment [44]–[46]. Other scholarly schools of thought on the circular economy are regenerative design, performance economy, cradle to cradle, industrial symbiosis, industrial ecology, biomimicry, blue economy, natural capitalism, and industrial metabolism.

3.5.1. Challenges of circular economy integration in TVET against food systems

The circular economy of the food system faces challenges in considering food production location and disposal after consumption [47]. The composition of food waste limits conversion efficiency, making it unsuitable for consumption [13], [48]. However, the insect industry offers a sustainable approach to manage food waste, as insects can be used as animal feed and crop fertilizer [49]. This circular economy, based on the cradle-to-cradle framework, promises efficient resource and waste use [46]. Schools and educational institutions often have canteen services, which contribute to food waste at various stages of food chain [50]. The concept of a circular economy can be effectively integrated into education [51], as well as TVET education where TVET institution can provide education in sustainable practices [52], resource management, waste reduction and closed-loop production processes. Food waste is the most waste produced by secondary school students [53]. Most of the food waste is thrown into the garbage bin along with other solid waste and collected by private agencies that manage garbage [54], [55]. By incorporating circular economy principles into TVET, pupils can acquire the knowledge and skills needed to apply sustainable practices in various sectors [56], [57]. In summary, the four themes described earlier act as pillars shown in Figure 2.

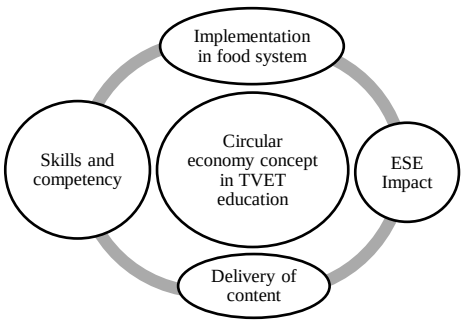

Figure 2. Pillars of circular economy concept in TVET education

4. CONCLUSION

This systematic study analyses the circular economy concept in the food system and its relationship with institutions. It suggests four pillars for integrating circular economy in TVET education, enabling students to develop skills and awareness for a sustainable circular economy. The study proposes strengthening skills training, encouraging circular economy practices, increasing awareness of economic, social, and environmental impacts, and improving interactive content delivery. The implication of this study is that students can develop skills for sustainable practices in order to become workers who have an awareness of the economic-social-environmental impact. Therefore, it is suggested that a new research area that can be studied is an effective teaching approach in the context of TVET education. The findings of this study expand knowledge and literature on the circular economy within the context of TVET.

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