The Impact of Science Curricula on Climate Change Mitigation in Saudi Arabia: A Sustainable Development Perspective

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Abstract

This study aimed to explore the role of science curricula in reducing climate change in light of the dimensions of sustainable development in KSA. The study employed the descriptive analytical method to analyze science textbooks of the three-grade intermediate stage (2023-2024). The study utilized a content analysis sheet based on an indicator framework designed to assess the role of these curricula in reducing climate change. The study results revealed that the science textbooks of the intermediate stage in KSA show a limited role in addressing climate change within the context of sustainable development dimensions. The overall presence of indicators related to climate change reductions was found to be very low (10.1%). The distribution of these indicators is as follows: changes in the economy and production (29.4%), changes in the environment and atmosphere (27.2%), changes in occupational safety and security standards (16.2%), changes in the Earth's crust, seas, and oceans (15.4%), and changes in health and social responsibility (11.8%). Most of the indicators were included implicitly within subtopics rather than being treated as core topics. Many key issues were largely neglected such as air pollution, global warming, water pollution, oil spills, fossil fuel combustion, radioactive leakage, and the disruption of ocean currents. The study recommended conducting a systematic review of the content and activities of the intermediate-stage science textbooks in KSA.

Keywords: *Science Curriculum, Intermediate Stage, Climate Change, Sustainable Development Dimensions.*

Introduction

Climate change is one of the greatest challenges facing humanity in the modern era. It affects all spheres of life which is evident in rising temperatures, melting glaciers, as well as increasing floods frequency and droughts. These changes raise significant concerns about the future of the coming generations. Scientific research indicates that human activities, particularly fossil fuel burning and deforestation, play a critical role in accelerating this phenomenon (Cherry, 2011; Stevenson, et al., 2017). Consequently, it has become domineering to adopt effective strategies to reduce the effects of climate change and enhance environmental awareness across various sectors.

Education is considered one of these critical solutions (Ledley, et al., 2017; Leal Filho et al., 2021; Mochizuki & Bryan, 2015; Monroe et al., 2019). Integrating climate change-related topics into school curricula is recommended to enhance knowledge and understanding of the associated challenges, thereby contributing to the creation of an informed generation capable of addressing this global issue. Therefore, climate change topics have been incorporated into the curricula of various countries (Roehrig, et al., 2012) to prepare students at the beginning of their educational journeys to face these changes and increase their awareness. Studies have shown that students equipped with such knowledge demonstrate a greater interest in environmental issues (Cherry, 2011).

In addition to that, addressing climate change is indeed one of the Sustainable Development Goals (SDGs) outlined in the United Nations' 2015 report, "Transforming our world: The 2030 Agenda for Sustainable Development," which emphasizes that urgent action must be taken to combat climate change and its impacts by regulating emissions and promoting renewable energy developments. The report also asserts that combating climate change will only be achievable through the attainment of the SDGs (Houlden, et al., 2015).

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While the SDGs present a vision for change and development, education facilitates and enables the achievement of these goals. Thus, acquiring the necessary knowledge and skills is crucial for sustainable development. For a sustainable future, individuals must possess the requisite knowledge, skills, values, and attitudes, making education essential for achieving sustainable development (Rieckmann, 2017).

Research indicates that academic curricula can shape students' awareness of the importance of sustainability. For example, Al-Baz (2024) highlighted the significance of raising awareness about the various SDGs and how this may influence students' future behaviours. Similarly, Subahi (2020) noted that increasing awareness about renewable energy sources can significantly enhance environmental consciousness, underscoring the need to modify curricula to achieve greater alignment with the SDGs.

To effectively implement climate change topics as part of the SDGs agenda, it is crucial to assess the extent to which climate education topics are integrated into the curricula so that any deficiencies can be addressed. Studies have examined the integration of climate change topics into academic curricula in several countries, including Ethiopia, Ghana, Türkiye, and Egypt (Abdul-Qader & Marzouk, 2022; Boakye, 2015; Chang & Pascua, 2017; Dalillo, 2012; Tatlılıoğlu, 2019). These studies employed content analysis to evaluate curricula and syllabi, revealing that climate change topics are minimally represented. Therefore, a similar evaluation is necessary for the curricula in KSA to determine the effectiveness of climate change topics integration and identify areas for improvement.

With this in mind, Neuendorf (2002) defined content analysis as "a summarizing, quantitative analysis of messages that relies on the scientific method (including attention to objectivity-intersubjectivity, a priori design, reliability, validity, generalizability, replicability, and hypothesis testing) and is not limited as to the types of variables that may be measured or the context in which the messages are created or presented" (p. 10). Kates, et al. (2005) defined the dimensions of sustainable development as "the environmental, social, and economic aspects of sustainable development that address the needs of the present without compromising the ability of future generations to meet their own needs" (p. 18). According to UNESCO/UNEP (2011), reducing climate change involves "human intervention to reduce sources of greenhouse gas emissions associated with human actions in production and consumption, through renewable energy investment, non-polluting and greener design technologies, energy conservation, and encouraging consumption patterns and lifestyles, as well as reorienting the economies, social structures, value systems, and ideologies that have led to excessive greenhouse gas emissions" (p. 60).

Therefore, this study seeks to evaluate how climate change is integrated into science curricula in KSA and determine whether improvements are needed to promote effective climate change education. This is particularly crucial because KSA is experiencing the effects of climate change and needs to educate its citizens to contribute to decreasing these impacts.

Achieving sustainable development in KSA requires a comprehensive vision with the necessary educational curricula reforms. In line with Saudi Vision 2030, there is a need to transform education to better align with the demands of the modern era. This is done by integrating SDGs concepts into the curriculum. Previous studies suggest that incorporating the SDGs into education enhances students' ability to address environmental, social, and economic challenges, which needs the development of some strategies to raise environmental awareness among students (Alshuwaikhat & Mohammed, 2017). Tumala et al. (2019) also emphasized the importance of providing sustainable development education opportunities at all study levels. Curricula should include topics related to climate change and professional approaches to analyzing these environmental issues.

Research Questions

Therefore, this research is a trial to bridge this gap and align with the strategic direction of education, which aims to build environmental awareness among students, thereby improving their ability to address climate challenges. Understanding the role of science curricula in this context is a research imperative that supports the Kingdom's efforts towards achieving SDGs. Furthermore, this study contributes to

guiding educational policies towards integrating climate change topics into curricula, thereby enhancing students' ability to scientifically analyze environmental problems.

What is the role of science curricula in KSA at the intermediate stage in reducing climate change according to the dimensions of sustainable development?

The following sub-questions derive from this main question:

1. What are the indicators for reducing climate change in light of the dimensions of sustainable development that should be present in the content of science textbooks for the intermediate stage in KSA?

2. What is the role of science curricula in KSA at the intermediate stage, across its three grades, in reducing climate change according to the dimensions of sustainable development?

Purpose of the Study

The current study aimed to:

1. Identify indicators of climate change reduction according to the dimensions of sustainable development that should be included in the content of science textbooks for the intermediate stage in KSA.

2. Explore the role of science curricula in KSA at the intermediate stage, across its three grades, in reducing climate change according to the dimensions of sustainable development.

3. Direct the attention of public education officials to the indicators of climate change reduction according to the dimensions of sustainable development and the extent of their inclusion in the content of science textbooks for the intermediate stage in KSA.

4. Reconsider the organization of intermediate science curricula in light of the indicators of climate change reduction according to the dimensions of sustainable development.

5. Draw science teachers' attention to the importance of considering indicators of climate change reduction according to the dimensions of sustainable development when selecting teaching and assessment strategies that align with the desired objectives.

6. Provide students with information on indicators of climate change reduction according to the dimensions of sustainable development within science textbooks, covering topics such as climate change in the air, land, or seas, and its impacts on community health, safety, security, and production.

Review of Literature

Saudi Arabia is experiencing the effects of climate change, with temperatures having risen by approximately 0.7°C during the study period. Based on this trend, it is projected that the average temperature in 2020 will reach approximately 26.30°C, and by 2080, it is expected to increase to around 27.51°C—an overall rise of 2.61°C compared to the period between 1985 and 2014. This indicates clear local evidence of climate change, specifically the increase in temperature in Saudi Arabia (Al-Misnad & Al-Nahil, 2017). Such changes have significant negative impacts on various sectors of life in the Kingdom, including detrimental effects on plant ecosystems, water resources, biological environments, soil moisture, energy consumption, and human health. As a result, Saudi Arabia has actively engaged in global efforts to combat climate change (Al-Dinawi, 2024). Additionally, the Kingdom has established numerous partnerships between the public and private sectors in the field of renewable energy as an alternative to depleting energy sources such as petroleum, coal, and gas to decrease the effects of climate change in the Gulf region (Qwadrah & Mabrouki,

2023).

Alghamdi and Hassan (2020) conducted a study investigating to what extent the issues of climate change and sustainability issues are considered in Saudi higher education. The research focuses on strategic planning and commitment. Interviews were conducted with eight institution decision makers sided by documents' analysis which were conducted to fulfil the study purpose. The results indicated that most public universities do not pay due attention to the issues of sustainability. The study recommended raising the awareness of the policymakers regarding the significance of sustainability goals. Neri (2012) also conducted a study exploring the role of educators in encouraging educators to adapt to climate change and help decrease the negative consequences of climate change. The study reviewed the documents and a plethora of decisions taken in the developed countries. The results revealed that leadership has a significant role in promoting sustainability and reducing the negative effects of climate change.

Ajoud and Ibrahim (2024) investigated to what extent the green transition practices impact sustainability. The study made use of PLS-SEM analysis and a questionnaire for collecting data concerning green practices. The study participants were 92 staff members from the College of Business Administration, Northern Borders University. The results of the study showed that there is a positive relationship between green transition effects and sustainability. Furthermore, the study identified five main practices and recommended making use of green transition concepts in faculty training. Bataeineh and Aga (2022) sought to assess to what extent the principles of sustainability are integrated into the curricula of Abdulrahman bin Faisal University. The study adopted the descriptive analytical method for analyzing the curricula considering the SDG principles of UNESCO and the Saudi 2030 vision. The result of the study underscored that there is a low degree of sustainability integration of the curricula; furthermore, there were no mandatory courses at the university.

Al-Sharif (2023) conducted a study to analyze to what extent the dimensions of sustainable development are included in the science books. The study adopted the descriptive analytical method to calculate the frequency of concepts. The science textbooks of the preparatory stage were subjected to analysis based on a checklist which was developed to guide the analysis process. The attained results uncovered that several subjects such as environment and population were missing; furthermore, there was a lack of sequence and inappropriacy of tackling the issues related to the environment. Alghamdi (2018) sought to explore the inquiry-based learning (IBL) approach to teaching the concepts of sustainability. The study, based on survey and feedback collection from students and pre-service teachers, elicited data from 135 university students and pre-service teachers in KSA. The participants demonstrate positive feedback regarding IBL as it is an effective strategy for increasing engagement and sustainability. Ashraf (2020) explored the integration of the concepts of sustainability in engineering programs in KSA. The study adopted the experimental method where a micro-curriculum approach was administered to the study participants. The students' perceptions were assessed via a survey and the results revealed that the sustainability concepts were successfully integrated into the curriculum, and they also enhanced the students' awareness of sustainability.

The review of the literature addressed the issue of sustainability and climate change from different perspectives. The studies also highlight a plethora of linked ideas such as strategic planning, curriculum integration, teaching strategies, and leadership roles. The studies adopted different methodologies such as interviews, surveys, and document analysis (Al-Ghamdi, 2018, Al-Sharif, 2023; Bataeineh, 2022; Neri, 2012). The studies also address different levels of education starting from the preparatory stage to the university stage with a special focus on Saudi Arabia. Most studies call for raising awareness, promoting environment protection practices, curriculum reform and increasing sustainability principles.

A significant gap in the inclusion of SDGs concepts was revealed in the current science curricula in KSA. Subahi (2020) found that the proportion of topics related to renewable energy in the science curricula does not exceed 16.62%. Additionally, both students and faculty were found to lack sufficient awareness of renewable energy issues. Al-Rwaythia and Al-Rubaianb (2020) also identified a gap between current curricula and international standards, which adversely affects students' ability to comprehend and apply scientific concepts related to climate change.

Science curricula serve as a fundamental pillar in educating students on how to address contemporary environmental challenges. Therefore, curricula must include educational elements that foster critical thinking and deepen awareness of the multifaceted aspects of climate change and its impact on daily life and society (Mochizuki & Bryan, 2015). Revising curricula is thus a crucial step towards achieving the SDGs, equipping students with the necessary skills to tackle climate change. Moreover, education in KSA needs to adopt an interdisciplinary approach that bridges the natural and social sciences, enhancing students' ability to comprehensively understand complex issues such as climate change (Alghamdi & El-Hassan, 2020).

Moreover, the Kingdom of Saudi Arabia is transferring towards a sustainable green future, based on its 2030 vision plan. The kingdom seeks to decrease its reliance on oil and change to a green country through many projects, such as the National Transformation Program (NTP) and the National Renewable Energy Program (NREP) to generate 58.7 gigawatts of renewable energy by 2030, with a significant amount coming from solar photovoltaic (PV) technology (Ali, 2023; Ali et al., 2021). Therefore, it aims to develop renewable energy sources, particularly solar and wind power (Ali, 2023; Al-Gahtani, 2024; Zohbi & AlAmri, 2020), which in turn should positively impact to reduce the climate change issues.

Method

Research Methodology

To achieve the purpose of the study, the descriptive analytical method was employed to explore the role of science curricula in KSA at the intermediate stage, across its three grades, in reducing climate change according to the dimensions of sustainable development. The current study utilized a list of indicators for reducing climate change based on the dimensions of sustainable development and a content analysis sheet to analyze these indicators in the science textbooks for the intermediate stage in KSA.

Participants of the Research

a)   *Selecting population and study sample*

The study population consisted of topics from the science textbooks assigned to the intermediate stage across the three grades in KSA for the academic year 2023/2024. The study sample encompassed the entire study population, comprising nine textbooks. The following table provides a detailed distribution of the study population and sample.

Table 1. Science textbooks in the intermediate stage in Saudi Arabia

Grade	Textbooks	Semester	Units	Chapters	Lessons	Pages
1	Science for the First Intermediate Grade	First	2	4	10	148
		Second	2	4	8	151
		Third	2	5	10	163
2	Science for the Second Intermediate Grade	First	2	4	9	142
		Second	2	4	8	165
		Third	2	4	10	141
3	Science for the Third Intermediate Grade	First	2	4	10	147
		Second	2	4	9	144
		Third	2	4	9	139

Total	9	18	37	83

Identifying the Indicators for Reducing Climate Change

To answer the first research question "What are the indicators for reducing climate change in light of the dimensions of sustainable development that should be present in the content of science textbooks for the intermediate stage in KSA?", the study relied on a list of indicators for decreasing climate change in light of the dimensions of sustainable development, which was used to develop an analysis sheet for the science curriculum at the intermediate stage in KSA.

The list of climate change reduction indicators in light of the dimensions of sustainable development was derived from the UNESCO document on decreasing the effects of climate change (UNESCO/UNEP, 2011), as well as several educational studies and research papers, including studies by Boakye (2015), Cordero, Centeno & Todd (2020), Mochizuki & Bryan (2015), and Tatlilioğlu (2019). This resulted in an initial list of 28 sub-indicators, which was presented to a panel of experts in science curricula and teaching methods to ensure its validity. The agreement rate among the panel members on the elements of the list was 91.6%. Some of the formulations were revised to better suit the scientific context in science education, but all indicators were retained.

The final version of the list of indicators for reducing climate change in light of the dimensions of sustainable development, as reflected in intermediate science textbooks, included (3) main dimensions of sustainable development, (5) associated climate changes, and (28) sub-indicators, as outlined below:

Table 2. Indicators for reducing climate change in light of the dimensions of sustainable development

Key Dimensions of SD	Associated Climate Change Concepts	Number of Indicators
Environment and Atmosphere	Atmosphere	5
	Land, Seas	8
Social	Community Health	5
	Security and Safety	4
Economic	Economy and Production	6
Total		28

Developing the content analysis sheet

This sheet was developed to explore the role of science curricula in KSA for intermediate-stage students across all three grades in reducing climate change in light of the dimensions of sustainable development. Its validity was assessed by a group of specialists in science curricula and teaching methods. The agreement rate among the experts was 92.9%, which confirms the tool's alignment with indicators for reducing climate change across the environmental, economic, and social dimensions of sustainable development. The sheet reliability was calculated using the interrupter method. The researcher and a colleague analyzed one of the nine books (specifically, the third-semester textbook for the first intermediate grade). Both the researcher and his colleague conducted the analysis independently, and Cooper's equation was used to calculate the agreement percentage.

Table 3. Agreement rates of the analysis sheet

Dimensions	Climate Change	Analysis		Agreements	disagreements	Agreement Rate
of SD	Concepts	Researcher	Colleague			
Environmental	Atmosphere	6	5	5	1	83.30%
	Land, Seas	12	11	11	1	91.70%
Social	Community Health	1	1	1	0	100%
	Security and Safety	3	3	3	0	100%
Economic	Economy and Production	16	15	15	1	93.80%
Total	5	38	37	34	3	91.90%

From the previous table, it is clear that the percentage of agreement between the two analyses reached 91.9%, indicating a high agreement rate, and thus the analysis sheet possesses a high degree of reliability.

Data Analysis Procedures

The procedures for conducting the analysis were as follows:

- Analysis Categories: The analysis categories were represented by indicators of climate change reduction across the three dimensions of sustainable development: environmental, social, and economic. These encompass five aspects of climate change and 28 sub-indicators.

- Units of Analysis: The paragraph was selected as the unit of analysis and recording due to its relevance to the study's subject matter.

- Analysis Sample: The sample comprised nine textbooks that included paragraphs, figures, pictures, activities, experiments, investigations, and exercises. Covers and indexes were excluded from the analysis.

- Conducting the Analysis: The analysis was performed by determining the degree of inclusion for each indicator, calculated by counting the repetitions in each book, summarizing the total repetitions for each academic year, and calculating the percentage of inclusion. The following table shows the four levels established as standards for the degree of inclusion

Table 4. Assessment of inclusion degree for climate change reduction indicators

Inclusion Percentage	Degree of Inclusion
75% - 100%	High
50% - 75%	Medium
25% - 50%	Low
0% - 25%	Very Low

Results of the Research

To answer the second research question, "What is the role of science curricula in KSA at the intermediate stage, across its three grades, in reducing climate change according to the dimensions of sustainable development?", frequencies and percentages of the degree of inclusion of climate change reduction indicators within the science textbooks across the three grades of the intermediate stage were calculated and presented below.

Table 5. Frequencies and percentages of climate change reduction indicators in science textbooks in the intermediate stage.

Dimensions of SD	Climate Change Indicators	First Grade	%	Second Grade	%	Third Grade	%	Total	%
Environmental	Atmosphere	11	21.60 %	10	21.30 %	16	34.00 %	37	27.20 %
	Land and Seas	16	31.40 %	3	6.40%	2	4.30%	21	15.40 %
Social	Community Health	1	2.00%	9	19.10 %	6	12.80 %	16	11.80 %
	Security and Safety	6	11.80 %	6	12.80 %	10	21.30 %	22	16.20 %
Economic	Economy and Production	17	33.30 %	19	40.40 %	4	8.50%	40	29.40 %
Total		51	**37.50 %**	47	**34.60 %**	38	**27.90 %**	136	**100%**
No. of Paragraphs		462		448		430		1340	
% of Climate Change inclusion		11.00 %		10.50 %		8.80 %		10.10 %	

The analysis reveals a concerning weak role of the intermediate science curricula in reducing climate change as indicated within the dimensions of sustainable development. The overall presence rate of climate change indicators within the content is notably low, averaging 10.1%. This presence is distributed across various climate change aspects as follows: economic and production-related changes (29.4%), environmental and atmospheric changes (27.2%), occupational safety and health standards (16.2%), changes in the Earth's crust, seas, and oceans (15.4%), and health and social responsibility changes (11.8%).

Regarding grade-level distribution, the percentage of climate change indicators available in the first intermediate grade was 11.0%; in the second grade, it was 10.5%; and in the third grade, it was 8.8%. The subsequent sections provide a detailed analysis of the results for each grade.

The Role of the First Intermediate Grade Science Curriculum in Decreasing Climate Change

The analysis of the science curriculum for the first intermediate grade in the Kingdom of Saudi Arabia was conducted to evaluate its effectiveness in addressing climate change within the context of sustainable development. Frequencies and percentage of inclusion of climate change reduction indicators were calculated, revealing the following findings:

Table 6. Frequencies and percentages of climate change reduction indicators in science textbooks for the first intermediate grade

Dimensions of SD	Climate Change Indicators	First Book	%	Second Book	%	Third Book	%	Total	%
Environmental	Atmosphere	2	3.00%	3	6.00%	6	12.00%	11	21.60%
	Land and Seas	2	4.00%	2	4.00%	12	24.00%	16	31.40%
Social	Community Health	-	-	-	-	1	2.00%	1	2.00%
	Security and Safety	1	2.00%	2	4.00%	3	6.00%	6	11.80%
Economic	Economy and Production	-	-	1	2.00%	16	32.00%	17	33.30%
Total		5	9.80%	8	15.70%	38	74.50%	51	100%
No. of Paragraphs		148		151		163		462	
% of Climate Change inclusion		3.40%		5.30%		23.30%		11.00%	

The analysis indicates a notably weak role of the science curriculum in the first intermediate grade in decreasing climate change within the framework of sustainable development dimensions. The overall presence rate of climate change indicators in the content is alarmingly low, averaging 11.0%. The distribution of these indicators reveals that the largest proportion is associated with changes in economy and production (33.3%), followed by changes in land and seas (31.4%), environmental and atmospheric changes (21.6%), occupational safety and health standards (11.8%), and community health changes (2.0%).

The Role of the Second Intermediate Grade Curriculum in Reducing Climate Change

The analysis of the science textbooks for the second intermediate grade was conducted to assess their role in addressing climate change through the dimensions of sustainable development. Frequencies and the percentage of inclusion of climate change reduction indicators were calculated, revealing the following results:

Table 7. Frequencies and percentages of climate change reduction indicators in science textbooks for the second intermediate grade

Dimensions of SD	Climate Change Indicators	First Book	%	Second Book	%	Third Book	%	Total	%
Environmental	Atmosphere	4	8.50%	-	-	6	12.80%	10	21.30%
	Land and Seas	-	-	-	-	3	6.40%	3	6.40%
Social	Community Health	-	-	5	10.60%	4	8.50%	9	19.10%
	Security and Safety	1	2.10%	4	8.50%	1	2.10%	6	12.80%
Economic	Economy and Production	6	12.80%	-	-	13	27.70%	19	40.40%

Total	11	23.40 %	9	19.10 %	27	57.40 %	47	100%
No. of Paragraphs	142		165		141		448	
% of Climate Change Inclusion	7.70 %		5.50%		19.10 %		10.50 %	

The overall findings indicate that the second intermediate-grade science curriculum plays a weak role in reducing climate change, with climate change indicators accounting for only 10.5% of the content. The distribution of these indicators reveals that the highest percentage relates to economic changes, particularly in the areas of economy and production (40.4%), followed by environmental changes in the atmosphere (21.3%), social responsibility in health (19.1%), occupational safety and security (12.8%), and lastly, changes in land and seas (6.4%).

The Role of the Third Intermediate Grade Curriculum in Decreasing Climate Change

The science textbook for the third intermediate grade was analyzed to assess its role in reducing climate change, considering the dimensions of sustainable development. The frequency and percentage of climate change reduction indicators in the curriculum content were calculated and are presented below.

Table 8. Frequencies and percentages of climate change reduction indicators in science textbooks for the third intermediate grade

Dimensions of SD	Climate Change Indicators	First Book	%	Second Book	%	Third Book	%	Total	%
Environmental	Atmosphere	8	17.00 %	7	14.90 %	1	2.10%	16	34.00 %
	Land and Seas	2	4.30%	-	-	-	-	2	4.30%
Social	Community Health	-	-	3	6.40%	3	6.40%	6	12.80 %
	Security and Safety	5	10.60 %	-	-	5	10.60 %	10	21.30 %
Economic	Economy and Production	1	2.10%	-	-	3	6.40%	4	8.50%
Total		16	42.10 %	10	26.30 %	12	31.60 %	38	100%
No. of Paragraphs		147		144		139		430	
% of Climate Change Inclusion		10.90 %		6.90%		8.60 %		8.80 %	

The overall occurrence of climate change indicators in the third intermediate grade curriculum is relatively low, accounting for only 8.8% of the total content. The highest percentage of indicators is related to environmental changes, particularly focusing on the atmosphere (34.0%), followed by occupational safety and health (21.3%), social health responsibility (12.8%), economic changes (8.5%), and changes in the Earth's crust, seas, and oceans (4.3%).

Discussion of the Results

The content of the first book demonstrates a very weak contribution to decreasing climate change, with an inclusion percentage of 3.4%. The topics covered include interactions of matter and energy, motion, forces, and simple machines. Climate change indicators are largely implicit, encompassing concepts such as combating desertification, atmospheric gas balance, and reducing the negative impacts of forest fires and chemical safety. The second book exhibits a similarly weak role in climate change reduction, with an inclusion percentage of 5.3%. It covers topics related to the changing Earth's surface, Earth's shaping forces, the moving atmosphere, and space exploration. The indicators presented are also implicit, addressing laboratory safety, the reduction of hazardous materials, the effects of melting ice on ecosystems, and protecting infrastructure from climate-related impacts. In contrast, the third book shows a slightly stronger emphasis on climate change reduction, with an inclusion percentage of 23.3%. Topics include cells as building blocks of life, invertebrates, vertebrates, ecology, and Earth's resources. Here, the climate change indicators are more fundamental, addressing issues such as maintaining safety and security, the adverse effects of technological products on the environment, the decline of amphibian and bird populations, and the impact of chemical pollutants on agriculture and water resources. Subsequently, the indicators of climate change echo with the UNESCO SDGs which address the issue of security and safety such as the negative effects of technology products and their impact on natural resources. However, when comparing such outcomes to those of international benchmarks, it becomes apparent that they are lower compared to international benchmarks. Dawson et al. (2022) indicated that the middle school science curricula have included climate change topics taking into account the considerable variability and depth; the coverage of the topic in the Saudi curriculum echoes with the findings of Bahreldin, et al. (2024). Furthermore, Landin and Stark (2022) conducted a study to assess biology textbooks and the results indicated a lack of inclusion of climate and environment topics.

The first book analysis shows a weak role in addressing climate change, with an inclusion rate of 7.7%. Its topics cover the nature of science, mixtures and solutions, matter and energy, and energy transformations. Climate change indicators are presented implicitly, focusing on protecting infrastructure and heritage, reducing the environmental impacts of scientific and technological developments, conserving agricultural products, energy conservation, and minimizing the negative effects of fuel combustion. Similarly, the second book also demonstrates a weak contribution to climate change mitigation, with an inclusion rate of 5.5%. Its topics include the circulatory and immune systems, digestion, respiration and excretion, and human support and response systems. The climate change indicators are implicit, addressing issues like reducing the negative effects of smoking on individuals and society, and highlighting that maintaining security and safety is a shared responsibility. The third book shows a slightly stronger emphasis, with an inclusion rate of 19.1%. Topics covered include plant biology, environmental resources and protection, thermal energy, and waves, sound, and light. The climate change indicators here are more explicit, addressing key issues such as fossil fuel conservation, air pollution reduction, prevention of acid rain, global warming risks, and ozone layer depletion. Other key indicators focus on reducing water and soil pollution, as well as guidelines for managing global warming. Monroe et al. (2019) called for the significance of employing effective strategies and projects related to environmental protection such as engaging students in projects, discussions, and brain-storming to encounter environmental issues effectively.

The first book covers topics such as the nature of science, Earth's changes, cellular processes, and genetics. Climate change indicators are present at a rate of 10.9%, but they are mainly implicit and non-essential. Key topics include reducing the negative environmental impacts of science and technology, such as minimizing water pollution from oil spills and ship waste, conserving freshwater and fish resources, managing the effects of earthquakes and volcanoes, and promoting energy conservation. The second book has a weak presence of climate change indicators, accounting for 6.9%. It covers atomic composition, the periodic table, atomic structure, and chemical reactions. Climate change mitigation is mentioned implicitly through the discussion of reducing radiation leakage, minimizing air pollution from vehicle exhausts (carbon monoxide and hydrocarbons), and promoting the use of clean technologies such as converted wallets. The book also emphasizes the negative impacts of chemical elements and compounds on public health and the environment. The third book includes topics related to matter, energy, and simple machines. The presence

of climate change indicators is 8.6%, with most references being implicit and non-essential. Topics include maintaining security and safety during scientific investigations, protecting against lightning using circuit breakers, reducing fossil fuel combustion, and using magnets to generate electricity. The book also briefly addresses the negative effects of burning fossil fuels on public health and the role of energy rationalization in climate change mitigation.

While some climate change indicators exist, several key environmental, social, and economic aspects of climate change are underrepresented or only briefly mentioned, such as combatting desertification, overgrazing, deforestation, ocean current collapse, and ice melting due to global warming. Moreover, issues such as reducing smoking and addressing the negative effects of fertilizer use, radioactive materials, and ozone depletion are also not thoroughly explored. Ensuring residential areas are safe from environmental hazards like volcanic clouds and radiation leaks is mentioned only implicitly. In addition, the textbook does not adequately cover protecting agricultural products from acid rain, promoting renewable energy investments, or safeguarding infrastructure from the negative impacts of climate change.

Conclusions of the Research

The science curriculum for the first intermediate grade predominantly implicitly features climate change indicators across the first two books, with only a small portion appearing explicitly in the third book. Despite the critical importance of these topics, several essential indicators remain inadequately addressed, including environmental issues such as oil spills, sewage disposal in water bodies, and the disruption of ocean currents. Social aspects, such as the negative effects of fossil fuel combustion, radiation leaks, and the ozone hole, alongside economic considerations regarding the protection of marine resources, are also insufficiently covered.

The role of the second intermediate-grade science curriculum in decreasing climate change remains inadequate. Most indicators are presented implicitly across the first and second books, with only a small portion appearing explicitly in the third book. Several critical climate change indicators, such as reducing desertification, preventing poaching, decreasing water pollution, and addressing the collapse of ocean currents, are only briefly mentioned or not sufficiently covered. Social and economic issues, including the negative effects of fertilizers on public health, the dangers posed by volcanic clouds, and the impact of radioactive materials, are similarly underexplored.

The science curriculum for the intermediate stage in Saudi Arabia demonstrates a significant weakness in addressing climate change within the framework of sustainable development, with a very low inclusion rate of 10.1%. This finding aligns with the study by Sayed and Marzouk (2022), which reported a similarly weak inclusion of climate issues in the preparatory stage of Al-Azhar education in Egypt, with an average rate of 8.96%. It also corresponds with the study by Boakye (2015), which found that climate change content in the intermediate school curriculum in Ghana was as low as 2%, and the study by Dalelo (2012), which indicated that the inclusion of biodiversity loss and climate change in Ethiopian science and biology curricula was at 8.6%.

Most of the climate change indicators included in the middle school science curriculum were embedded implicitly in subtopics rather than addressed as primary topics. These subtopics included ecology, Earth's resources, environmental protection, forms of energy, and thermal energy. This observation is consistent with the findings of Asante, Yalley, and Amissah (2024), who noted that while climate change was integrated into primary and secondary science curricula in Ghana at various levels, the approach focused more on the technical aspects of greenhouse gas emissions and climate impacts, neglecting the broader global context of human-induced climate change.

Additionally, the middle school science curricula in Saudi Arabia failed to address several critical topics related to climate change mitigation, particularly those with environmental significance. These topics include air pollution from fossil fuel combustion, radiation leakage, the use of chemicals in science and technology, global warming, polar ice melting, desertification, and water pollution caused by oil spills and the collapse of ocean currents. Socially relevant climate change indicators, such as radiation leakage and the

expansion of the ozone hole due to radioactive materials and fertilizers, were also overlooked, as were economic indicators like the promotion of renewable energy and the management of natural resources.

This gap in the curriculum contradicts recommendations from various studies, including Boakye (2015), Mochizuki and Bryan (2015), and UNESCO/UNEP (2011), which emphasize the need to support curricula with essential indicators for reducing climate change.

Bearing this in mind, it is recommended to analyze science lesson content through the lens of climate change reduction indicators and sustainable development dimensions, identifying technological tools and innovations that can support teaching. Furthermore, incorporating exploratory activities throughout each lesson, not just at the end of units, would help to explore new ways of mitigating climate change. More importantly, engaging in ongoing research and professional development is a necessity for individuals so as to stay informed about the latest findings in climate change mitigation, including results from the Conference of the Parties (COP) and UNESCO publications on sustainable development. Finally, enhancing teaching skills to effectively convey science concepts within the framework of sustainable development, with a specific focus on climate change reduction is of crucial importance.

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