sustainability

MDPI

Article

Applying Circular Economy Principles in Public Schools in Muscat Governorate, Sultanate of Oman: Current Reality and Future Aspirations

Muna Alsalmi *, Houda Abdullha AL-Housni and Fathi M. Abunaser *

College of Education, Sultan Qaboos University, Al-Khoudh, P.O. Box 32, Muscat 123, Oman; alhousni@squ.edu.om

* Correspondence: s18566@student.squ.edu.om (M.A.); f.abunaser@squ.edu.om (F.M.A.)

Abstract

With growing global attention to sustainability, integrating Circular Economy (CE) principles into school education has become increasingly relevant. This study examined teachers' perceptions of CE implementation in public schools in Muscat Governorate, Sultanate of Oman, identified perceived implementation barriers, and explored teachers' proposals for strengthening CE-related practices. A descriptive cross-sectional survey was conducted with a convenience sample of 291 teachers. Quantitative data were analyzed using descriptive statistics, while 165 substantive responses to an open-ended question were examined through inductive qualitative content analysis. Teachers perceived CE implementation to be high across the five assessed dimensions, with mean scores ranging from 3.80 to 3.89. Teachers also reported high perceived barriers, with the lack of tools for monitoring resource consumption and environmental data receiving the highest individual item rating. Their proposals emphasized circular resource management, awareness and capacity building, financial and infrastructural support, student participation, curriculum integration, community partnerships, and institutional coordination. The coexistence of high perceived implementation and substantial perceived barriers suggests that CE-related practices may be evident while their systematic development and continuity remain constrained. The findings suggest that a coordinated school-level approach may support further development of CE-related practices. These findings reflect participating teachers' perceptions rather than independently verified school practices.

Keywords: Circular Economy; school leadership; public schools; Sultanate of Oman

Check for updates

Academic Editor: Rosabel Roig-Vila

Received: 23 August 2026
Revised: 19 October 2026
Accepted: 19 October 2026
Published: 22 October 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

The world is experiencing rapid transformations toward the adoption of sustainability and CE concepts as innovative solutions to address environmental changes and economic challenges. CE is regarded as one of the most promising models, aiming to ensure the sustainability of natural resources, reduce resource waste, promote reuse and recycling, and achieve a balance between environmental sustainability and development requirements.

In consequence of worldwide and national endeavors to implement sustainability objectives, there is an acute necessity to integrate CE concepts into educational curricula and pedagogical practices within education systems. This would help ensure the alignment of educational policies with countries' aspirations to construct a sustainable future [1–3]. The Finnish experience is considered one of the leading international models for integrating CE concepts into the education system. In this model, students' professional competencies are

developed progressively across different educational stages. This contributes to preparing specialists in the CE who can lead the transition toward more sustainable economic models while linking education to national and international development [1,4,5].

Similarly, studies such as those by [6–8] emphasized the necessity of integrating theory with practical application to consolidate and clarify students' understanding of CE and sustainability concepts. These studies highlight the importance of integrating CE and sustainability concept and experiential learning approaches [6–8]. They further the need for more comprehensive and integrated educational strategies to prepare students to understand sustainability and its associated challenges and to enable them to play an active role in advancing sustainable change. Likewise, Ref. [9] emphasized the importance of strengthening educational interventions to promote young people's participation and contribute to social change toward a more sustainable future.

Furthermore, recent studies conducted in diverse educational contexts, including Spain, Greece, and Vietnam, have highlighted the need to deepen teachers' understanding of circularity and sustainability concepts and to improve their attitudes, perceptions, and behaviors. These studies also underscored the need for educational policies that integrate these concepts into curricula at all educational levels, emphasizing the implementation of specific and diverse teaching approaches to narrow the gap between the theoretical conceptualization of sustainability and CE and the practical skills required by students, while fostering the long-term development of the necessary knowledge [6,10,11]. In addition, Ref. [10] confirmed the clear need for continuous professional development for primary school teachers in sustainability and CE. Moreover, several studies, including those by [3,7,10], emphasized the need for educational approaches to support the transition towards CE and the systematic integration of circular principles into practice. Such efforts contribute to translating CE principles into more systematic and sustainable practices in the future [7,12]. Likewise, Ref. [3] affirmed that education constitutes one of the principal drivers of the transition toward CE and that the success of this transition requires a systematic transformation of education systems, with implementation adapted to the cultural and social characteristics of each society.

Within the local context of the Sultanate of Oman, Ref. [13] emphasized the need to organize professional development workshops for teachers and enhance their awareness of the importance of promoting green economy practices in education, curriculum development, and strengthening partnerships between the Ministry of Education and public and private community institutions to support the implementation of green economy domains in education. The study also highlighted the importance of developing sustainable school buildings in accordance with sustainability standards is consistent with Oman Vision 2040 in promoting green education and advancing the green economy. It also emphasized the importance of using environmentally friendly building materials. In addition, Ref. [14] revealed that integrating CE principles into curricula and educational practices is associated with several challenges. These include the limited availability of specialized experts and training programs and the risk of integrating CE through traditional content-based approaches rather than through skills and values. The study recommended integrating sustainable CE into Omani science and social studies curricula, activating classroom and extracurricular educational activities, and strengthening the role of families, the media, and community partnerships in promoting a circular culture. Furthermore, the Ministry of Education launched the Green Schools project to raise awareness among students, teachers and the local community of environmental issues, CE and sustainability and to promote sustainability principles and CE applications through school-based activities and projects [15]. The Ministry also launched, in collaboration with the Oman Environmental Society, Namat Schools Competition in public schools, which aims to promote sustainable practices in

schools and engage students in environmental action by focusing on several themes, including waste management, water management, energy management, curriculum integration and school initiatives, community engagement, innovation, and entrepreneurship [16]. These efforts reflect the emphasis of Oman Vision 2040 on a green and circular economy, environmental awareness, sustainable consumption and production, and the sustainable use of natural resources [17].

1.1. Statement of the Problem

Despite global focus on CE as a paradigm for sustainable development and resource conservation, empirical research has extensively examined industrial and energy systems [18,19]. Its application in school education remains comparatively nascent [10]. The efficacy of CE education hinges on the transition from theoretical foundations to experiential learning and practical applications that interconnect sustainability concepts with students' everyday experiences [6,7]. However, its integration within school curricula and institutional practices appears to be limited and inconsistent, suggesting that CE education remains an emerging field that necessitates further research and development [10].

International research has highlighted a persistent discrepancy between sustainability commitments and their institutional implementation in education. Recent UNESCO publications have emphasized the need to integrate sustainability into teaching, school operations, governance, and community engagement [20–22]. Within this broader context, CE education remains an emerging area of research, particularly at the school level [7,10]. A parallel challenge exists within the Arab region, where CE efforts have often focused on waste management and recycling [23,24]. Broader CE strategies extend beyond recycling to include reduction, reuse, product-life extension, redesign, and other approaches that retain the value of resources for longer [23,24]. Studies of Arab educational institutions have identified challenges in the institutional implementation of sustainability [25,26]. These challenges reinforce the need for coherent frameworks and mechanisms to support sustainability integration [26,27].

Oman's Ministry of Education has initiated sustainability projects. However, these include initiatives aimed at raising environmental awareness. Further efforts are needed to integrate principles of CE into school curricula and institutional practices [15,20]. Furthermore, research conducted within the Omani educational context has addressed themes related to sustainability, including education for sustainable development and the integration of CE concepts into school curricula. However, comparatively little attention has been given to CE as an integrated operational framework encompassing multiple dimensions of school practice [13,14]. Accordingly, the research problem lies in the limited availability of empirical evidence regarding teachers' perceptions of the extent to which CE principles are implemented in public schools in Oman and the challenges hindering their transition from sustainability-oriented initiatives to integrated institutional practices. The present study investigates teachers' perceptions of the implementation of CE principles in public schools in Muscat Governorate. It explores the major challenges to their implementation and identifies future directions for strengthening these practices from the perspectives of teachers of Grades 5–12. Accordingly, the study seeks to answer the following research questions:

1.2. Research Questions

RQ1. What is the status of school leaders' implementation of CE principles in schools from the perspectives of teachers in Muscat Governorate?

RQ2. What are the major challenges faced by school leaders in implementing CE principles in schools from the perspectives of teachers in Muscat Governorate?

RQ3. What mechanisms can enhance the implementation of CE principles in public schools from the perspectives of teachers in Muscat Governorate?

Research Objectives

The objectives of this study are to:

(1) Examine the status of school leaders' implementation of CE principles within the school environment in public schools in Muscat Governorate from the perspectives of teachers of Grades 5–12.
(2) Identify the major challenges faced by school leaders in implementing CE principles within the school environment.
(3) Propose mechanisms for implementing CE principles within the school environment in public schools in Muscat Governorate.

1.3. Significance of Study

1.3.1. Theoretical Significance

(1) Contribute to enriching the Arab educational literature on the CE, which remains a relatively emerging topic within the Arab and Gulf educational contexts and requires further scholarly investigation and theoretical development.
(2) Highlight a knowledge gap concerning the integration of CE principles into education, thereby providing a scholarly contribution to the academic community and educational researchers.

1.3.2. Practical Significance

(1) Provide empirical evidence on the status of school leaders' practices in implementing CE principles in public schools in Muscat Governorate, which may contribute to improving institutional and environmental performance.
(2) Support educational policymakers in the Ministry of Education in developing educational policies and strategies that promote the CE and environmental sustainability within the school environment.
(3) Enhance the knowledge of educational professionals, including school principals, supervisors, and teachers, regarding the importance of adopting CE principles within school operational processes and educational activities.
(4) Propose practical implementation mechanisms for applying CE principles in public schools in ways that enhance both the effectiveness and sustainability of their implementation.

1.4. Delimitations of the Study

1.4.1. Subject Delimitations

This study examined the status of implementing CE principles and the challenges faced by school principals in public schools in Muscat Governorate from the perspectives of teachers, and proposed mechanisms to strengthen their implementation in these schools.

1.4.2. Population Delimitations

The study was conducted among male and female teachers in public schools serving Grades 5–12.

1.4.3. Temporal Delimitations

The study was conducted during the 2025/2026 academic year.

1.4.4. Geographical Delimitations

The study was conducted in public schools serving Grades 5–12 in Muscat Governorate, Sultanate of Oman.

2. Literature Review

2.1. The CE: Concept and Principles

The CE represents a paradigm shift from the linear model of production, consumption and disposal. The objective of this approach is to preserve the value of sources throughout their life cycles [28]. The CE model operates across three distinct levels: micro, meso, and macro. The overarching objective of the CE model is to achieve a balance between environmental quality, economic prosperity, and social equity while reducing dependence on finite resources [2].

The CE paradigm is predicated on three foundational principles: the elimination of waste and pollution, the circulation of products and materials, and the regeneration of natural systems [28]. These principles advocate for the implementation of closed-loop systems, wherein products and materials are retained for continued use through maintenance, reuse, repair, refurbishment, remanufacturing, and recycling [28–30]. This approach prioritizes the sustainable return of biological materials to natural systems [31]. This approach also promotes product durability, reparability, and sustainable design as alternatives to planned obsolescence [32,33].

The conceptual evolution of CE mirrors its transition from a predominant focus on waste management to a more comprehensive resource management framework. Earlier approaches commonly emphasized the 3R model—that is, reduce, reuse, and recycle. The scope has expanded to include practices such as repair and refurbishment. Broader frameworks also incorporate strategies such as redesign, rethink, and recovery. This evolution indicates a growing emphasis on prolonging product life cycles, safeguarding resource value, and integrating circularity within production and consumption systems [2,31,33].

In this study, the concept of CE is distinguished from the broader concept of sustainability. Despite the close relationship between the two concepts, they are not synonymous. The concept of CE offers a more nuanced approach to the utilization of resources, emphasizing the reduction in consumption and the minimization of waste, while promoting the reuse, recycling, and recovery of resources as part of a comprehensive systemic transition towards more circular resource flows [2]. In contrast, green schools embody a comprehensive, whole-school approach to sustainability, encompassing school governance, facilities and operations, teaching and learning, and community engagement [20]. In this study, environmental awareness is not conceptualized as a direct CE practice in itself; rather, it is defined as the knowledge and understanding that can facilitate engagement with circular practices. This conceptualization is consistent with the educational role identified by [3], who emphasized the importance of developing CE-related knowledge and skills to support the transition towards a CE. Consequently, sustainability, green schools, environmental awareness, and CE are regarded as interconnected yet conceptually distinct concepts in this study. CE is specifically conceptualized as the focal point for examining circular resource utilization and the school conditions that facilitate its implementation.

2.2. The Role of Educational Institutions in Promoting the CE

Education plays an important role in supporting the transition towards CE by developing knowledge, values, and competencies related to sustainability and resource use. Educational institutions can contribute to this transition by integrating sustainability principles into teaching and learning and by connecting educational activities with broader institutional practices [20,34]. Within this context, integrating CE concepts into education

can help learners understand the relationship between resource use, consumption, and waste [11]. Furthermore, CE education can connect theoretical knowledge with practical approaches to resource use, reuse, waste reduction, and circular innovation [7,11].

CE implementation requires attention not only to resource-related practices but also to the institutional and social dimensions that shape circular practices [35]. At the school level, leadership can support this transition through policies and decisions that translate CE principles into everyday school practices [36,37]. Digital transformation and digital resource management can support more efficient resource use and contribute to the sustainability of educational operations [38,39].

Furthermore, school leaders can support problem-based learning and practical projects involving recycling, reuse, and redesign, thereby connecting CE principles with students' everyday experiences [7,11,40]. Moreover, collaborations with local organizations and the provision of professional development may enhance institutional capacity to implement circular practices [3,11]. Therefore, the successful implementation of CE in educational institutions requires moving beyond isolated environmental activities towards sustained institutional practices. These practices should integrate leadership, teaching, resource management, professional development, and community engagement [20,37].

2.3. The CE in the Omani Context

In the Sultanate of Oman, the implementation of CE initiatives is linked to national objectives pertaining to environmental sustainability and the effective management of natural resources, as set out in Oman Vision 2040 [17]. National initiatives encompass the Circularity Gap Assessment, which contributes to the development of a national roadmap for circularity [41]. In the educational sector, national efforts have also included collaboration between the Ministry of Education and Be'ah to promote sustainability and CE concepts within schools [42]. These efforts include initiatives such as the Sustainability and CE Concepts Document [43], the Green Schools Project [13], and the Namat Schools Competition [16].

Within the field of education, the Ministry of Education has undertaken initiatives to promote sustainability and CE in collaboration with national organizations. These initiatives include the Sustainability and CE Concepts Document [43], the Green Schools Project [13], and the Namat Competition [16]. The development of the Sustainability and Circular Economy Concepts Document involved identifying age-appropriate concepts for Grades 1–12, analyzing existing curricula, developing a scope-and-sequence framework, and preparing interactive enrichment activities. The document thus provides a curricular mechanism intended to support the systematic integration of sustainability and CE concepts into school education, extending beyond general environmental awareness [43].

The Green Schools Project also promotes sustainable development, including resource and waste management, climate change, renewable energy, water conservation, afforestation, and carbon reduction. The second phase of the program involved 52 schools [44]. The Namat Schools Competition is an additional initiative that seeks to engage students, teachers, and parents in school sustainability projects addressing waste, water, energy, curriculum integration, community engagement, innovation, and entrepreneurship [16,45]. In 2023/2024, a total of 164 schools across Oman's educational governorates registered for the initiative [16].

Collectively, these initiatives demonstrate an emerging institutional foundation for CE-related education in Oman. However, there remains a need to examine how these national directions and initiatives are translated into systematic CE-related practices across school policies, teaching, resource management, environmental behavior, and infrastructure.

2.4. International Models and Experiences in Schools

International experiences offer valuable insights into the integration of sustainability and CE principles within school systems, with the interaction of national policies, curricula, school operations, leadership, and student participation playing a pivotal role.

The 2020 CE Action Plan of the European Union provides a broad framework that emphasizes sustainable product design, waste prevention, resource efficiency, and extended product life cycles [46]. These policy efforts have been complemented by educational frameworks such as the Council Recommendation on Learning for the Green Transition and Sustainable Development and Green Comp, which promote sustainability competencies across education and training [47,48]. European Eco-Schools initiatives further connect classroom learning with everyday practices involving waste segregation, water and energy conservation, and school environmental improvement, reflecting a transformative approach that links sustainability knowledge with action [49].

Japan's Sound Material-Cycle Society provides another national model that is based on the reduction in resource consumption and the promotion of waste reduction, reuse, and recycling. These principles are also promoted through in educational and awareness activities aimed at encouraging students and school communities to adopt responsible consumption behaviors, including waste segregation and reuse [44]. China has similarly incorporated CE into national policies and development strategies aimed at improving resource efficiency, reuse, and recycling, while CE-related educational initiatives have also received attention in the literature [33,50].

Internationally, the Eco-Schools program provides a school-based model in which students take part in the development and implementation of environmental action plans related to energy, water, waste, and climate [49,51,52]. Such involvement has the capacity to enhance students' environmental responsibility and leadership skills, while translating sustainability knowledge into practical applications [53].

The integration of CE into education is a multifaceted process that requires several interconnected conditions for its effective implementation. These conditions include the establishment of coherent national policies, the provision of institutional support for school leaders and teachers, opportunities for students to engage in practical sustainability activities, and the establishment of partnerships between schools and external organizations [53,54]. These international experiences suggest that Oman's current national initiatives can be strengthened through greater alignment among policy, leadership, professional development, student participation, and community partnerships, in accordance with the principles outlined in Oman Vision 2040 [17].

3. Methodology

3.1. Research Design, Data Collection, and Participants

This study employed a quantitative descriptive research design to examine the teachers' perceptions of the implementation of CE principles within the school environment in public schools in Muscat Governorate. The study also sought to identify teachers' perceptions of the major challenges associated with implementing CE principles within the school environment and to propose practical mechanisms for enhancing their implementation in public schools in Muscat Governorate.

The quantitative descriptive approach enables the systematic collection of data from the study sample and its transformation into numerical indicators suitable for statistical analysis, thereby providing an accurate description of participants' perceptions and opinions. This is consistent with [55], who explain that quantitative survey research enables the numerical description of participants' attitudes and opinions through the collection and analysis of survey data. Accordingly, the quantitative approach was considered appropriate for

the present study because it facilitates the assessment of teachers' perceptions of current practices, the identification of perceived implementation challenges, and the development of improvement mechanisms based on systematically collected empirical data. The study population consisted of all male and female teachers in public schools serving Grades 5–12 in Muscat Governorate, Sultanate of Oman. According to the Annual Educational Statistics Yearbook for the 2024/2025 academic year [45], the total study population comprised 6881 teachers, as presented in Table 1. The study was conducted during 2025.

Table 1. Distribution of the Study Population by Male and Female Public Schools (N = 6881; Study Sample = 291).

School Grade Category	Male	Female	Total
Grades 5–10	1969	1783	3752
Grades 10–12	618	703	1321
Grades 5–12 *	476	1332	1808
Grand Total	3063	3818	6881

* Continuous schools.

Study Sample

The target sample size was determined as 364 participants, based on the sample size table developed by [10]. The administration of the questionnaire was conducted electronically, with the survey link being distributed to eligible teachers working in public schools within Muscat Governorate. A convenience sampling approach was used. The questionnaire was administered electronically, and the survey link was circulated to eligible teachers in public schools in Muscat Governorate through school administrations, educational supervisors, and teacher groups. Participation was voluntary. Because the survey link was circulated through multiple channels, the exact number of schools and eligible teachers reached by the survey could not be determined. The final number of teachers who completed the questionnaire was 291, and all responses were included in the subsequent statistical analysis because no incomplete questionnaires were received or excluded. Therefore, the final analytical sample comprised 291 respondents, constituting approximately 79.9% of the target sample size. Because the number of eligible teachers who received or accessed the survey link was unknown, a conventional response rate could not be calculated. Accordingly, 79.9% represents the proportion of the target sample size achieved rather than a response rate. In addition to the closed-ended questionnaire items, participants were invited to respond to an optional open-ended question concerning challenges to CE implementation. Of the 291 respondents, 165 (56.7%) provided responses to this question. The remaining 126 participants (43.3%) did not provide a response, as the question was optional. Accordingly, the 165 responses were analyzed separately, while the full sample of 291 participants was retained for the quantitative analysis of the closed-ended items.

With respect to demographic characteristics, the final sample consisted of 149 females (51.2%) and 142 males (48.8%). Regarding years of professional experience, 168 respondents (57.7%) had more than 10 years of experience, whereas 123 respondents (42.3%) had between 1 and 10 years of experience. The sample also represented a range of teaching specializations, with Mathematics accounting for the largest proportion (18.9%), followed by Arabic Language (16.8%) and English Language (14.8%). Table 2 presents the demographic characteristics of the study sample in detail.

Table 2. Distribution of the Study Sample by Gender, Years of Experience, and Teaching Specialization.

Variable	Category	Frequency	Percentage
Gender	Male	142	48.8%
	Female	149	51.2%
Years of Experience	1–10 years	123	42.3%
	More than 10 years	168	57.7%
Teaching Specialization	Mathematics	55	18.9%
	Arabic Language	49	16.8%
	English Language	43	14.8%
	Information Technology	32	11.0%
	Islamic Education	28	9.6%
	Chemistry	22	7.6%
	Social Studies	21	7.2%
	Biology	15	5.2%
	Music Education	12	4.1%
	Physics	9	3.1%
	Visual Arts	5	1.7%
Total		291	100%

3.2. Study Instrument

The study instrument (questionnaire) was developed based on a review of the relevant theoretical literature and earlier studies [2,33,56]. In its initial form, the questionnaire consisted of 26 items organized into five main dimensions as follows: Dimension 1: Administrative Policies and Practices, including 4 items. Dimension 2: Resource and Consumption Management, including 6 items. Dimension 3: Curriculum and Educational Practices, including 5 items. Dimension 4: Environmental Awareness and Behavior, including 6 items. Dimension 5: School Infrastructure and Facilities, including 5 items. The questionnaire was designed using a five-point Likert scale, which provided respondents with five response options: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). The five implementation dimensions were designed to capture different but interconnected aspects of CE implementation in schools. The section on 'Administrative Policies and Practices' addresses the governance and organizational mechanisms required to integrate circularity into school planning and decision-making. Conversely, the section on 'Resource and Consumption Management' directly reflects core CE practices by reducing resource use and waste, facilitating reuse, recycling, and enhancing resource efficiency [2,33]. The Curricula and Educational Practices dimension refers to the integration of CE concepts into teaching and learning through educational activities and pedagogical approaches that promote students' understanding of circular economy principles [11]. The Environmental Awareness and Behavior dimension refers to school-based efforts to foster environmental awareness, responsible behavior, participation, and a supportive culture for sustainability. In this study, the behavioral and educational conditions are treated as enabling factors that can support the implementation of CE practices rather than as CE practices in themselves [34,54]. Finally, the topic of School Infrastructure and Facilities explores the physical and operational conditions that facilitate circular resource use, encompassing waste segregation, resource-efficient facilities, maintenance, and extending the lifespan of school assets [12,33]. Consequently, the dimensions are not intended to imply that every sustainability-related practice is inherently a CE practice; rather, they collectively assess how circular principles are translated into school governance, resource management, teaching and learning, behavior, and school operations [56].

The questionnaire also included an open-ended question that invited respondents to propose practices or actions that could support the implementation of CE principles in

schools. The open-ended item was used to provide supplementary qualitative data for addressing the third research question and to capture respondents' proposals beyond the predefined questionnaire items.

3.2.1. Validity of the Study Instrument

Preliminary evidence concerning the validity of the research instrument was examined through expert review, as described below. Reliability was assessed separately using Cronbach's alpha, as reported in Section 3.3.

Face Validity (Expert Review)

The face validity of the questionnaire was assessed through a review of its initial version by four expert reviewers from the educational leadership departments at Sultan Qaboos University and the University of Nizwa. The reviewers were invited to evaluate the clarity, linguistic appropriateness, and relevance of the items to their corresponding dimensions, and to suggest additions, modifications, or deletions where appropriate. Based on the reviewers' feedback, several revisions were made to both the questionnaire dimensions and individual items. A separate Challenges scale was added, comprising four sub-dimensions: Administrative and Organizational Challenges, consisting of 2 items; Financial and Material Challenges, consisting of 3 items; Educational and Pedagogical Challenges, consisting of 5 items; and Cultural Challenges, consisting of 3 items. Following these revisions, the final questionnaire comprised 39 items: 26 items covering five implementation dimensions—Administrative Policies and Practices, Resource Management and Consumption, Curriculum and Educational Practices, Environmental Awareness and Behavior, and School Infrastructure and Facilities—and 13 items assessing perceived challenges. The Implementation and Challenges scales were treated as conceptually distinct measures and analyzed separately. The questionnaire was refined based on expert feedback to enhance its content relevance, clarity, and alignment with the study objectives.

3.2.2. Item–Dimension and Scale-Score Associations

Associations between the five dimensions measuring the perceived implementation of CE principles and the overall implementation score were examined using Pearson correlation coefficients. Pearson correlation coefficients were calculated between each implementation dimension and the overall implementation score. As shown in Table 3, positive and statistically significant correlations were observed between each of the five dimensions and the overall implementation score ($p < 0.001$). The challenges dimension was not included in this analysis because it is a conceptually distinct construct measuring perceived barriers to implementation rather than the level of implementation itself. Consequently, the Challenges dimension was examined independently, and its internal consistency was evaluated using Cronbach's alpha.

Table 3. Pearson Correlation Coefficients Between the Five Implementation Dimensions and the Overall Implementation Score.

Dimensions	**1**	**2**	**3**	**4**	**5**
Correlation with the Overall Score	0.845	0.922	0.916	0.931	0.870

Note: All correlation coefficients are statistically significant at the $p < 0.001$ significance level.

As shown in Table 3, correlations between the five implementation dimensions and the overall implementation score ranged from 0.845 to 0.931 and were all statistically significant ($p < 0.001$). These coefficients indicate strong positive associations between the dimension scores and the composite implementation score. However, because each dimension

contributes to the composite score, these part–whole correlations should be interpreted cautiously and should not be regarded as independent evidence of internal consistency or confirmation of the instrument's proposed multidimensional structure.

As shown in Table 4, all item–dimension correlation coefficients were positive and statistically significant 0.01 level, ranging from 0.618 to 0.915. These findings indicate that the items were consistently associated with their respective dimensions. Similarly, all item–total correlation coefficients were positive and statistically significant, ranging from 0.547 to 0.834. The item–total correlations were calculated separately for the Implementation scale (Items 1–26) and the Challenges scale (Items 27–39), reflecting the conceptual distinction between perceived implementation and perceived barriers. Accordingly, the Implementation and Challenges scales were analyzed separately, and a combined score across all 39 items was not used as an indicator of implementation, consistent with the principle that summary scoring should reflect the conceptual structure of the measure [57]. In multidimensional instruments, internal consistency should be considered at the subscale level when the subscales represent conceptually distinct constructs [58]. Accordingly, Cronbach's alpha was calculated separately for each of the six main dimensions.

Table 4. Item–Dimension and Item–Total Correlation Coefficients for the Implementation and Challenges Scales.

Dimension	Item No.	Item–Dimension Correlation	Item–Total Correlation
Administrative Policies and Practices	1	0.799	0.665
	2	0.843	0.658
	3	0.885	0.757
	4	0.863	0.687
Resource and Consumption Management	5	0.661	0.721
	6	0.820	0.775
	7	0.857	0.755
	8	0.870	0.818
	9	0.888	0.795
	10	0.676	0.676
Curriculum and Educational Practices	11	0.880	0.814
	12	0.885	0.815
	13	0.891	0.78
	14	0.879	0.781
	15	0.851	0.733
Environmental Awareness and Behavior	16	0.881	0.833
	17	0.900	0.834
	18	0.906	0.784
	19	0.909	0.833
	20	0.876	0.775
	21	0.855	0.797

Table 4. *Cont.*

Dimension	Item No.	Item–Dimension Correlation	Item–Total Correlation
School Infrastructure and Facilities	22	0.808	0.757
	23	0.901	0.774
	24	0.915	0.76
	25	0.899	0.734
	26	0.844	0.658
Challenges	27	0.618	0.547
	28	0.627	0.563
	29	0.730	0.676
	30	0.785	0.740
	31	0.809	0.767
	32	0.822	0.786
	33	0.798	0.752
	34	0.809	0.768
	35	0.756	0.708
	36	0.787	0.743
	37	0.747	0.693
	38	0.685	0.628
	39	0.774	0.731

Note: Item–total correlations were calculated separately for the Implementation scale (Items 1–26) and the Challenges scale (Items 27–39), with each item excluded from its respective total score. All correlation coefficients are statistically significant at the 0.01 level.

3.3. Reliability of the Study Instrument

To establish the reliability of the research instrument, Cronbach's alpha coefficient was calculated for each questionnaire dimension and for the overall Implementation scale (Items 1–26), while the Challenges scale (Items 27–39) was assessed separately. The results are presented in Table 5.

Table 5. Cronbach's Alpha Coefficients for the Questionnaire Dimensions (N = 291).

Dimension	Number of Items	Cronbach's Alpha	Reliability Level
Administrative Policies and Practices	4	0.869	Good
Resource and Consumption Management	6	0.919	Excellent
Curriculum and Educational Practices	5	0.925	Excellent
Environmental Awareness and Behavior	6	0.946	Excellent
School Infrastructure and Facilities	5	0.922	Excellent
Overall Implementation Scale	26	0.974	Excellent
Challenges	13	0.935	Excellent

As shown in Table 5, the results of Cronbach's alpha reliability analysis show a high degree of internal consistency for both the questionnaire dimensions and the two scales. The reliability coefficients for the five implementation dimensions ranged from 0.869 to 0.946, reflecting good to excellent levels of internal consistency, while the Challenges scale

also demonstrated high internal consistency (Cronbach's $\alpha = 0.935$). These findings show that the items within each dimension demonstrate an appropriate level of homogeneity in measuring their intended construct. Specifically, Dimension 1 (Administrative Policies and Practices) yielded a Cronbach's alpha coefficient of 0.869, indicating a good level of reliability. The remaining dimensions demonstrated excellent reliability, with Cronbach's alpha coefficients of 0.919 Resource and Consumption Management, 0.925 for Curriculum and Educational Practices, 0.946 for Environmental Awareness and Behavior, 0.922 for School Infrastructure and Facilities, and 0.935 for Challenges. Given the conceptual distinction between perceived implementation and perceived challenges, a single reliability coefficient across all 39 items was not used. Instead, the overall Implementation scale (Items 1–26) demonstrated excellent internal consistency (Cronbach's $\alpha = 0.974$), while the Challenges scale (Items 27–39) was assessed separately (Cronbach's $\alpha = 0.935$). These findings demonstrate that the research instrument possesses a high degree of reliability and is therefore suitable for application in the present study.

3.4. Data Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS Version 27). Means and standard deviations were calculated to summarize teachers' perceptions of CE implementation and associated barriers. Each implementation dimension score was calculated as the mean of its constituent items. The overall Implementation score was calculated as the mean of the five-dimension scores, giving equal weight to each dimension despite differences in their numbers of items. The overall Challenges score was calculated as the mean of Items 27–39. The Implementation and Challenges scales were analyzed separately because they represent conceptually distinct constructs; no combined score across all 39 items was used. Mean scores reflected teachers' perceptions rather than independently verified school practices or conditions, while standard deviations described variability in their responses.

Pearson correlations were calculated between items and their corresponding dimension and scale scores, and between the five implementation dimensions and the overall Implementation score. Item–total correlations were calculated separately within the Implementation and Challenges scales, excluding each item from its respective total score. Because the implementation dimensions contribute to the overall Implementation score, dimension–total correlations were interpreted as part–whole associations rather than independent evidence of internal consistency or confirmation of the questionnaire's proposed multidimensional structure. Cronbach's alpha was calculated for each implementation dimension and separately for the Implementation and Challenges scales, as reported in Section 3.3.

To facilitate descriptive interpretation, mean scores were classified into five categories, ranging from Very Low to Very High, using the criteria presented in Table 6. The five-point Likert scale range was divided into equal intervals of 0.80, calculated as $(5 - 1) \div 5$. Higher Implementation scores indicated greater perceived implementation, whereas higher Challenges scores indicated greater perceived barriers. These classifications did not establish objective implementation levels or the practical significance of differences between scores.

Table 6. Criterion for Interpreting Mean Scores (N = 291).

Mean Score Range	Interpretation
1.00–1.80	Very Low
1.81–2.60	Low
2.61–3.40	Moderate
3.41–4.20	High
4.21–5.00	Very High

Responses to the optional open-ended question were analyzed using inductive qualitative content analysis [59,60]. Of the 291 questionnaire records, 165 contained substantive responses and were retained for analysis while blank, placeholder, and non-substantive responses were excluded. The lead researcher conducted the initial coding and categorization, repeatedly reading the responses, identifying meaningful proposals, and generating codes from their content rather than from the predefined questionnaire dimensions. Related codes were compared, grouped, and refined into seven categories. The first and second co-authors subsequently reviewed the initial coding and category assignments. Differences identified during this review were discussed with reference to the original responses, and the researchers agreed on the final coding and categorization. This procedure constituted a collaborative review of the initial analysis rather than independent parallel coding.

Multiple coding was permitted when a response contained more than one relevant proposal. Category frequencies represented the number of substantive responses assigned to each category, with each response counted once within a given category. Percentages were calculated using the 165 retained responses as the denominator. Because individual responses could contribute to more than one category, the percentages were not expected to sum to 100%.

The optional open-ended responses were analyzed using inductive qualitative content analysis to address the third research question [59,60]. Of the 291 questionnaire records, 165 contained substantive responses that were retained for analysis, while blank, placeholder, and non-substantive responses were excluded. The retained responses were read repeatedly to gain an overall understanding of their content and to identify recurring ideas. Initial codes were then derived inductively from the respondents' statements rather than from the predefined questionnaire dimensions. Similar codes were compared, grouped, and progressively refined into seven categories representing the proposals expressed by the respondents. Multiple coding was permitted when a single response contained more than one relevant proposal. To enhance the dependability of the analysis, the codes and emerging categories were iteratively checked against the original responses, and the category structure was reviewed and refined to maintain a clear and traceable connection between the respondents' statements and the final categories. Frequencies and percentages were subsequently calculated for the seven categories based on the 165 substantive responses. Because individual responses could be assigned to more than one category, the percentages were not expected to sum to 100%.

4. Results and Discussion

4.1. Research Question 1: What Is the Status of School Leaders' Implementation of CE Principles Within the School Environment from the Perspectives of Teachers in Muscat Governorate?

To answer this research question and examine teachers' perceptions of the implementation of CE principles in their schools, means and standard deviations were calculated for the questionnaire dimensions assessing the perceived level of implementation. These dimensions included Administrative Policies and Practices, Resource and Consumption

Management, Curriculum and Educational Practices, Environmental Awareness and Behavior, and School Infrastructure and Facilities. Table 7 presents the means and standard deviations for the questionnaire dimensions and their corresponding items.

Table 7. Means and Standard Deviations of the Questionnaire Items and Dimensions for the Perceived Implementation of CE Principles in Public Schools (N = 291).

Dimensions	Items	Means	SD	Rank
Administrative Policies and Practices	1	4.04	0.84	1
	2	3.88	0.93	2
	3	3.87	1.00	3
	4	3.76	1.02	4
	Overall Dimension	3.89	0.80	
Resource and Consumption Management	5	3.92	0.97	1
	6	3.86	0.97	2
	7	3.85	0.97	3
	8	3.85	0.95	4
	9	3.82	1.05	5
	10	3.81	0.98	6
	Overall Dimension	3.85	0.83	
Curriculum and Educational Practices	11	3.88	0.96	1
	12	3.88	0.91	1
	13	3.86	0.97	2
	14	3.72	1.00	3
	15	3.67	0.99	4
	Overall Dimension	3.80	0.85	
Environmental Awareness and Behavior	16	4.05	0.91	1
	17	4.03	0.88	2
	18	3.86	0.97	3
	19	3.83	1.00	4
	20	3.67	1.07	5
	21	3.66	1.04	6
	Overall Dimension	3.85	0.87	
School Infrastructure and Facilities	22	3.97	0.98	1
	23	3.85	0.99	2
	24	3.84	1.11	3
	25	3.79	1.12	4
	26	3.76	1.05	5
	Overall Dimension	3.84	0.92	

Note: All items and dimensions, mean scores were classified as "High" according to the interpretation criteria adopted in this study.

The results presented in Table 7 indicate that the implementation of CE principles in public schools was perceived to be high across all dimensions, with overall mean scores

ranging from 3.80 to 3.89. The relatively small variation in the dimensions suggests that teachers perceived CE-related practices and supporting conditions as being reflected across multiple aspects of school practice. These aspects include administrative policies and procedures, resource management and consumption, curriculum and educational practices, environmental awareness and behavior, and school infrastructure and facilities. Nevertheless, the ranking of the dimensions suggests that teachers perceived implementation to be more evident in administrative and organizational practices than in curriculum and educational practices, which received the lowest overall mean.

With a mean score of 3.89, the Administrative Policies and Practices dimension ranked first, indicating that teachers perceived sustainability and CE issues to be incorporated into school planning and administrative practices. This finding is supported by the highest-rated item within this dimension, "Incorporating environmental and sustainability objectives into the school's operational plan". This result may be interpreted in light of the Ministry of Education's official commitment to integrating sustainability and CE concepts into education through the Concepts of Sustainability and CE Document and their incorporation into the Omani curriculum [43]. It is also consistent with the priorities of Oman Vision 2040 and the National Strategy for Education 2040, both of which emphasize aligning education with sustainable development objectives [17]. However, the comparatively lower mean for the item "Establishing committees or working groups concerned with environmental issues and the CE" suggests that teachers perceived the incorporation of CE into school planning as more evident than the establishment of internal organizational structures for continuous implementation and monitoring. This finding is consistent with the whole-school approach to sustainability, which emphasizes that sustainability cannot be achieved solely by incorporating it into school plans but requires the integration of school leadership, curriculum, facilities, and everyday school practices [53]. Taken together, these findings suggest a possible gap between the perceived integration of sustainability and CE into school planning and the establishment of organizational structures to support their sustained implementation. From a whole-school perspective, institutionalizing such practices requires moving beyond their inclusion in formal plans toward embedding them across school leadership, operations, curriculum, and everyday practices [53]. However, this interpretation is based on teachers' perceptions and does not constitute independently verified evidence of differences in school-level implementation. This suggests that, within the Omani context, alignment with broader sustainability and CE initiatives was perceived by teachers as more evident than the development of school-level organizational structures to institutionalize CE practices and support continuous monitoring of their implementation.

The Resource and Consumption Management dimension also received a high perceived level of implementation, with an overall mean of 3.85. The highest-rated item within this dimension was "Encouraging teachers and students to reuse office materials instead of disposing of them after first use". This finding suggests that teachers perceived reuse practices to be relatively evident in their schools, particularly those related to extending the useful life of resources and minimizing waste. It is consistent with CE frameworks emphasizing the shift from a linear model of resource use and disposal to one that promotes reuse and prolonged resource utilization [2,33]. However, the relatively lower ranking of the item "Reducing the use of single-use materials" suggests that teachers perceived reuse practices as more evident than practices aimed at reducing single-use materials. Taken together, the findings of the present study suggest that reuse practices were perceived to be comparatively well-established in the participating schools, while practices requiring reductions in the use of single-use materials were perceived to be comparatively less prominent. The significance of this distinction is rooted in the fact that CE implementation extends

beyond individual reuse behaviors, to include reducing material demand and integrating circularity into institutional resource management systems [2,12].

The Curriculum and Educational Practices dimension ranked last among the five dimensions, with a mean score of 3.80. Although this result indicates that teachers perceived CE principles to be reflected in educational practices, it also suggests that their implementation was perceived to be less evident than in the other dimensions. The highest-rated items were "Encouraging teachers to relate lesson content to local environmental issues and CE principles" and "Collaborating with the local community to implement sustainable environmental projects and activities." These findings suggest a perceived emphasis on connecting learning with local environmental and community contexts, which is consistent with studies advocating that CE education should extend beyond theoretical knowledge to include problem-based learning, project-based learning, and authentic real-world applications [7,12]. The findings are also consistent with those reported by [14], who found that experts emphasized educational and learning activities as an important means of integrating sustainable CE concepts into Omani science and social studies curricula. However, the comparatively lower rating of the item "Organizing educational exhibitions or open days on CE" suggests that such organized CE-related educational activities were perceived as less evident than linking lesson content to local issues and engaging with the community. Taken together, the comparatively lower mean for Curriculum and Educational Practices suggests that curricular and educational practices were perceived as somewhat less evident than those represented by the other dimensions of CE implementation. However, given that all five dimensions were perceived to be at a high level and the differences between their means were relatively small, this finding should not be interpreted as evidence of weak perceived curricular implementation. Rather, it indicates a potential area for further development, particularly in strengthening the systematic integration of CE concepts into teaching and learning.

The Environmental Awareness and Behavior dimension also received a high perceived level of implementation, with an overall mean of 3.85. The highest-rated item, "Promoting a school-wide culture that supports environmentally responsible behavior," was among the highest-rated items in the entire questionnaire. This finding suggests that teachers perceived their schools as having a supportive cultural environment for environmentally responsible behavior. However, environmental awareness should not be equated with the implementation of CE. As outlined in the theoretical framework, awareness is considered an enabling condition that can encourage circular behavior. In this regard, research on CE education emphasizes the importance of complementing awareness with practical engagement, skill development, and opportunities to translate CE knowledge into action [3,40]. The findings suggest that teachers perceived the participating schools as having a relatively strong foundation for environmental awareness, although the present findings do not establish the extent to which this supportive culture is translated into structured, CE-specific behavioral practices. This interpretation is consistent with the broader ESD literature, which emphasizes that sustainability education extends beyond knowledge acquisition to include competencies, participation, and action [32,54]. The finding may also be considered in the context of environmental initiatives implemented in the Sultanate of Oman, such as the Green Schools Project and the Namat Competition, which engage schools in practical environmental and sustainability-related projects [16,44]. Nevertheless, the relatively lower mean for the item "Conducting regular awareness campaigns on the importance of the CE" suggests that teachers perceived general environmental awareness to be more widespread than structured awareness programs explicitly addressing CE concepts.

The School Infrastructure and Facilities dimension received a high perceived level of implementation, with a mean score of 3.84, indicating that teachers perceived the presence

of infrastructure- and facility-related practices associated with sustainability within schools. The highest-rated item in this dimension was "Conducting maintenance activities that minimize waste and support environmental sustainability". This finding suggests that maintenance practices and waste reduction were perceived as relatively evident practices related to extending the useful life of resources and reducing the need for replacement, both of which represent fundamental principles of CE [12,33]. However, the relatively larger standard deviations observed for certain items—such as the installation of water conservation systems and the use of energy-saving technologies—suggest greater variation in teachers' perceptions of these practices. This finding is consistent with whole-school approaches to sustainability, which extend beyond curriculum integration to include school operations and the environmental management of areas such as resources, energy, water, and waste [49,52,53]. From a CE perspective, maintenance and the extension of product life are also important strategies for retaining the value of resources and reducing the need for replacement [28,33]. The present findings suggest that teachers perceived maintenance and waste reduction as relatively evident within the participating schools; nevertheless, the greater variability in teachers' responses regarding water-saving systems and energy-efficient technologies suggests that infrastructure-dependent practices may not be perceived as equally established by all teachers. Thus, the findings point to greater consistency in teachers' perceptions of maintenance-related practices than of practices involving water-saving systems and energy-efficient technologies; however, the present data do not establish the reasons for this variation.

Overall, the findings indicate that teachers perceived administrative planning, environmental awareness, and resource reuse as relatively more evident aspects of CE-related practices and supporting conditions in public schools. This pattern is consistent with the literature, which emphasizes that sustainability in education cannot be achieved through isolated initiatives but requires a comprehensive whole-school approach [53]. From a whole-school perspective, this highlights the importance of integrating leadership, curriculum, school operations, and participation rather than addressing these areas as separate components [53]. This pattern suggests differences in the relative emphasis perceived by teachers on CE-related practices across school domains rather than differences between successful and unsuccessful implementation. These finding can also be considered within the broader national context of sustainability-related educational initiatives and the sustainability objectives of Oman Vision 2040 [15,17]. Nonetheless, the differences among the means of the five dimensions were relatively small (3.80–3.89). Consequently, these findings should be interpreted as differences in relative perceived emphasis rather than as evidence of strong implementation in some dimensions and weak implementation in others.

4.2. Research Question 2: What Are the Major Challenges Faced by School Leaders in Implementing CE Principles Within the School Environment from the Perspectives of Teachers in Public Schools in Muscat Governorate?

To answer this research question, means and standard deviations were calculated for the respondents' perceptions of the Challenges dimension. The analysis aimed to determine the extent to which these challenges were perceived to hinder the implementation of CE principles in schools and to rank them according to their perceived magnitude. Table 8 presents the results of the analysis. The questionnaire items are arranged in descending order according to their mean scores, reflecting the perceived size of each challenge.

Table 8. Means and Standard Deviations for the Challenges Dimension (N = 291).

Dimension	Items	Means	SD	Rank
Administrative and Organizational Challenges	27	3.99	0.94	1
	28	3.91	0.96	2
Financial and Material Challenges	29	3.89	0.98	3
	30	3.86	0.92	4
	31	3.83	0.88	5
Educational and Pedagogical Challenges	32	3.82	0.97	6
	33	3.79	0.90	7
	34	3.79	0.87	8
	35	3.78	0.92	9
	36	3.72	1.02	10
Cultural Challenges	37	3.72	0.99	11
	38	3.71	0.91	12
	39	3.57	0.96	13
Overall Dimension		3.80	0.71	High

Note: All item and overall dimension mean scores were classified as "High" according to the interpretation criteria adopted in this study.

The results presented in Table 8 show that respondents perceived the challenges associated with implementing CE principles in public schools to be high overall, with a mean score of 3.80 and a standard deviation of 0.71. This finding suggests that the relatively high perceived level of implementation observed for the earlier dimensions does not imply the absence of implementation barriers. Rather, it indicates that teachers perceived CE practices to be implemented within schools while simultaneously reporting high levels of perceived institutional, operational, and educational challenges.

The findings show that the most highly rated individual challenge was of a technological nature. The item "Lack of smart or modern tools for monitoring resource consumption and analyzing environmental data within the school" ranked first among all challenge items. This finding suggests that teachers perceived the lack of technological tools for monitoring resource consumption and environmental data as a particularly prominent barrier to CE implementation. Such tools can support the systematic monitoring of resource use and provide information relevant to school-level environmental management and decision-making. This interpretation is consistent with the whole-school approach to sustainability, which emphasizes the integration of educational and operational practices across the school rather than treating sustainability as a set of isolated activities [53].

The results also show that insufficient funding and the lack of specialized personnel responsible for maintaining and operating environmentally sustainable facilities were perceived as major implementation challenges. These findings suggest that teachers perceived financial and human-resource capacity as important conditions for supporting CE implementation, alongside environmental awareness and responsible behavior. This interpretation is consistent with the findings of [25], who reported, within the context of higher education, that the implementation of sustainability practices is shaped by institutional and organizational factors, highlighting the important role of organizational actors and institutional culture in translating sustainability objectives into institutional practices.

Another prominent challenge identified by respondents was the absence of assessment mechanisms capable of measuring students' acquisition of sustainability and CE competencies. This finding suggests that the implementation of CE principles within schools should not be evaluated solely by the number of environmental activities or initiatives undertaken but rather by the extent to which these initiatives translate into meaningful student learning outcomes reflected in students' knowledge, competencies, attitudes, and behaviors. This interpretation aligns with the literature on education for sustainable development, emphasizes the integration of sustainability into institutional practices and everyday learning experiences, rather than treating it as isolated theoretical content [61]. It is also consistent with research on CE education, which emphasizes the need for educational practices that enable students to progress from conceptual understanding to practical application [7,10].

The heavy administrative workload of school principals also emerged as a prominent challenge. This finding suggests that implementing CE initiatives requires dedicated time for planning, coordination, monitoring, and partnership development, while routine administrative responsibilities may limit school leaders' capacity to manage environmental initiatives effectively. This interpretation is consistent with the whole-school approach, which collaborative structures and the integration of leadership, curriculum, school facilities, and community engagement rather than placing responsibility solely on the school principal [61,62]. Accordingly, based on the interpretation of these findings, addressing this challenge may involve not merely assigning more responsibilities to school leaders but establishing formal organizational structures within schools, such as sustainability teams or CE committees, with clearly defined and accountable responsibilities.

The findings also indicate several perceived curricular and instructional challenges, including the limited availability of instructional materials and curricular and extracurricular activities related to responsible consumption and recycling, the inadequate integration of CE principles into the formal curriculum, limited teacher preparation for adopting instructional approaches that support CE principles, and the tendency to address these concepts theoretically without connecting them to students' everyday experiences. These findings suggest that one of the principal implementation challenges lies in bridging the gap between the theoretical understanding of CE and its translation into practical classroom instruction and authentic school-based learning experiences. This interpretation aligns with the findings of [10], which highlighted the significance of teacher education in fostering an understanding of sustainability and CE concepts, and translating this knowledge into practical action. Similarly, ref. [7] concluded that CE and sustainability education can be strengthened through applied and participatory learning approaches, such as problem-based learning and authentic learning environments, rather than through traditional theoretical instruction alone. In the Omani context, teachers perceived challenges related to integrating CE concepts into structured curricula, instructional practices, and students' learning experiences.

In addition, the findings highlight several perceived cultural and societal challenges, including prevailing consumption habits within schools, limited awareness of CE among members of the school community, and insufficient collaboration between schools and families in promoting CE principles. These findings suggest that implementing CE principles in schools may require attention to cultural and behavioral factors beyond school operations, including collaboration with families and the wider community. More specifically, teachers identified the continued use of single-use materials, limited parental engagement, and inadequate public awareness as potential barriers to promoting CE practices within schools. This interpretation is consistent with the broader whole-school approach to sustainability, which emphasizes the importance of participation and collaboration within and beyond the school community [53,62]. These findings also suggest that future research could examine

how family engagement and community participation relate to the implementation of CE practices in schools.

Although the item "Absence of policies supporting CE within schools" ranked last among the challenge items, its mean score nevertheless remained within the high category, indicating that respondents still perceived it as a meaningful challenge, albeit less prominent than technological, financial, and human resource constraints. This pattern suggests that the perceived challenges were not limited to the absence of supportive policies but also extended to practical and organizational aspects of implementation, including technological resources, financial support, qualified personnel, assessment mechanisms, and administrative capacity. This interpretation is consistent with the findings reported for the previous dimensions, which indicated relatively strong perceived implementation in planning and environmental awareness alongside slightly lower mean scores for certain curriculum-related and educational practices.

The standard deviations for the individual challenge items ranged from 0.87 to 1.02, indicating variation in respondents' perceptions of the reported barriers. Item 36 showed the greatest variability (SD = 1.02), followed by Items 37 (SD = 0.99) and 29 (SD = 0.98), whereas Item 34 showed the lowest variability (SD = 0.87). These differences describe the relative dispersion of teachers' responses and do not establish differences in the actual extent of these barriers across schools.

Overall, teachers perceived CE implementation in public schools in Muscat Governorate as facing technological, financial, human-resource, educational, and cultural barriers. The lack of monitoring tools received the highest mean score among the individual challenge items, while funding limitations and a lack of specialized personnel were also perceived as prominent constraints. Although the absence of supportive policies received the lowest mean score among the challenge items, it remained within the high category and should therefore not be interpreted as an insignificant barrier. Together, these findings suggest that further development of CE-related practices may benefit from coordinated attention to school capacity, consistent with the whole-school perspective [53]. Oman Vision 2040 and existing sustainability-related educational initiatives provide a broader context for interpreting these perceptions [13,17,49]; however, the study did not assess their effectiveness or independently verify the availability and adequacy of school resources.

4.3. Research Question 3: What Mechanisms Can Enhance the Implementation of CE Principles Within the School Environment in Public Schools from the Perspectives of Teachers in Muscat Governorate?

Inductive qualitative content analysis of the 165 substantive open-ended responses identified seven categories of actions proposed by teachers for strengthening CE implementation. Table 9 presents the category definitions, frequencies, percentages, and illustrative responses. Percentages were calculated using the 165 substantive responses as the denominator. Because a response could be assigned to more than one category, the percentages do not sum to 100%.

Table 9. Categories of Teachers' Proposals for Enhancing CE Implementation in Public Schools (n = 165).

Category	Definition	Frequency n (%)	Representative Verbatim Responses
Circular Resource-Management Practices	Practical measures aimed at reducing resource consumption and waste and promoting segregation, reuse, recycling, and other circular uses of materials.	68 (41.2%)	"Providing recycling containers in all corners of the school—reducing plastic consumption." (R013) "Allocating small containers to convert food leftovers into organic compost and then using the compost in the school garden." (R052)
Awareness, Training, and Capacity Building	Awareness and training activities aimed at strengthening teachers' and students' understanding and practical application of CE.	67 (40.6%)	"Conducting workshops for students that contribute to increasing awareness of the CE and involving the community and parents in circular-economy-related education." (R096) "Intensive courses and sessions on the CE." (R267)
Resources, Infrastructure, and Financial/Technical Support	Provision of the financial, material, infrastructural, and technical resources required for CE implementation.	45 (27.3%)	"Providing a budget to adopt diverse projects and maintain the school in a way that contributes to providing sound infrastructure, thereby rationalizing the use of devices and tools in the school." (R047) "Supporting the school economically and materially with materials and tools that contribute to increasing the school's productive efficiency, provided by the Ministry." (R021)
Student Participation, Projects, Competitions, and Incentives	Direct student involvement in CE projects, competitions, innovation, and practical environmental activities.	32 (19.4%)	"There are now many competitions that help in understanding the CE; therefore, students and teachers should be involved." (R025) "Innovation competitions; encouraging students to devise solutions or products from recycled materials." (R137)

Table 9. *Cont.*

Category	Definition	Frequency n (%)	Representative Verbatim Responses
Curriculum Integration and Experiential Learning	Integration of CE into formal curricula and linking conceptual knowledge with practical and experiential learning.	27 (16.4%)	"Integrating the CE into curricula as a course." (R020) "The CE can be incorporated into school curricula." (R287)
Partnerships with Families, Communities, and External Organizations	Collaboration between schools, families, communities, and relevant external organizations to support CE implementation.	20 (12.1%)	"Strengthening the partnership between the school and the community so that efforts are integrated and combined." (R048) "Cooperation between the parent and the school." (R261)
Governance, Policy, Institutionalization, and Monitoring	Formalizing CE through policies, systems, coordination, institutional responsibilities, and monitoring arrangements.	19 (11.5%)	"With habituation, it becomes easier, but it needs to be made into a system for implementation." (R011) "First, increasing awareness and knowledge; second, financial support and continuity in follow-up." (R093)

Note: Percentages were calculated based on 165 substantive responses. Multiple coding was allowed when a response had more than one proposal; therefore, categories were not mutually exclusive, and percentages do not sum to 100%.

4.3.1. Circular Resource-Management Practices

The most frequently identified category was circular resource-management practices, identified in 68 of the 165 substantive responses (41.2%). Teachers emphasized waste segregation, recycling, reuse, and consumption reduction as strategies for reducing environmental impact. For instance, one teacher proposed the installation of recycling containers in all areas of the school to support waste segregation and reduce plastic waste (R013), while another suggested providing small containers to convert food waste into organic compost for use in the school garden (R052). These findings complement the quantitative results, which showed a high perceived level of implementation for Resource and Consumption Management, and suggest that teachers viewed practical resource management as an important pathway for strengthening CE implementation. This emphasis is consistent with core CE principles that seek to reduce resource consumption and waste and maintain materials in use through strategies such as reuse and recycling [2,12]. In the context of Omani schools, these proposals illustrate how teachers envisioned translating CE principles into practical resource-management activities within everyday school operations.

4.3.2. Awareness, Training, and Capacity Building

Awareness, training, and capacity building were identified in 67 of the 165 substantive responses (40.6%). Teachers emphasized training and awareness activities; for example, one proposed "intensive courses and sessions on CE" (R267). This finding complements the quantitative finding that limited teacher preparation was perceived as a challenge and highlights teachers' perceived need for greater practical capacity to support CE implementation. This is consistent with research emphasizing the role of education in developing CE knowledge and competencies and supporting its integration into educational practice [3].

In the Omani school context, strengthening teachers' and students' CE knowledge and skills may therefore represent an important area for supporting CE-related practices in schools.

4.3.3. Resources, Infrastructure and Financial/Technical Support

Resources, infrastructure, and financial/technical support were identified in 45 responses (27.3%). Teachers emphasized the need for funding, materials, facilities, and technical support. For example, one respondent proposed 'supporting the school economically and materially with materials and tools that contribute to increasing the school's productive efficiency' (R021). This is consistent with the quantitative findings concerning perceived limitations in funding, the availability of monitoring tools, and specialized personnel. Similarly, Ref. [20] identified facilities and operations as key components of a whole-institution approach to sustainability. Taken together, these findings suggest that respondents perceived adequate financial, material, infrastructural, and technical support as important for facilitating more systematic CE implementation in schools.

4.3.4. Student Participation, Projects, Competitions, and Incentives

Student participation, projects, competitions, and incentives were identified in 32 responses (19.4%). Teachers emphasized the importance of active student involvement in projects and innovation competitions. For instance, one teacher proposed "innovation competitions that encourage students to devise solutions or products from recycled materials" (R137). This category is broadly consistent with the quantitative findings indicating high perceived levels of Environmental Awareness and Behavior and Curriculum and Educational Practices. Such participation is consistent with CE educational approaches that emphasize active and experiential learning [7]. In the Omani school context, these proposals suggest opportunities to connect CE concepts with practical problem solving and everyday school experiences.

4.3.5. Curriculum Integration and Experiential Learning

Curriculum integration and experiential learning were identified in 27 responses (16.4%). Teachers called for CE to be more explicitly integrated into formal learning. For example, one teacher said that "CE can be incorporated into school curricula" (R287). This finding is particularly relevant because the Curriculum and Educational Practices dimension recorded the lowest mean score among the five perceived implementation dimensions, although it remained within the high category. Similarly, CE education research emphasizes curriculum integration and active learning approaches [7]. Taken together, the qualitative and quantitative findings suggest that a more systematic curricular integration of CE represents a potential area for further development in the participating schools, particularly through classroom and experiential learning.

4.3.6. Partnerships with Families, Communities, and External Organizations

Partnerships with families, communities, and external organizations were identified in 20 of the 165 substantive responses (12.1%). Teachers emphasized collaboration beyond the school. For example, one respondent proposed "strengthening the partnership between the school and the community so that efforts are integrated and combined" (R048). This finding highlights the perceived importance of extending CE-related efforts beyond the school through collaboration with families and the wider community. The UNESCO Green School Quality Standard [20] identifies community engagement as one of the four core dimensions of its whole-institution approach to school sustainability. In the Omani context, stronger partnerships may provide opportunities to support CE-related activities beyond the school environment and draw on community expertise and support.

4.3.7. Governance, Policy, Institutionalization and Monitoring

Governance, policy, institutionalization, and monitoring were identified in 19 of the 165 substantive responses (11.5%). Teachers emphasized the importance of systematic implementation and follow-up. For example, one teacher stated, "With habituation, it becomes easier, but it needs to be made into a system for implementation" (R011). Although the Administrative Policies and Practices dimension recorded the highest mean among the perceived implementation dimensions, these responses highlight teachers' perceived need for institutionalization and systematic follow-up. This aligns with the UNESCO Green School Quality Standard [20], which identifies school governance as a core dimension of the whole-institution approach to sustainability. Within the context of the present study, these responses suggest that teachers viewed the integration of CE into school planning, clearly defined responsibilities, and monitoring processes as important for supporting more systematic and sustained implementation.

Overall, the findings suggest that teachers considered stronger CE implementation to require coordinated action in several areas, including resource management, awareness and capacity building, infrastructure, student participation, curriculum integration, partnerships, and governance. Rather than emphasizing a single mechanism, their responses suggest that the implementation of CE in schools was perceived to depend on the interaction of educational, operational, and institutional practices. These findings highlight teachers' perceived need for a coordinated, school-level approach that links these areas, rather than relying on individual environmental initiatives.

5. Conclusions

The present study examined teachers' perceptions of the implementation of CE principles in public schools in Muscat Governorate, Sultanate of Oman. To this end, the study first investigated the perceived level of implementation, then identified the major perceived challenges, and finally identified practical mechanisms suggested by teachers to strengthen CE practices within the school environment. The findings indicate that, although perceived implementation was high across all five dimensions, several institutional, educational, infrastructural, and cultural challenges were perceived as barriers to implementation. These findings suggest that the perceived presence of CE-related practices can coexist with constraints on their systematic development and continuity. Taken together, teachers' perceptions and proposals suggest that a coordinated school-level approach linking strategic planning, leadership practices, curriculum development, professional learning, infrastructure, and community partnerships may support more systematic CE-related practices. However, the study did not evaluate the effectiveness of such an approach or establish causal relationships between these components and implementation outcomes. The comparatively lower perceived level of implementation in the Curriculum and Educational Practices dimension suggests scope for strengthening the integration of CE concepts into teaching and learning processes. Nevertheless, all five dimensions were rated highly, and the differences between their means were small; this finding should therefore be interpreted as a potential area for further development rather than evidence of weak curricular implementation.

A further methodological limitation is that the proposed multidimensional structure of the questionnaire was not evaluated using exploratory factor analysis (EFA) or confirmatory factor analysis (CFA). Therefore, the reported reliability coefficients and correlations should not be interpreted as sufficient evidence of factorial validity. Future research should employ factor-analytic techniques to further examine the questionnaire's dimensional structure and strengthen the evidence supporting its construct validity.

6. Recommendations

Based on teachers' reported perceptions and open-ended proposals, the following priorities are suggested for consideration and evaluation:

1. Strengthen CE integration into school planning through clearly assigned responsibilities and regular follow-up.
2. Provide targeted professional development and curriculum support to connect CE concepts with practical classroom learning, student projects, and circular resource-management practices.
3. Improve access to tools and indicators for monitoring resource consumption, waste, and CE-related learning activities.
4. Address school-specific financial, technical, and infrastructural needs, including waste segregation, resource conservation, and maintenance support.
5. Strengthen partnerships with families and community organizations to sustain practical CE activities.

These priorities could be coordinated through a school-level approach connecting leadership, teaching, resource management, and infrastructure. Their effectiveness should be evaluated through pilot implementation. As a broader policy implication, educational authorities could consider coordinated guidance for CE integration, informed by evidence from additional governorates and stakeholders before wider adoption.

7. Suggestions for Future Research

1. Conduct a study examining perceptions of the implementation of CE principles in public schools across other governorates of the Sultanate of Oman to identify regional similarities and differences in perceived implementation and associated challenges.
2. Conduct a qualitative study investigating the implementation of CE principles in public schools in Muscat Governorate from the perspectives of school principals.
3. Conduct comparative studies examining perceptions of the implementation of CE principles in public and private schools.
4. Investigate the relationship between school-based CE practices and students' environmental awareness and environmentally responsible behavior.

Author Contributions: Conceptualization, Methodology, Writing—original draft, Writing—review & editing, M.A.; Supervision, review & editing, H.A.A.-H. and F.M.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Research Ethics Committee of Sultan Qaboos University (REAAF/EDU/DEFA/2025/Form 15) on 10 September 2025.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data is available from the authors upon request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CE Circular Economy

References

1. Garcia-Saravia Ortiz-De-Montellano, C.; Ghannadzadeh, A.; Van Der Meer, Y. The CIRCULAR pathway: A new educational methodology for exploratory circular value chain redesign. *Front. Sustain.* **2023**, *4*, 1197659. [CrossRef]
2. Kirchherr, J.; Reike, D.; Hekkert, M. Conceptualizing the Circular Economy: An analysis of 114 definitions. *Resour. Conserv. Recycl.* **2017**, *127*, 221–232. [CrossRef]
3. Tiippana-Usvasalo, M.; Pajunen, N.; Holuszko, M. The role of education in promoting Circular Economy. *Int. J. Sustain. Eng.* **2023**, *16*, 92–103. [CrossRef]
4. Sysoiev, O. Comparative analysis of professional training trends for circular economy specialists in the Republic of Finland, the Republic of Poland, and Ukraine. *Contin. Prof. Educ. Theory Pract.* **2024**, *78*, 132–144. [CrossRef]
5. Sysoiev, O. Learning the circular economy in the Republic of Finland: Educational projects. *Contin. Prof. Educ. Theory Pract.* **2024**, *80*, 126–137. [CrossRef]
6. Keramitsoglou, K.; Litseselidis, T.; Kardimaki, A. Raising effective awareness for Circular Economy and sustainability concepts through students' involvement in a virtual enterprise. *Front. Sustain.* **2023**, *4*, 1060860. [CrossRef]
7. Kirchherr, J.; Piscicelli, L. Towards an Education for the Circular Economy (ECE): Five Teaching Principles and a Case Study. *Resour. Conserv. Recycl.* **2019**, *150*, 104406. [CrossRef]
8. Pakšiová, R.; Příbilová, P.; Ambrozová, E.; Koleňák, J.; Brauner, R. Innovation of the curriculum of management study programs in the context of sustainability and development of environmental skills. *Maneko* **2024**, *2*, 168–179. [CrossRef]
9. Carbonell-Alcocer, A.; Romero-Luis, J.; Gértrudix-Barrio, M.; Borges-Rey, E. Educating for a sustainable future through the Circular Economy: Citizen involvement and social change. *Comunicar* **2022**, *30*, 21–32. [CrossRef]
10. Krejcie, R.V.; Morgan, D.W. Determining sample size for research activities. *Educ. Psychol. Meas.* **1970**, *30*, 607–610. [CrossRef]
11. Nguyen, T.P.L. Integrating Circular Economy into STEM education: A promising pathway toward circular citizenship development. *Front. Educ.* **2023**, *8*, 1063755. [CrossRef]
12. Suárez-Eiroa, B.; Fernández, E.; Méndez-Martínez, G.; Soto-Oñate, D. Operational principles of CE for sustainable development: Linking theory and practice. *J. Clean. Prod.* **2019**, *214*, 952–961. [CrossRef]
13. Al-Dayri, H.; Ambusaidi, A. The extent to which public schools principals and their teachers practice their roles in activating the green economy domains in education and the mechanisms for enhancing them in the light of Oman 2040 Vision. *J. Educ. Sci.* **2023**, *20*, 73–101. [CrossRef]
14. Al-Naaimi, M.R. Experts' perceptions towards employing the sustainable circular economy in Omani science and social studies curricula. *Sci. J. King Faisal Univ. Humanit. Manag. Sci.* **2025**, *26*, 31–39. [CrossRef]
15. Ministry of Education (Sultanate of Oman). *Green Schools Project*; Oman Educational Portal: Muscat, Oman, 2023. Available online: https://home.moe.gov.om/en/topics/0/show/2230 (accessed on 5 August 2026).
16. Environment Society of Oman (ESO). Namat Schools Competition. Available online: https://eso.org.om/ar/namat-competition/ (accessed on 5 August 2026).
17. Oman Vision 2040 Implementation Follow-Up Unit. *Oman Vision 2040 Document*; Sultanate of Oman: Muscat, Oman, 2020. Available online: https://www.oman2040.om/oman2040 (accessed on 5 August 2026).
18. Di Vaio, A.; Hasan, S.; Palladino, R.; Hassan, R. The transition towards Circular Economy and waste within accounting and accountability models: A systematic literature review and conceptual framework. *Environ. Dev. Sustain.* **2023**, *25*, 734–810. [CrossRef] [PubMed]
19. Khan, S.; Haleem, A. Investigation of Circular Economy practices in the context of emerging economies: A CoCoSo approach. *Int. J. Sustain. Eng.* **2021**, *14*, 357–367. [CrossRef]
20. UNESCO. *Green School Quality Standard: Greening Every Learning Environment*; UNESCO: Paris, France, 2024. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000391218 (accessed on 5 August 2026).
21. UNESCO. Greening Education Partnership. Available online: https://www.unesco.org/en/sustainable-development/education/greening-future (accessed on 5 August 2026).
22. UNESCO. Greening Every School. Available online: https://www.unesco.org/en/sustainable-development/education/greening-future/schools (accessed on 5 August 2026).
23. United Nations Economic and Social Commission for Western Asia (ESCWA). *Accelerating Circularity in the Arab Region*; E/ESCWA/CL1.CCS/2023/Policy Brief.2; ESCWA: Beirut, Lebanon, 2023. Available online: https://www.unescwa.org/publications/accelerating-circularity-arab-region (accessed on 5 August 2026).
24. United Nations Economic and Social Commission for Western Asia (ESCWA). *Mainstreaming a Circular Economy in the Arab Region: Guidelines for a Cross-Sectoral Transition*; E/ESCWA/CL1.CCS/2024/Guidelines.1; ESCWA: Beirut, Lebanon, 2025. Available online: https://www.unescwa.org/publications/mainstreaming-circular-economy-arab-region (accessed on 5 August 2026).
25. Al Mahameed, M.; Riaz, U.; Aldoob, M.S.; Halari, A. The implementation of sustainability practices in Arab higher education institutions. *J. Financ. Report. Account.* **2025**, *23*, 1161–1185. [CrossRef]

26. Baroudi, S.; Abi Haidar, H. Sustainability in the United Arab Emirates secondary schools: A policy practice analysis. *Sustainability* **2025**, *17*, 3129. [CrossRef]
27. Vare, P.; Arro, G.; de Hamer, A.; Del Gobbo, G.; de Vries, G.; Farioli, F.; Kadji-Beltran, C.; Kangur, M.; Mayer, M.; Millican, R.; et al. Devising a competence-based training program for educators of sustainable development: Lessons learned. *Sustainability* **2019**, *11*, 1890. [CrossRef]
28. Ellen MacArthur Foundation. What Is a CE? Available online: https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview (accessed on 5 August 2026).
29. U.S. Environmental Protection Agency (EPA). Sustainable Materials Management. Available online: https://www.epa.gov/smm (accessed on 5 August 2026).
30. Ellen MacArthur Foundation. *Towards the Circular Economy Vol. 2: Opportunities for the Consumer Goods Sector*; Ellen MacArthur Foundation: Cowes, UK, 2013. Available online: https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-2-opportunities-for-the-consumer-goods (accessed on 5 August 2026).
31. Ellen MacArthur Foundation. *Completing the Picture: How the Circular Economy Tackles Climate Change*; Ellen MacArthur Foundation: Cowes, UK, 2021. Available online: https://www.ellenmacarthurfoundation.org/completing-the-picture (accessed on 5 August 2026).
32. European Parliament. *Making Durable, Reparable Goods for Consumers and Tackling Planned Obsolescence*; Press Release; European Parliament: Strasbourg, France, 2017. Available online: https://www.europarl.europa.eu/news/en/press-room/20170530IPR76313/making-durable-reparable-goods-for-consumers-and-tackling-planned-obsolescence (accessed on 5 August 2026).
33. Ghisellini, P.; Cialani, C.; Ulgiati, S. A review on Circular Economy: The expected transition to a balanced interplay of environmental and economic systems. *J. Clean. Prod.* **2016**, *114*, 11–32. [CrossRef]
34. Tilbury, D. Environmental education for sustainability: Defining the new focus of environmental education in the 1990s. *Environ. Educ. Res.* **1995**, *1*, 195–212. [CrossRef]
35. Hobson, K.; Lynch, N. Diversifying and de-growing the Circular Economy: Radical social transformation in a resource-scarce world. *Futures* **2016**, *82*, 15–25. [CrossRef]
36. Yuana, S.; Wiliyanto, W.; Hadiyantono, T.; Figueroa, M.J.; Hapsari, M.; Pinem, M.L. Mundane Circular Economy policy: Mainstreaming Circular Economy education through the agency of schools. *J. Clean. Prod.* **2024**, *440*, 140847. [CrossRef]
37. Yuana, S.L. Mundane Circular Economy policy: Peta kebijakan dan kriteria sekolah sirkular di level pendidikan dasar. *Indones. Perspect.* **2023**, *8*, 180–205. [CrossRef]
38. Martinez, S.; Rodríguez, J.C.; Lestari, S. Exploring digital Circular Economy principles in educational institutions. *Int. Trans. Educ. Technol.* **2024**, *3*, 17–25. [CrossRef]
39. Meria, L.; Bangun, C.S.; Edwards, J. Exploring sustainable strategies for education through the adoption of digital circular economy principles. *Int. Trans. Educ. Technol.* **2024**, *3*, 62–71. [CrossRef]
40. Ab Hamid, N.; Rasul, M.S.; Kamaruzaman, F.M. Identifying strategies to cultivate students' attitude towards Circular Economy. *J. Tech. Educ. Train.* **2024**, *16*, 12–24. [CrossRef]
41. Ministry of Economy, Sultanate of Oman. Circular Economy Gap Assessment Project in the Sultanate of Oman. Available online: https://economy.gov.om/NewsDetails.aspx?id=353 (accessed on 27 September 2026).
42. Oman News Agency. Integrating the Concepts of Sustainability and the Circular Economy into Omani School Curricula. Oman News Agency. 2023. Available online: https://omannews.gov.om/topics/ar/3/show/415472 (accessed on 5 August 2026).
43. Ministry of Education (Sultanate of Oman). The Ministry of Education Launches the Concepts Document on Sustainability and the Circular Economy. *Educational Portal*, 9 October 2023. Available online: https://home.moe.gov.om/en/topics/0/show/2237 (accessed on 5 August 2026).
44. Ministry of the Environment (Government of Japan). *Annual Report on the Environment, the Sound Material-Cycle Society and Biodiversity in Japan 2016*; Ministry of the Environment: Tokyo, Japan, 2016. Available online: https://www.env.go.jp/en/wpaper/ (accessed on 5 August 2026).
45. Ministry of Education, Sultanate of Oman. *Annual Educational Statistics Book, Issue 55, 2024/2025*; Ministry of Education: Muscat, Oman, 2025. Available online: https://home.moe.gov.om/images/library/file/Book795368.pdf (accessed on 25 September 2026).
46. European Commission. *A New Circular Economy Action Plan: For a Cleaner and More Competitive Europe*; COM/2020/98 final; Publications Office of the European Union: Luxembourg, 2020. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0098 (accessed on 5 August 2026).
47. Council of the European Union. *Council Recommendation of 16 June 2022 on Learning for the Green Transition and Sustainable Development*; Council of the European Union: Brussels, Belgium, 2022. Available online: https://education.ec.europa.eu/node/2164 (accessed on 5 August 2026).
48. Bianchi, G.; Pisiotis, U.; Cabrera Giraldez, M. *GreenComp: The European Sustainability Competence Framework*; Publications Office of the European Union: Luxembourg, 2022. [CrossRef] [PubMed]
49. Foundation for Environmental Education (FEE). *Eco-Schools Handbook: Empowering Students for a Sustainable World*; FEE: Copenhagen, Denmark, 2023. Available online: https://www.ecoschools.global (accessed on 5 August 2026).

50. Qu, D.; Shevchenko, T.; Yan, X. University curriculum education activities towards Circular Economy implementation. *Int. J. Sci. Technol. Res.* **2020**, *9*, 200–206.
51. Sousa, S. Some reflections on the role of the Eco-Schools program in the promotion of sustainable HEIs: A case study in Portugal. *Adm. Sci.* **2022**, *12*, 149. [CrossRef]
52. Trukšāns, D. Towards municipal environmental development: Environmental management systems for local formal education establishments. *Reg. Format. Dev. Stud.* **2022**, *23*, 175–185. [CrossRef]
53. Henderson, K.; Tilbury, D. *Whole-School Approaches to Sustainability: An International Review of Whole-School Sustainability Programs*; Australian Government Department of the Environment and Heritage: Canberra, Australia, 2004. Available online: https://researchers.mq.edu.au/en/publications/whole-school-approaches-to-sustainability-an-international-review/ (accessed on 5 August 2026).
54. Rieckmann, M. Learning to transform the world: Key competencies in education for sustainable development. In *Issues and Trends in Education for Sustainable Development*; Leicht, A., Heiss, J., Byun, W.J., Eds.; UNESCO: Paris, France, 2018; pp. 39–59. ISBN 978-92-3-100244-1.
55. Creswell, J.W.; Creswell, J.D. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 5th ed.; SAGE Publications: Thousand Oaks, CA, USA, 2018.
56. Andrews, D. The Circular Economy, design thinking and education for sustainability. *Local Econ.* **2015**, *30*, 305–315. [CrossRef]
57. Avila, M.L.; Stinson, J.; Kiss, A.; Brandão, L.R.; Uleryk, E.; Feldman, B.M. A critical review of scoring options for clinical measurement tools. *BMC Res. Notes* **2015**, *8*, 612. [CrossRef] [PubMed]
58. Rattray, J.; Jones, M.C. Essential elements of questionnaire design and development. *J. Clin. Nurs.* **2007**, *16*, 234–243. [CrossRef] [PubMed]
59. Hsieh, H.-F.; Shannon, S.E. Three approaches to qualitative content analysis. *Qual. Health Res.* **2005**, *15*, 1277–1288. [CrossRef] [PubMed]
60. Elo, S.; Kyngäs, H. The qualitative content analysis process. *J. Adv. Nurs.* **2008**, *62*, 107–115. [CrossRef] [PubMed]
61. Holst, J.; Grund, J.; Brock, A. Whole institution approach: Measurable and highly effective in empowering learners and educators for sustainability. *Sustain. Sci.* **2024**, *19*, 1359–1376. [CrossRef]
62. Bugallo-Rodríguez, A.; Vega-Marcote, P. Circular Economy, sustainability and teacher training in a higher education institution. *Int. J. Sustain. High. Educ.* **2020**, *21*, 1351–1366. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.