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Developing a unit from the geography textbook in light of the circular economy and measuring its effectiveness in developing students' understanding and comprehension of geography and rationalizing consumption

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Abstract

The study aimed to develop a unit from the geography textbook in light of the circular economy and measure its effectiveness in enhancing geographical understanding and comprehension, as well as promoting consumption rationalization among students. To achieve this objective, a quasi-experimental approach was adopted. The study tools included a geographical understanding and comprehension test consisting of 20 questions and a consumption rationalization scale comprising 26 items distributed across three dimensions: electricity, water, and economic activities. The validity and reliability of these tools were verified. The study was conducted on a sample of 60 ninth-grade female students from Aisha Al-Ba'ouniyah Basic Mixed School in the Northern Mazar District, divided into two groups: an experimental group (30 students) who studied using the developed unit and a control group (30 students) who studied using the conventional unit. The results revealed statistically significant differences in the scores of the study participants on the geographical understanding and comprehension test based on the instructional unit (developed vs. conventional), in favor of the experimental group who studied the developed unit, with an effect size of 40.7%. Additionally, the results indicated statistically significant differences in the consumption rationalization scale scores, both at the overall level and across all its dimensions, favoring the experimental group who studied the developed unit, with an effect size of 75.1%. The study recommended utilizing the developed instructional unit in light of the circular economy due to its significance in enhancing students' geographical understanding and comprehension, as well as their consumption rationalization. It also urged geography textbook authors to incorporate indicators and concepts of the circular economy in textbooks during the authoring process.

Keywords: Circular economy, Consumption rationalization, Developed unit, Geographical understanding and comprehension, Geography textbook.

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1. Introduction

Geography is no longer merely a discipline that describes phenomena superficially. With modern scientific and technological advancements, it has evolved to rely on analysis, measurement, interconnection, and the application of contemporary models and theories. This transformation in methodologies and tools has been termed the "quantitative revolution in geography." Geography is distinguished by its study of both natural and human sciences, making its role particularly significant. It is one of the disciplines that fosters critical thinking, as developing and acquiring thinking skills are primary objectives of geography education across all academic stages [1].

With the onset of the current millennium, global attention has shifted toward the new development model known as the "circular economy," which serves as an alternative to the prevailing linear industrial development model. The linear model is based on resource extraction for manufacturing products, which are then discarded as waste without recovery, often through polluting and unsustainable methods such as incineration and landfill disposal. The negative consequences of this linear model pose a serious threat to economic stability and the sustainability of essential resources for economic development [2].

When designed in a well-structured and comprehensive manner, the circular economy has the potential to protect the environment, enhance economic performance, and promote social justice. Sustainability fundamentally requires social justice, as the ways in which we extract, use, and dispose of resources can disproportionately impact vulnerable communities. Historically, disadvantaged communities have borne the brunt of the environmental and health hazards associated with a non-circular economy, as many waste disposal sites, manufacturing facilities, and processing plants are located near low-income communities. Consequently, the circular economy aims to minimize waste and toxic materials, reuse critical resources during manufacturing, ensure safe employment practices, and promote consumption rationalization [3].

Geography, as a branch of social studies, provides fertile ground for developing and teaching thinking skills. It is a discipline centered on examining and understanding the relationships between humans and their natural environment and analyzing their interactions. The nature of geography as a subject fosters students' abilities in observation, research, reasoning, understanding causality, and recognizing the various forms and degrees of human-environment interaction [4].

The study of geography is based on observing natural and human phenomena on Earth's surface, requiring students to research, think critically, and investigate the causes of these phenomena to understand their outcomes. Through research, inquiry, and reflective thinking, students can acquire a vast array of geographical facts, concepts, and generalizations in a structured and sequential manner, equipping them with essential geographical thinking skills for effective and thorough learning [5].

A new concept of the circular economy, known as the "service economy," has emerged, promoting a global shift from individual ownership to the idea of "usage licenses and shared services." This transformation is driven by the need to address climate change, rapid population growth, and the limited availability of natural resources. The circular economy can thus be defined as an innovative approach that optimizes the use of natural resources within closed-loop systems, reinforcing sustainability principles by responding to the environmental, social, and economic challenges posed by current production and consumption practices [6].

The significance of the circular economy lies in fostering the concept of consumption rationalization, which can be instilled in and developed among school students. Consumption is inherently linked to education, as it represents a form of human behavior known as consumer behavior. Education plays a crucial role in shaping and refining this behavior for the better. The environment serves as the medium that absorbs the beneficial or harmful byproducts of consumption. Therefore, all societal institutions must collaborate in the educational process to fulfill their role in modifying individuals' consumption behaviors [7].

Ayman [8] highlighted that the consumption and growth patterns accompanying industrialization since the Industrial Revolution have led to resource depletion, increased greenhouse gas emissions and pollution, and the accumulation of waste. These trends have placed ecosystems at risk and jeopardized the availability of resources and ecosystem services, thereby steering societies and development trajectories toward unsustainable paths. The linear industrial model has been characterized as waste-intensive, failing to incorporate recycling and reuse. Consumption rationalization can be achieved through various measures and actions taken by individuals, families, and governments to ensure the optimal and most efficient use of resources, ultimately yielding positive impacts on individuals, families, and society as a whole.

Geographical understanding is one of the key objectives of geography education. This is reflected in the range of skills it cultivates in students, such as the ability to conduct geographical comparisons and analyses, interpret and comprehend maps, graphs, and diagrams, extract relevant information, apply logical reasoning, and use rules and generalizations to explain

new situations. Additionally, it enhances students' abilities to recognize relationships and apply generalizations to real-life contexts [9].

The dimensions of geographical understanding play a crucial role in structuring the knowledge framework of geography curricula. They help organize information, knowledge, facts, and experiences covered in the curriculum, facilitating the learning process amid the rapid expansion of knowledge. Moreover, these dimensions serve as a cornerstone of education by deepening students' comprehension of the subject matter, establishing connections between facts, and equipping them with a structured knowledge base that enables them to identify new examples and interpret various real-world scenarios [10].

Abdullah [11] highlighted that geographical understanding consists of three main levels:

1. Translation Skills – the ability to express a particular idea through different formats, whether visual, verbal, or written. This cognitive process facilitates comprehension by converting thoughts into corresponding representations.
2. Interpretation Skills – The ability to discover and utilize relationships between two or more ideas.
3. Inferential Reading Skills – The ability to predict and deduce knowledge from given information, typically when a topic is presented concisely.

According to Ababneh [12], geographical understanding and comprehension among students help achieve geography education objectives, including:

- Acquiring geographical knowledge (facts, concepts, generalizations, theories, laws).
- Developing values, attitudes, and inclinations toward environmental conservation and resource sustainability.
- Preparing students for the present and future by fostering predictive abilities.
- Enhancing geographical thinking through observation, reasoning, inference, comparison, and analysis.
- Appreciating the interaction between humans and their environment.
- Strengthening students' spatial awareness.

Scholars have increasingly focused on the circular economy and its role in sustainable development.

- Gujarati [13] examined the relationship between the circular economy and sustainable development in the face of accelerating global economies. The study emphasized the need for a conscious approach to product design and production to ensure sustainability. Advanced economies have developed recycling-based economies, fostering circular principles as a critical aspect of sustainable development. The study found that the circular economy effectively integrates biological science principles into socio-economic activities, promoting clean production, comprehensive resource utilization, and sustainable consumption. It also highlighted the necessity of policies, regulations, taxation, and technological advancements to support the transition to a circular economy.
- Albanna [14] conducted a study on developing the geography curriculum for first-year secondary students in Egypt by incorporating green economy principles to enhance sustainable development and social responsibility. The study designed a modified curriculum, including updated units, student activities, and a teacher's guide. The results showed the effectiveness of the revised curriculum in improving students' cognitive and behavioral aspects of sustainability.
- Al-Obaidi and Al-Obaidi [15] explored the role of the circular economy in achieving sustainable development in Iraq using an analytical approach. The findings indicated that the circular economy serves as a new economic model, replacing traditional linear consumption and production practices by minimizing waste and promoting recycling. The study recommended revitalizing Iraqi industries and prioritizing this sector.
- Laius et al. [16] investigated students' understanding of the circular economy and recycling in 9th and 12th grades. The study involved a sample of 27 students from a rural school and assessed prior knowledge using a drawing-based tool. A two-hour training session was conducted, including practical activities followed by worksheets and questionnaires to evaluate new knowledge and perceptions. The results revealed significant differences in prior knowledge and attitudes between 9th and 12th-grade students, with older students demonstrating greater awareness of the circular economy's importance. Additionally, students' attitudes improved beyond mere comprehension, showing increased motivation toward sustainable actions.
- Rakaban et al. [17] studied the relationship between household consumption rationalization and the circular economy, focusing on women's roles in sustainable household consumption. The study used a questionnaire-based survey with 500 housewives in Menoufia, Egypt, exploring consumer attitudes toward sustainability and the impact of women on promoting sustainable household practices. The study applied a descriptive and analytical approach and found a strong correlation between women's ability to manage household spending and circular economy principles.

The literature emphasizes that geographical understanding and circular economic principles are crucial for achieving sustainability goals. Integrating sustainable consumption, waste reduction, and resource efficiency into education and daily practices can enhance environmental responsibility and long-term economic stability. Studies suggest that curriculum development, policy implementation, and social awareness initiatives play a vital role in shaping sustainable behaviors and fostering circular economy principles.

2. Research Problem and Questions

Through a review of geography textbooks, researchers observed a lack of emphasis on circular economic concepts, a finding supported by the studies of Al-Azzam [18]. The research problem emerged from the researchers' observation that students lack understanding and comprehension of circular economy principles and consumption rationalization. This gap may be attributed to traditional teaching methods still used by some geography teachers, negatively impacting students'

learning. Additionally, the researchers noted a deficiency among geography teachers in integrating circular economy concepts into geography lessons.

As a response to these findings, this study aligns with recommendations advocating for the inclusion of circular economy and sustainable development topics in geography textbooks. The study aimed to develop a geography textbook unit based on circular economy principles and evaluate its effectiveness in enhancing students' consumption rationalization and geographical comprehension.

Specifically, the study addresses the following research questions:

1. Are there statistically significant differences at a significance level of ($\alpha \leq 0.05$) between the mean scores of the control and experimental groups in the consumption rationalization scale, attributed to the type of instructional unit (traditional vs. developed)?
2. Are there statistically significant differences at a significance level of ($\alpha \leq 0.05$) between the mean scores of the control and experimental groups in the geographical comprehension test, attributed to the type of instructional unit (traditional vs. developed)?

3. Study Significance

This study is expected to benefit various educational stakeholders:

- Curriculum developers: By encouraging the integration of circular economy concepts into geography textbooks in Jordan.
- Geography teachers: By providing insights into how circular economic principles can be incorporated into geography instruction.
- Geography students: By improving their understanding of circular economic topics and their importance in geographical comprehension and consumption rationalization.
- The Ministry of Education's Training Directorate: By offering training programs for social studies teachers, particularly geography teachers, on incorporating circular economy principles into social studies instruction.

4. Study Terms and Operational Definitions

- Developing a unit based on the circular economy: The researchers define this as modifying all aspects of a ninth-grade geography textbook unit to align with circular economy principles, including learning objectives, content, teaching methods, activities, and assessments. Additional activities and enrichment materials were incorporated.
- Circular Economy: Defined as an economic system that seeks to preserve the value of products, materials, and resources for as long as possible, thereby decoupling manufacturing, production, and consumption growth from natural resource use while offering economic, social, and environmental benefits [19].

Operational Definition: The structured knowledge, experiences, and planned activities that help students understand how to apply circular economy principles within the unit "Contemporary Environmental Issues" in the ninth-grade geography textbook. This includes topics such as water purification, seawater desalination, air filtration, and proposing solutions to environmental problems using circular economy standards.

- Consumption Rationalization: Defined as the efficient and sustainable use of resources, products, and services, aiming to reduce waste, minimize excessive consumption, and conserve natural resources while balancing individual and community needs to ensure the well-being of future generations. It also encompasses social justice, biodiversity conservation, and climate change considerations [7].

Operational Definition: Students' ability to demonstrate skills related to water and food consumption rationalization, as well as sustainable economic activities. This was assessed using a test specifically designed for this study.

- Geographical comprehension: a cognitive process beyond simple recall, involving students' analysis and interpretation of geographical phenomena, as indicated by behaviors such as explaining, translating, interpreting, and inferring [20].

Operational Definition: Students' ability to comprehend, analyze, interpret, and apply geographical knowledge, as well as make judgments and demonstrate creativity. This was assessed using a geographical comprehension test developed for this study.

5. Study Scope and Limitations

- Subject Scope: This study focuses on evaluating the effectiveness of a developed geography unit, "Contemporary Environmental Issues," based on circular economy principles in enhancing consumption rationalization and geographical comprehension among students.
- Time limit: The study was conducted during the 2024/2025 academic year.
- Location: The study was conducted at Aisha Al-Baouniyah Mixed Basic School, Al-Mazar Al-Shamali District, Jordan.
- Participants: The study targeted a sample of ninth-grade female students.

6. Methodology and Procedures

6.1. Research Method

Given the nature of the study, a quasi-experimental design was employed to measure the effectiveness of a developed geography textbook unit based on circular economy principles in enhancing students' geographical comprehension and consumption rationalization. The study utilized an experimental group and a control group to test the research hypotheses.

6.2. Study Participants

The study sample consisted of 60 ninth-grade female students enrolled in the 2024/2025 academic year at Aisha Al-Baouniyah Mixed Basic School, located in Al-Mazar Al-Shamali District. The school was chosen purposefully due to the cooperation of the geography teacher and her willingness to support the study's implementation.

The study sample was randomly divided into two groups:

- Control Group: 30 students, taught using the traditional geography unit.
- Experimental Group: 30 students, taught using the developed geography unit ("Contemporary Environmental Issues").

6.3. Research Instruments

The study relied on two primary tools:

6.3.1. Geographical Comprehension Test

The geographical comprehension test was developed following these steps:

1. Reviewing relevant literature and previous studies related to geographical comprehension, such as Jassim [21], Fahd and Al-Baili [22] and Abu Zeid [23].
2. Analyzing the "Contemporary Environmental Issues" unit from the ninth-grade geography textbook to determine its key learning outcomes.
3. Formulating multiple-choice questions to measure students' geographical comprehension, with an initial version containing 20 questions.

6.3.1.1. Validity of the Geographical Comprehension Test

To ensure validity, the test was evaluated by 22 experts, including curriculum specialists, geography educators, and university professors. They assessed:

- The clarity and appropriateness of the questions.
- The extent to which the test measures geographical comprehension.
- The scientific and linguistic accuracy of the questions.

Based on expert feedback:

- The test was revised to include only three answer choices per question.
- Minor linguistic modifications were made to improve clarity.
- The final version contained 20 multiple-choice questions.

6.3.1.2. Construct Validity

To verify construct validity, the test was administered to a pilot sample of 28 students (not part of the main study). The Pearson correlation coefficient was calculated to assess the relationship between each test item and the overall test score.

6.3.2. Consumption Rationalization Scale

The consumption rationalization scale was developed as follows:

1. Defining the objective: Measuring ninth-grade students' consumption rationalization in geography.
2. Reviewing educational literature and previous studies related to consumption rationalization, such as Darwish [24].
3. Formulating the initial version with 26 statements, distributed across three key dimensions:

- Electricity Consumption (10 items)
- Water Consumption (6 items)
- Economic Activities (10 items)

The scale used a five-point Likert scale:

- Very High
- High
- Moderate
- Low
- Very Low

6.4. Validity of the Consumption Rationalization Scale

The scale was reviewed by 22 experts specializing in curriculum design, geography education, and sustainable development. They evaluated:

- Clarity and appropriateness of the statements.
- Relevance to the study objectives.

- Necessary modifications, including merging similar statements and standardizing terminology (e.g., grouping "devices" and "electronics" under electrical appliances).
- Replacing the three-point Likert scale with a five-point Likert scale to improve response accuracy.
  After incorporating expert feedback, the final version of the scale consisted of 26 statements, categorized as follows:
- Electricity Consumption: 10 statements
- Water Consumption: 6 statements
- Economic Activities: 10 statements

6.5. Study Variables

6.5.1. Independent Variable

- The development of a geography textbook unit based on circular economy principles.

6.5.2. Dependent Variables

- Geographical comprehension.
- Consumption rationalization.

6.5.3. Study Procedures

To achieve the study objectives, the following steps were taken:

- Conducting a literature review through online databases, academic journals, and previous studies on contemporary environmental issues and circular economy principles.
- Defining the research problem and formulating the research questions.
- Selecting the "Contemporary Environmental Issues" unit from the ninth-grade geography textbook for the first semester (2024/2025). This unit consists of six lessons:

1. Atmospheric Issues
2. Water Pollution
3. The Shrinking of the Dead Sea
4. Food Security in the Arab World
5. Energy Resources in the Arab World

The unit was then modified in alignment with circular economic indicators.

- Developing the study instruments (Geographical Comprehension Test & Consumption Rationalization Scale) and verifying their validity and reliability.
- Selecting the control and experimental groups using a random sampling method from Aisha Al-Baouniyah Mixed Basic School in Al-Mazar Al-Shamali District.
- Obtaining an official approval letter from Yarmouk University addressed to the Directorate of Education in Al-Mazar Al-Shamali.
- Securing an official letter from the Directorate of Education to the principal of Aisha Al-Baouniyah Mixed Basic School.
- Pre-testing the Geographical Comprehension Test and Consumption Rationalization Scale on both study groups (experimental and control) before implementing the developed unit on January 19, 2024.
- Conducting experimental intervention as follows:

1. Experimental Group: Taught using the developed unit.
2. Control Group: Taught using the traditional teaching method.
3. The intervention took place from January 19, 2024, to February 11, 2024, with three weekly sessions (total: 12 sessions).
4. The researcher provided all necessary tools, including digital devices, learning activities, and teaching aids.
5. The lessons were conducted in the computer lab using a data show projector to display the modified content. Each student had access to a computer, along with a notebook and pen for note-taking and activity completion.
6. The geography teacher at the school taught both control and experimental groups, with the researcher maintaining constant communication for feedback and support.

- Post-testing was conducted on February 11, 2024, using the Geographical Comprehension Test and Consumption Rationalization Scale.
- The responses and scores were recorded and analyzed using appropriate statistical methods.
- The results were interpreted and discussed, followed by recommendations.

6.6. Statistical Analysis

Data analysis was performed using the following statistical techniques:

1. Descriptive Statistics:
   - Mean scores and standard deviations for the pre-test and post-test scores in both study groups.
2. Inferential Statistics**:**

- An Independent Samples t-test was used to examine the equivalence of the control and experimental groups in the pre-test.

- Analysis of Covariance (ANCOVA) was employed to analyze differences between the two groups in terms of:
- Geographical Comprehension Test results.
- Consumption Rationalization Scale scores.
- Multivariate Analysis of Covariance (MANCOVA) was used to analyze differences in the three dimensions of the Consumption Rationalization Scale.

7. Study Results

7.1. Findings Related to the First Research Question

The first research question investigated whether there were statistically significant differences at ($\alpha = 0.05$) between the control and experimental groups in the Geographical Comprehension Test due to the teaching method (traditional vs. developed unit).

To address this question, the mean scores and standard deviations of both groups in the pre-test and post-test were calculated. Table 6 presents the results.

Table 1.
Mean Scores and Standard Deviations of the Control and Experimental Groups in the Pre-Test and Post-Test of the Geographical Comprehension Test Based on the Educational Unit Variable.

Group	**Pre-Test**		**Pre-Test**	
Experimental Group (Developed Unit)	**9.97**	**2.33**	**Mean**	**Standard Deviation**
Control Group (Traditional Unit)	9.80	2.86	16.43	2.13
Group	Pre-Test Mean	Pre-Test Standard Deviation	12.77	2.45

Source: Total Score: 20.

It is evident from Table 1 that there are apparent differences between the mean scores of the study participants on the geographical comprehension skills test in the pre-test and post-test according to the educational unit (traditional - developed). To determine whether these differences are statistically significant, a one-way ANCOVA was used for the post-test scores of the geographical comprehension test as a whole, based on the educational unit (traditional - developed), after controlling for the effect of the pre-test. The following presents these results, as shown in Table 2.

Table 2.
One-Way ANCOVA Analysis of the Post-Test Scores of the Study Participants on the Geographical Comprehension Test According to the Educational Unit (Traditional - Developed) After Controlling for the Effect of the Pre-Test.

Source of Variation	**Sum of Squares**	**Degrees of Freedom**	**Mean Square**	**F Value**	**Significance Level**	**Eta Squared (η^2)**
Pre-Test	16.676	1	16.676	3.300	0.075	0.055
Teaching Method	197.702	1	197.702	39.121	0.000	0.407
Error	288.057	57	5.054			
Total	13296.000	60				
Corrected Total	506.400	59				

It is evident from Table 2 that there are statistically significant differences at the significance level ($\alpha = 0.05$) in the study participants' scores on the geographic understanding and comprehension skills test according to the teaching unit (conventional - developed). The F-value was found to be (39.121), with a statistical significance of (0.000), indicating a statistically significant effect of the teaching strategy. Furthermore, the table shows that the effect size of the teaching method was large; the Eta squared (η^2) value explained (40.7%) of the variance in the dependent variable, which is the geographic understanding and comprehension test. To determine where the differences lie, the adjusted means and their standard errors for each group were calculated as shown in Table 3.

Table 3.
Shows the adjusted means and standard errors for the geographic understanding and comprehension skills test according to the teaching unit.

Teaching Method	**Adjusted Mean**	**Standard Error**
Developed Unit	16.416	0.41
Conventional Unit	12.784	0.41

It appears from Table 3 that the differences favored the experimental group, whose members were taught using the developed unit, compared to the control group (conventional unit). According to the results of the ANCOVA analysis in Table 7, the developed unit had a statistically significant effect on improving the performance of the experimental group in developing geographical understanding and comprehension.

This result can be attributed to the fact that the content of the unit, which was developed by the teacher, was applied through a scientific methodology that contributed to the students' geographical understanding and comprehension. The

teacher employed group work by dividing the students into groups, which led to the development of dialogue, discussion, and teamwork. This resulted in an increased understanding and comprehension of various concepts in the unit.

This result can also be explained by the fact that the educational material was presented through video, which significantly helped in understanding many geographical concepts, unlike traditional methods that focus on rote learning and memorization. This contributed to the quality of dialogue and discussion between both the teacher and students, as well as among the students themselves.

Second: Results Related to the Second Question: The second question asked, "Are there statistically significant differences at the significance level (α=0.05) between the means of the control group and the experimental group on the Consumption Rationalization Scale due to the teaching method (conventional vs. developed)?"

To answer this question, the means and standard deviations of the ninth-grade students' scores on the Consumption Rationalization Scale in the pre- and post-tests were calculated, according to the group (experimental group, which studied using the developed unit, and the control group, which studied using the conventional unit), as shown in Table 8.

Table 4.
Means and Standard Deviations of the Study Participants' Scores on the Consumption Rationalization Skills Scale in the Pre- and Post-tests Based on the Group (Experimental, Control).

Group Mean	Pre-test Level		Post-test Level	
	Standard Deviation	Mean	Mean	Standard Deviation
Experimental (Developed Unit)	2.34	0.27	3.55	0.22
Control (Conventional Unit)	2.36	0.23	2.67	0.29

It is evident from Table 8 that there are apparent differences between the means of the study participants' scores on the Consumption Rationalization Scale in the pre-test and post-test applications according to the instructional unit (conventional - developed). To determine whether these differences are statistically significant, a one-way analysis of covariance (One-way ANCOVA) was conducted for the post-test measurement of the Consumption Rationalization Scale as a whole, based on the instructional unit (conventional - developed), after controlling for the effect of the pre-test application. The results are presented in Table 10.

Table 5.
One-Way ANCOVA for the Post-Test Scores of Study Participants on the Consumption Rationalization Scale According to the Instructional Unit (Conventional - Developed) After Controlling for the Pre-Test Application Effect.

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Squares	F Value	Significance Level	Eta Squared (η^2)**
Pre-Test Measurement	0.011	1	0.011	0.168	0.683	0.003
Teaching Method	11.568	1	11.568	171.594	0.000	0.751
Error	3.843	57	0.067			
Total	595.430	60				
Corrected Total	15.414	59				

It is evident from Table 5 that there are statistically significant differences at the significance level ($\alpha = 0.05$) in the study participants' scores on the Consumption Rationalization Scale based on the instructional unit (traditional - developed). The F-value reached 171.594 with a statistical significance of 0.000, indicating a statistically significant effect of the teaching strategy.

Furthermore, the table shows that the effect size of the teaching method was large, as the Eta squared (η^2) value accounted for 75.1% of the explained variance in the dependent variable, which is the Consumption Rationalization Scale.

To determine the direction of these differences, the adjusted means and their standard errors were calculated based on the group, as shown in Table 6.

Table 6.
Adjusted Means and Standard Errors for the Consumption Rationalization Scale According to the Group.

Group	Adjusted Mean	Standard Error
Experimental (Developed Unit)	3.549	0.047
Control (Traditional Unit)	2.670	0.047

It is evident from Table 6 that the differences favored the experimental group, whose members were taught using the digital science stations method, compared to the control group (traditional method). According to the results of Table 10, ANCOVA analysis indicated that the developed unit had a statistically significant effect on improving the performance of the experimental group in developing consumption rationalization skills.

Subsequently, the means and standard deviations for the pre- and post-performance of the study participants were calculated separately for each domain of the Consumption Rationalization Scale, according to the group variable, as shown in Table 7.

Table 7.
Means and Standard Deviations for the Pre- and Post-Performance of Study Participants in the Consumption Rationalization Scale Separately for Each Domain.

Domain		Pre-Test		Post-Test	
	Group	Mean	Standard Deviation	Mean	Standard Deviation
Electricity	Experimental	2.45	0.38	3.67	0.20
	Control	2.46	0.33	2.93	0.54
	Total	2.45	0.35	3.30	0.55
Water	Experimental	2.15	0.46	3.43	0.50
	Control	2.20	0.24	2.49	0.35
	Total	2.18	0.36	2.96	0.64
Economic Activities	Experimental	2.40	0.40	3.54	0.47
	Control	2.42	0.53	2.59	0.65
	Total	2.41	0.46	3.06	0.74

It can be observed from Table 7 that there are apparent differences between the mean scores in the pre-test and post-test of the Consumption Rationalization Scale. To verify the significance of these apparent differences, a one-way repeated measures analysis of variance was applied as shown in Table 8.

Table 8.
Results of the one-way repeated measures analysis of variance for the effect of group (experimental, control) on the Consumption Rationalization Scale.

Effect	Type of Multiple Test | Value of Multiple Test | F (Total) |	Type of Multiple Test Value of Multiple Test | F (Total) |	Type of Multiple Test Value of Multiple Test | F (Total) |	Hypothesis Degrees of Freedom	Error Degrees of Freedom	Statistical Significance	Effect Size (η^2)
Group	Hotelling´s Trace	2.442	45.579	3.000	56.000	0.000	0.709

It can be observed from Table 8 that there is a statistically significant effect of the teaching strategy variable on consumption rationalization skills. The values of Eta squared indicate that the group variable explains 70.9% of the variance in performance across the three areas of consumption rationalization. To test the statistical significance of the observed differences in the post-performance of study participants in the areas of electricity, water, and economic activities after controlling for the pre-test effect according to the group, a one-way analysis of variance (Subject Effect Test of Between) was performed.

Table 9.
One-Way ANCOVA (Subject Effect Test of Between) to test the statistical significance of the differences in the post-performance of study participants on the areas of the consumption rationalization scale (individually) after controlling for the pre-test performance effect according to the group.

Source of Variance	Domain	Sum of Squares	Degrees of Freedom	Mean Square	F	Statistical Significance	Effect Size (η^2)
Pre-test Covariate	Electricity	0.162	1	0.162	0.987	0.325	0.017
	Water	0.462	1	0.462	2.552	0.116	0.043
	Economic Activities	0.032	1	0.032	0.096	0.758	0.002
Teaching Method	Electricity	8.323	1	8.323	50.644	0.000	0.470
	Water	12.835	1	12.835	70.898	0.000	0.554
	Economic Activities	13.625	1	13.625	41.309	0.000	0.420
Error	Electricity	9.368	57	0.164			
	Water	10.319	57	0.181			
	Economic Activities	18.800	57	0.330			
Total	Electricity	671.292	60				
	Water	550.553	60				
	Economic Activities	596.028	60				
Corrected Total	Electricity	17.826	59				
	Water	23.969	59				
	Economic Activities	32.435	59				

It is observed from Table 9 that there are statistically significant differences at the significance level ($\alpha = 0.05$) regarding the effect of the group (developed unit, traditional unit) in all domains. To determine which group the significant differences favor, the adjusted means and standard errors for the skills were calculated according to the group, as shown in Table 9.

Table 10.
Adjusted Means and Standard Errors for the Post-test Application of the Consumption Rationalization Scale According to the Group.

Doman	Group	Adjusted Mean	Standard Error
Electricity	Experimental Group (Developed Unit)	3.673	0.074
	Control Group (Traditional Unit)	2.928	0.074
Water	Experimental Group (Developed Unit)	3.426	0.078
	Control Group (Traditional Unit)	2.499	0.078
Economic Activities	Experimental Group (Developed Unit)	3.541	0.105
	Control Group (Traditional Unit)	2.588	0.105

It is observed from Table 10 that there is a difference between the performance of the experimental and control groups in the areas of consumption rationalization (electricity, water, economic activities), in favor of the experimental group. According to the results of the one-way ANCOVA in Table 10, it is shown that the developed unit has a statistically significant effect on improving the performance of the experimental group in the areas of consumption rationalization (electricity, water, economic activities). It is worth noting that the effect size for the skills ranged between 42.0% and 55.4%.

This result can be attributed to the fact that the developed unit was designed based on the concepts of circular economy, which aims to preserve materials and resources for as long as possible, and to promote growth in manufacturing, production, and consumption through the use of natural resources. This contributes to economic, social, and environmental benefits. Therefore, the circular economy upon which the developed unit was based contributed to enhancing the level of consumption rationalization among ninth-grade students by making the best use of natural resources that cannot be dispensed with. At the same time, their waste could lead society into decline. Water, for example, is a scarce resource in Jordan, which ranks among the lowest countries in terms of water sources globally. Therefore, the developed unit contributed to instilling behaviors among students to conserve water and use it optimally, while saving as much water as possible to prevent wastage. Similarly, in the case of electricity, citizens suffer from high electricity costs and may pay large amounts every month for electricity. However, some of these bills might be due to poor usage. The developed unit, based on the circular economy, worked to teach students how to optimally use and conserve electricity, ensuring there is no wastage, such as turning off lights in unused areas and maximizing the use of solar energy.

This result can also be attributed to the fact that the developed unit contained real-life examples, which contributed to improving the level of consumption rationalization in the field of economic activities. It included activities showing students how to use recycled goods, the importance of knowing them, avoiding the purchase of harmful chemical fertilizers for humans or the environment, how to care for and preserve trees, take care of livestock, and achieve self-sufficiency through the optimal use of available resources and prioritizing based on what is most important.

8. Recommendations

In light of the findings of this study, the researcher recommends the following:

- To benefit from the developed educational unit based on the circular economy for its importance in enhancing geographic understanding and consumption rationalization among students.
- To call on the Ministry of Education to add indicators of the circular economy in geography textbooks for their role in promoting consumption rationalization among students.

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