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What Does It Take to Develop an Effective Climate Change Curriculum?

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What Does It Take to Develop an Effective Climate Change Curriculum?

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Abstract: The present conceptual paper addresses the question: What does it take to develop an effective climate change (CC) curriculum? Three different lenses are applied in developing a comprehensive critical analysis of CC curriculum development. The first lens consists of examining current literary approaches for addressing CC curriculum development. The second lens takes an empirical approach by examining CC inclusion in two exemplary curricula, the Next Generation Science Standards (NGSS), and the State of New Jersey Student Learning Standards (NJSLS), United States of America (USA). The third lens focuses on discussing critical gaps revealed in the analysis. These include CC inclusion through a cross-curricular approach unproblematized; key socio-economic-political concepts underpinning CC not articulated; lack of thematic organization; the importance of non-linear CC thematic organization; terminological consistency; insufficient consideration given for learning progression; and disaster risk reduction—a neglected theme. The paper concludes with a set of recommendations for CC curriculum development.

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1. Introduction

In their contemplation of the reality of education in an era of climate change (CC), Stein et al. (2020) highlighted the urgency and acuteness of the need to prepare students effectively. In their paper entitled "From 'education for sustainable development' to 'education for the end of the world as we know it'", they suggested that

the educational task is not, how do we make 'the house modernity built' more sustainable, nor even how do we prepare people living inside the house for the moment when it fails to live up to the promises it has made for those inside its walls, which indeed is already happening. Rather, it is, how do we prepare people for the moment when the house can no longer provide even the basic resources necessary to sustain human life? (Stein et al., 2022, p.280).

Similarly, the philosopher Bruno Latour pondered on the immense challenges involved in transitioning humanity into living with CC, "a land so different from nature" (Latour, 2021, p. 18). He posited: "Adapting? Adjusting? Coping? All sorts of words that mean how to live in the ruins" (p. 20).

Inspired by these philosophers' provocations, this study poses the question: What does it take to educate all students to live and thrive in an era of CC? An era of uncertainties, frequent disasters, and social-economic-environmental instabilities, where tipping points are crossed leading to the unknown. More specifically I ask: What does it take to develop an effective CC curriculum?

In addressing this question, the present study put forward the objectives, to:

1. Conduct a literature review for
    (i) examining literary approaches for addressing CC curriculum development; and
    (ii) examining reviews of existing CC curricula, with a focus on the USA.
2. Analyze and evaluate two exemplary state curricula, with the purpose of elucidating critical gaps in current approaches to CC inclusion in curricula.

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Ultimately this study aims to identify and discuss hindrances for effective CC curriculum development and suggest practical recommendations for informing future CC curriculum development. The study is also underpinned by the epistemological question as to whether Science curricula can and should accommodate CC education, or whether CC requires a curriculum of its own, in which Science is included as one of the themes constituting CC. I believe that answering this epistemological question is critical for developing quality CC curriculum.

Methodologically, this conceptual article reaches its conclusions through critical analysis of the literature (see Objective 1); and the empirical evaluation of two existing curricula (see Objective 2).

The herby analysis commences with defining the term *curriculum*. It continues to present literary approaches for addressing CC curriculum and reviews of existing CC curricula. This is followed by an empirical analysis of CC inclusion in the Next Generation Science Standards (NGSS) and in the New Jersey Student Learning Standards (NJSLS). The Discussion that follows elucidated critical gaps in CC curriculum development, and a set of recommendations are offered in conclusion. For the convenience of the readers, a list of acronyms used in this article is presented in Appendix 1.

1.1. Defining Curriculum

Curriculum can be defined broadly as "anything that schools do that affects pupils' learning" (Ross, 2000, p. 9); or it may be defined narrowly "as specialized knowledge organized for transmission" (Young, 2004, p. 198). Across this broad spectrum, Ornstein and Hunkins (2018) offered four categories of definitions for *curriculum*. First, curriculum is "a plan for achieving goals" (p. 26). This definition involves a formally organized set of learning intentions. A second definition perceives curriculum as dealing with 'learning experiences" (p. 26). Rooted in Dewey's philosophy, this definition allows for any educational experience in or out of school to be considered as a *curriculum*. A third definition conceptualizes *curriculum* as "a field of study with its own foundations, knowledge domains, research, theory, principles, and specialists" (p. 27). This definition focuses on curriculum primarily from a theoretical perspective. Finally, *curriculum* may be defined in relation to the subject matter or content organization, dissemination, and assimilation. Often the contents are organized by grade level.

Young emphasized the role of curriculum in enabling students "to acquire knowledge that takes them beyond their experience, and they would be unlikely to acquire it if they did not go to school" (Young, 2014, p. 196). Scholars have also noted the tendency over the past 100 years, for curricular universalization, where curricula are becoming increasingly similar (Baker, 2015). The present study takes the view of *curriculum*, as consisting of any formal document that outlines what students should learn at school and holds some level of authority. From this perspective, both the NGSS and the NJSLS constitute curricula. The first receives its authority through its adoption by USA Departments of Education, whereas the later forms an official state curriculum, mandated by the State of New Jersey.

1.2. Literary Approaches to Addressing Climate Change Curriculum

Climate change literature rarely addresses the question of what constitutes CC curriculum in a deep and epistemologically meaningful way. Studies discussing CC curriculum commonly belong to one of the following three types: (i) Ideation − studies discussing general ideas that need to be present in CC curriculum, without specifying content and concepts constituting the curriculum (e.g., Cantell et al., 2019); (ii) Science-based − studies specifying the science concepts relevant to CC processes, however, failing to specify critical non-scientific concepts responsible for causing CC and inherently implicated in CC processes (e.g., Shepardson et al., 2012); and (iii) Thematic organization − studies presenting thematic organization of CC, however, lacking concept-specificity (e.g., Eilam et al., 2020). Alongside these three main approaches for addressing CC curriculum, a fourth approach emerged in parallel with CC education literature discussing Disaster Risk Reduction (DRR) education (Selby & Kagawa, 2012). While this body of work positions itself as adjacent to CC education, in this publication it is being considered in the context of CC curriculum development because of its high relevance.

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1.2.1. Ideation: Studies Discussing General Ideas That Need to Inform Climate Change Curriculum

A multitude of publications present aspirations for CC curricula. These are often quite general and not easily translatable into an applicable curriculum, as demonstrated in the following two examples.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) (2016), in its publication "Getting Climate-Ready. A guide for schools on climate action", calls for inclusion of environmental, economic, social, cultural, ethical, political, scientific and technological issues in CC education. However, UNESCO repeatedly stresses in its publication that there is no need for a special CC course, but rather, that it should be included in every subject. This approach is criticized theoretically and empirically later in this paper. The guide provides examples of ways in which CC may be included in different subjects. However, none of the examples provided present coherent CC concepts, or fully developed themes. They read as an anecdotal collection of minor aspects related to CC.

Cantell et al. (2019) developed a model to demonstrate what the authors regard as the essential aspects of CC education. The model uses a bicycle as a metaphor for representing ten aspects: knowledge, thinking skills, values, identity, worldview, action, motivation, participation, future orientation, hope and other emotions, and operational barriers. The model remains at the ideation level and does not specify the scope of contents constituting CC education.

1.2.2. Science-Based: Studies Specifying the Science Concepts Relevant to Climate Change

In 2009, several leading United States of America (USA) science organizations, scientists, and educators created a framework entitled "The Essential Principles of Climate Science Literacy" (United States Global Change Research Program [USGCRP], 2009). According to this framework, CC is purely a field within science. The framework presents specific scientific concepts that are important for developing individual and community understanding about Earth's climate, including: (i) The Sun is the primary source of energy for Earth's climate system; (ii) Climate is regulated by complex interactions among components of the Earth system; (iii) Life on Earth depends on, is shaped by, and affects climate; (iv) Climate varies over space and time through both natural and man [*cisgenderism*]-made processes; (v) Our understanding of the climate system is improved through observations, theoretical studies, and modelling; (vi) Human activities are impacting the climate system; and (vii) Climate change will have consequences for the Earth system and human lives (USGCRP, 2009, pp. 9–16). While the framework views CC as a field of science, it acknowledges that to be fully climate literate there is a need for input from the social sciences related to economic and social considerations. Regardless of this acknowledgment, the approach to CC is reductionist in that it fails to recognize that CC processes cannot be explained in full, or even in part, while disregarding socio-economic-political driving mechanisms.

In line with this CC conceptualization, Shepardson et al. (2012) developed content scoping for CC school curricula, presenting a "climate system framework for teaching about climate change" (p. 323). Their framework is guided by three questions: (i) What is a climate system and what are the components of the system? (ii) What happens to the system when components within the system change? and (iii) What are the impacts of these changes?

In addition to outlining the CC contents, Shepardson et al. (2012) provide a learning progression consisting of three levels of conceptual development related to the greenhouse effect. To the best of knowledge this is the first systematic attempt to address the issue of progression points in CC curriculum. In their progression framework, Level 1 reflects Grade 6 beginners' conceptual understanding, Level 2 reflects intermediate conceptual understanding reached by the end of Grade 8, and Level 3 reflects advanced conceptual understanding reached by a high-school graduate (Shepardson et al., 2017).

In summary, both frameworks (USGCRP (2009) and Shepardson et al. (2012)) contribute to advancing CC curriculum development by focusing on explaining the scientific basis of CC, with Shepardson et al. (2012) additionally contributing a learning progression. However, both conceptualize CC as a field of science. This narrow epistemological conceptualization ignores critical

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socio-economic-political concepts and paradigms that give meaning and trajectories to CC processes. In both frameworks these remain undefined, appearing as invisible unspecified forces captured by descriptors such as: "**We enhanc**e the greenhouse effect **by changing** the carbon and the broader biogeochemical cycles through changes **such as burning** fossil fuels or **changing land** cover (deforestation) …" (Shepardson et al., 2012, p. 330). Regardless of these invisible forces having the power to "enhance", "change" and "burn", they appear nameless, conceptually unexplained, pushed into the background and overlooked, thus making their contribution to CC curriculum development, partial and incomplete. Future curriculum development needs to bring these CC driving forces to the forefront and identify the underpinning key socio-economic-political concepts. This critical issue is elaborated upon in the final section of this paper.

1.2.3. Thematic Organization: Studies Presenting Thematic Organization of Climate Change Contents

An attempt to scope CC contents beyond the scientific basis was presented by Eilam et al. (2020). Here, CC contents were presented along a continuum, ranging from Science perspectives to Humanity: Socio-economic-political structures, Networks, Ethics and Conduct Perspectives. Eight themes were identified along this continuum: Observed Changes in Climate; Drivers of CC; Future CC; Risks and Impacts; Adaptation and Mitigation; Socio-Economic; Policy and Governance; and Ethics. Each theme is based on fundamental key questions and essential content knowledge.

While the framework lays out the scope of CC, emphasizing the interconnected nature of the scientific and humanistic bases, further work is required to identify the key concepts and their organization in a curriculum. Also, it is worth noting that regardless of the critical importance of preparing students to deal with CC-related DRR, none of the frameworks developed thus far for informing CC curriculum development specifically addressed this issue.

1.3. Emphasizing the Role of Disaster Risk Reduction in Climate Change Education

Preparing students to protect themselves from CC hazards is imperative, given that the incidence of CC disasters worldwide is increasing. In addressing the growing disaster risks, the "Sendai Framework for Disaster Risk Reduction 2015–2030" (United Nations International Strategy for Disaster Reduction [UNISDR], 2015), was developed as a roadmap for creating preparedness for disasters and resilience among communities and nations. The role of education is highlighted in Objective L of the framework, which aims "to promote the incorporation of disaster risk knowledge, including disaster prevention, mitigation, preparedness, response, recovery and rehabilitation, in formal and non-formal education …" (UNISDR, 2015, p. 10). This document and its predecessor the "Hyogo Framework for Action 2005–2015" provide the rationale for including DRR in CC education. Accordingly, Selby and Kagawa (2012) developed a list of specific learning outcomes, which could potentially be incorporated into CC curriculum, recognizing the importance of developing the learning outcomes across grade levels. This critical aspect seems missing from most discussions regarding CC curricula.

In 2014, UNESCO and the United Nations International Children's Emergency Fund, now referred to as the United Nations Children's Fund, (UNICEF) developed guidelines for supporting the implementation of DRR education in schools. The guidelines outline five essential dimensions of DRR education. These include: "(1) Understanding the science and mechanisms of natural disasters; (2) learning and practicing safety measures and procedures; (3) understanding risk drivers and how hazards can become disasters; (4) building community risk reduction capacity; and (5) building an institutional culture of safety and resilience" (United Nations Educational Scientific and Cultural Organization and United Nations Children's Fund [UNESCO & UNICEF], 2014, p. 11). Thus far there is limited research examining the application of the guidelines in the context of CC education. In this paper, their application is analyzed in the context of analyzing CC curriculum of the state of New Jersey in the USA. The role of DRR in CC curriculum development is further discussed in the final section of this paper.

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1.4. Examination of Climate Change Curricula

Worldwide, there is dearth of fully developed and rationalized CC curricula. To the best of knowledge, the New Jersey Student Learning Standards (NJSLS) (New Jersey Department of Education [NJDOE], n.d.) is worldwide, one of the first few fully developed K–12 CC curricula to be published in English (Eilam, 2022). Additionally, it was reported that Italy has a K–12 CC curriculum (UNESCO, 2021a); and that Israel has also developed in 2022 a comprehensive CC curriculum (Government of Israel Ministry of Education, n.d.). Both curricula are currently not accessible in English.

Based on this current state of play, the present analysis focuses on CC curricula developed in the USA, the NJSLS (NJDOE, n.d.) and the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013). The NJSLS was selected for its innovativeness in CC curriculum development. The NGSS was selected due to its influence on CC education through Science and Engineering Education. The NGSS is not a national or state curriculum. However, it forms the main curriculum framework for teaching Science and Engineering in the USA K–12 school systems, and influences Science curriculum development worldwide. Furthermore, the NGSS is incorporated in the NJSLS, thus forming a structural component of this CC curriculum. Together the examination of the two curricula provides critical insights into current practices in CC curriculum development, and the evidence-basis for identifying gaps in existing curricula.

In what follows, a brief literature review of CC in USA Science curricula sets the background for the subsequent analysis of the two curricula, first the NGSS, followed by the NJSLS. The analyses include examining CC conceptualization, approach to CC curricular inclusion, and scope of CC contents.

Climate Change Presence in the USA Science Curricula

Thus far, few studies have conducted in-depth analysis of CC in existing curricula. Such evaluation was conducted by Johnson and Anderson (2017), and the National Center for Science Education and the Texas Freedom Network Education Fund (2020), in relation to CC representation in the NGSS.

Johnson and Anderson (2017) highlighted as strengths the aspects of addressing: CC mechanisms; analyzing large-scale data; developing arguments from evidence; characterizing uncertainty; making predictions about the future; and linking Earth's physical and biological processes at multiple scales. In relation to weaknesses, Johnson and Anderson (2017) criticize the curriculum for not recognizing the limits of science, not recognizing the important role of political and economic aspects and ignoring issues of social justice. Overall, they suggest that "the NGSS Performance Expectations fall short of describing the knowledge and practices students will need to be ethical and effective decisionmakers about climate-change-related issues" (Johnson & Anderson, 2017, p. 118).

The National Center for Science Education and the Texas Freedom Network Education Fund (2020), conducted an in-depth analysis of CC in the Science curricula of the 50 USA states. Three expert CC reviewers assessed the standards by answering six focus questions[1] and assigning a

[1] The reviewers considered six focus questions for each state's science curriculum:
A. To what extent is the treatment of the issue in the standards helpful in permitting students to reach these conclusions? B. To what extent is the treatment of the issue in the standards appropriately explicit? C. To what extent is the treatment of the issue in the standards integrated in a coherent learning progression? D. To what extent do the standards make it clear to teachers what knowledge and skills students are expected to attain? E. To what extent would a student who met the performance expectations in the standards relevant to the issue be prepared for further study in higher education? F. To what extent would a student who met the performance expectations in the standards relevant to the

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numerical score ranging from A+ (highest score) to F (lowest score). The overall score of a given curriculum was calculated as the average score across the six focus areas. The findings revealed that only 27 states earned a score of B+ or above for their CC representation in the Science curricula. Of these 27 states, 20 and DC have adopted the NGSS. Another 20 states received scores of C+ or below, out of which 10 received a D. Six states received a Fail. The NGSS itself earned a B+. Four states that based their Science curriculum on the National Research Council (NRC) (2012) framework, but not on the NGSS, received an A-, and one other state that did the same received an A. Importantly, the reviewers expressed concern over all the reviewed standards including the NGSS. Therefore, the authors caution that even states that received Grades A and A- require improvements in their CC education.

The reviewers commented on a set of recurring problems in the treatment of CC within the Science curricula. The first problem was with regard to promoting false debate. The reviewers noted that curricula should not yield to the misrepresentation of science facts, and furthermore, that curricula should highlight and expose attempts to manipulate and misrepresent data. Another criticism by the reviewers was the avoidance of some curricula to clearly name CC when addressing CC issues—meaning that some CC issues are addressed without explicitly naming them as such. Still further criticism relates to "muddling the science", by using ambiguous wording, suggesting unclear evidence (National Center for Science Education and the Texas Freedom Network Education Fund, 2020, p. 6). These findings are helpful in identifying some issues related to the conceptualization of CC. However, the analysis does not address the structure and organization of CC concepts in the curricula. Organization, substantive structure and syntactic structure are critical in curricular evaluation, and thus merit further examination. To gain a better understanding of the gaps in CC representation in Science curricula, further in-depth analysis of the NGSS is presented in what follows.

2. Analysis of Climate Change in the Next Generation Science Standards

The analysis of the NGSS begins with a brief background, followed by a critical discussion of CC conceptualization within the NGSS. It continues to discuss the inclusion of CC in the NGSS by Grade Band. Finally, the findings are summarized.

2.1. Background

The NGSS consists of three interconnected dimensions of learning: Disciplinary Core Ideas (DCIs); Science and Engineering Practices; and Crosscutting Concepts. The Performance Expectations (PE) (standards) reflect the integration of these three dimensions, specifying the knowledge and skills that students need to be able to demonstrate at or across a Grade Band (Harris et al., 2022).

The NGSS was developed on the basis of the NRC's "Framework for K–12 Science Education (National Research Council [NRC], 2012), by a consortium of states and organizations working with the NRC (National Center for Science Education and the Texas Freedom Network Education Fund, 2020). Climate change is incorporated in the NGSS as a recommended concept within the DCIs and in most of the Crosscutting Concepts. However, the topic of CC only appears explicitly in Earth and Space Science in one standard in middle-school and four standards in high-school. Foundational climate-related ideas such as the carbon cycle appear at every level from K–12, across four DCIs (DeWaters et al., 2014; Drewes et al., 2018; NGSS Lead States, 2013).

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issue be prepared for responsible participation in civic deliberation about climate change? (The National Center for Science Education and the Texas Freedom Network Edu-cation Fund, 2020, p. 3).

2.2. Interrogating Climate Change Conceptualization Within the Next Generation Science Standards

The epistemological interrogation of the NGSS consists of first identifying CC positioning within the framework, followed by examining the conceptualization of CC within the rationales of the relevant core ideas.

CC positioning among the DCIs, suggests that epistemologically, CC forms a sub-idea (ESS3.D: Global Climate Change) within a broader core idea (ESS3: Earth and Human Activity), within the discipline of Earth and Space Science. Thus, conceptually CC is conceived as an idea within another idea within the discipline (NGSS Lead States, 2013). Appendix 2 presents this epistemological positioning within the framework.

This epistemological positioning of CC becomes even more ambiguous in the reorganizing of the NRC framework into the NGSS curricular standards. In this process some core ideas were regrouped into new categories, which the NGSS identifies as *topics*. In the new topical-organization, CC appears mainly across the topics of: Weather and Climate; and Human Sustainability. Appendix 3 presents the domains and their topics for high-school.

Examination of the rationale explaining Weather and Climate reveals a reductionist approach where CC is conceptualized primarily as a science problem, "with a major emphasis on the mechanisms and implications of climate change" (NGSS Lead States, 2013, p. 90). The focus is on unpacking CC underlying mechanisms and their effects, in what seems to be a primarily science and engineering problem.

In the rationale explaining Human Sustainability, the term CC is conspicuous by its absence. CC is addressed without using the term. Instead, the term *climate* is used when addressing the question of: "How do people model and predict the **effects of human activities on Earth's climate**?" (NGSS Lead States, 2013, p. 91).

In summary, the conceptual analysis of the NGSS suggests that CC is conceptualized as a mere idea, subsumed under other ideas. A reductionist view is taken, presenting CC as primarily a scientific issue.

2.3. Analysis of Climate Change in the NGSS by Grade Band

This section presents a brief summary of the main findings concerning CC presence in each of the Grade Bands in the NGSS.

Primary-school (Grades K-5). The curriculum specifically instructs not to include CC in primary-school, in two PEs. For example, in Grade 3, PE 3-LS4-4 specifically excludes CC stating that the "assessment **does not include the greenhouse effect or climate change**" (NGSS Lead States, 2013, 3-LS4-4). This age-related decision is further addressed in the Discussion. However, the primary science curriculum does address the development of foundational CC science knowledge from as early as kindergarten. This foundational knowledge is systematically developed across the primary grade levels under the following topics: Kindergarten and Grade 3: Weather and Climate; Grades 2, 4 and 5: Earth Systems; and Kindergarten, Grade 2 and 3: Interdependent Relationships in Ecosystems. Additionally, aspects of DRR address PEs as early as in Grade 3.

Middle-school (Grades 6-8). The analysis reveals three main issues concerning CC representation. First, I note the ambiguous use of terms related to CC. Secondly, muddling the science by suggesting that "human activities ... are major factors" (MS-ESS3-5), rather than the only factors. These two issues may be exemplified in Weather and Climate, core idea ESS3.D: Global Climate Change, as follows:

Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (**global warming**). Reducing the level of **climate change** and reducing human vulnerability to whatever **climate changes** do occur depend on the understanding of **climate science**, engineering capabilities, and other kinds of knowledge ... (MS-ESS3-5).

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Thirdly, across the curriculum there is lack in clear distinction between current anthropogenic CC and changes in the climate over geological timescales. This will be discussed in the context of the high-school curriculum.

High-school (Grades 9-12). Five issues emerge from the analysis, which call for attention. The first finding concerns CC conceptualization primarily as a science issue. Secondly, the ambiguity concerning making a clear distinction between the current anthropogenic CC and natural changes in the climate that occurred over geological time scales. This to the extent of muddling the science by suggesting that humans are one factor among others causing CC. Thirdly, there is ambiguity and lack of consistency relating to the use of terms associated with CC. Fourthly, the term CC often appears as an effector or an example of something else. Finally, at times CC is addressed without being explicitly mentioned. Table 1 presents exemplars of these CC appearances, drawn from the high-school curriculum, and presented alongside critical commentary.

Table 1. Exemplars of CC Appearances in the NGSS High-School Curriculum, by Topics, DCIs/PEs, Citations and Comments.

Topic	DCIs / PEs	Citation	Comments
Interdependent Relationships in Ecosystems	LS2.C: Ecosystem Dynamics, Functioning, and Resilience	Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and **climate change**—can disrupt an ecosystem and threaten the survival of some species (HS-LS2-7).	CC appears by title only with no further explanations. The term is used to demonstrate an effector of something else. Here CC appears as one cause among others of ecosystems disruptions.
	LS4.D: Biodiversity and Humans	Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and **climate change**. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth … (secondary to HS-LS2-7), (HS-LS4-6).	CC appears by title only with no further explanations. The term is used to demonstrate an effector of something else. Here CC appears as an example for human activities that negatively impact biodiversity.
Natural Selection and Evolution	PE: HS-LS4-4	Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, **long-term climate change**, acidity, light,	• The term *long term CC* appears unexplained. It is assumed to denote "10–100s of millions of years: long-term changes in atmospheric composition" (HS-ESS2-4). • Lack of distinction between current anthropogenic CC and natural changes in the climate

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		geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] (HS-LS4-4).	that occurred over geological time scale. • The term is used to demonstrate an effector of something else.
	PE: HS-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include **climate feedbacks**, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice …] (HS-ESS2-2).	• The text refers to "climate feedbacks", which form CC processes. Thus, CC is discussed without explicitly being mentioned. • CC conceptualized primarily as a science issue. • Lack of distinction between current anthropogenic CC and natural changes in the climate that occurred over geological time scale.
Earth's Systems	PE: HS-ESS2-4	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in **changes in climate**. [Clarification Statement: Examples of the causes of **climate change** differ by timescale, over 1–10 years: large volcanic eruption, ocean circulation; 10–100s of years: changes in human activity, ocean circulation, solar output; 10–100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10–100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of **changes in climate** is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution] (HS-ESS2-4).	• CC conceptualized primarily as a science issue. • Lack of distinction between current anthropogenic CC and natural changes in the climate that occurred over geological time scales. The term CC is used for describing both phenomena, regardless of the fundamental differences in their root causes. The two distinct phenomena are intertwined in a way that may cause CC to be erroneously conceived as a natural phenomenon. • Ambiguous use of terms related to CC.
Weather and Climate	PE: HS-ESS3-5	Analyze geoscience data and the results from global **climate models** to make an evidence-based forecast of the current rate of global or regional **climate change** and associated future impacts to Earth	• CC conceptualized primarily as a science issue. • Ambiguous use of terms related to CC.

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		systems. [Clarification Statement: Examples of evidence, for both data and **climate model** outputs, are for **climate changes** (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of **a climate change** and its associated impacts.] (HS-ESS3-5).	
	ESS1.B: Earth and the Solar System	Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual **climate changes** (secondary to HS-ESS2-4).	Ambiguous use of terms related to CC. Here the plural form of CC is used in the context of changes in the climate over geological timescales.
	ESS2.A: Earth Materials and System	The geological record shows that **changes to global and regional climate** can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles (HS-ESS2-4).	• CC conceptualized primarily as a science issue. • Lack of distinction between current anthropogenic CC and natural changes in the climate that occurred over geological time scales. • Muddling the science by suggesting that humans are one factor among others causing CC. • CC is discussed without being explicitly mentioned.
	ESS3.D: Global Climate Change	Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts" (HS-ESS3-5).	CC is discussed without being explicitly mentioned.
Human Sustainability	PE: HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural	• CC is discussed without being explicitly mentioned.

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	resources, occurrence of natural hazards, and **changes in climate** have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of **changes in climate** that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.] (HS-ESS3-1).	• Ambiguous use of terms related to CC. CC implicitly referred to by "changes in climate". • CC appears as one factor among others impacting human activity. • CC is used to demonstrate an effector of something else.
ESS2.D: Weather and Climate	Current models predict that, although future regional **climate changes** will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global **climate models** strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere (ESS2.D).	• CC conceptualized primarily as a science issue. • CC is discussed without being explicitly mentioned. • Ambiguous use of terms related to CC.
ESS3.A: Natural Resources	All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors (HS-ESS3-2).	CC is discussed without being explicitly mentioned.
ESS3.D: Global Climate Change	Through computer simulations and other studies, important discoveries are still being made about how the ocean, the	CC is discussed without being explicitly mentioned.

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	atmosphere, and the biosphere interact and are modified in response to human activities" (HS-ESS3-6).

Note. Adapted from NGSS Lead States, 2013. https://www.nextgenscience.org/search-standards?&tid[]=107.

2.4. Summary

The review of the NGSS suggests that this curriculum takes CC education a step forward by formally including it in the curriculum, with particular focus on the science aspects of CC. Science concepts are introduced through a learning progression beginning in Grade Band 6–8, with the highest level of complexity introduced in Grade Bands 9–12. This form of conceptual progression seems age-appropriate, as concepts are gradually being developed from simple to complex concepts, systematically constructed.

The analysis reveals areas of ambiguity, four of which are of particular concern, including: (i) the lack in clear distinction between the current anthropogenic CC and natural changes in climate over geological time scales; (ii) lack of conceptual organization; (iii) ignoring non-science based key concepts in CC; and (iv) terminological inconsistency and incoherency. These are discussed sequentially.

The lack of a clear distinction between the current anthropogenic CC and changes in climate over geological timescales may lead to the erroneous conclusion that current anthropogenic CC involves non-human caused factors. In the present political context, there is a concern that this approach may be inadvertently contributing to the false debate about the causes of CC. The findings of the present analysis reaffirm previous critique by the National Center for Science Education and the Texas Freedom Network Education Fund (2020), which criticized the curriculum for its ambiguity by framing human activity as a 'major factor' rather than the only factor causing CC.

While the NGSS is successful in addressing key scientific concepts in CC, these concepts appear scattered across various topics and disorganized. The lack of conceptual organization forms a hindrance to teaching and learning CC, as it leaves teachers and students on their own to integrate the various concepts and form a complete understanding of CC key concepts and their interactions across systems. For knowledge to be processed effectively it needs to be systematically structured and organized. In other words, there is "overwhelming research on learning showing the importance of organizational structures for helping students progress to become experts" (California State Board of Education Policy on the Teaching of Natural Sciences, 2018, n.d.).

The curriculum fails to identify non-science-based key concepts in CC and address them comprehensively and systematically. This issue is elaborated upon in the final section. Here it is sufficed to state that this finding echoes the critique by Johnson and Anderson (2017). Additionally, this finding has also emerged in the analysis of CC conceptualization by USGCRP (2009) and Shepardson et al. (2012) earlier in this paper. All three frameworks leave the human originators and drivers of CC in the background, making these critical aspects invisible.

Across the curriculum there is terminological ambiguity and incoherency. For example, in the core idea Global Climate Change (HS-ESS3-5), the term *global climate change* reads ambiguous. It suggests that when conceived as a phenomenon, there may be alternative types of CC, which is *local*, or *regional CC*. In other words, there may be two types of CC—*global* and *local*. The fact is that CC is a global phenomenon. While local and regional drivers, processes and impacts may differ, CC is still essentially global, and there are no two types. Further ambiguity appears throughout the curriculum in relation to the use of terms, such as: "climate changes" (MS-ESS3-5), "long-term climate change" (HS-LS4-4), "changes in climate" (HS-ESS2-4), "changes to global and regional climate" (HS-ESS2-4), "… affect climate" (HS-ESS2-4), "global climate models" (ESS2.D). Together, the diverse terms associated with CC, signify that epistemologically, CC is not conceived as a coherent body of knowledge to which there is a designated term. This is a conceptual problem no less than referring to the noun *Biology* by using a verb such as *Biologes* (as analogous to *climate changes*); or disregarding the designated term *Biology* by referring to it by another noun such as *Global bio models* (as analogous to *global climate models*). Furthermore, clarity required regarding the use of the term *long term CC*. The explanation of the term needs to go beyond the definition presented in PE HS-ESS2-4 concerning CC timescales. The current use of the term *long-term CC* may inadvertently be misleading, suggesting that there may be two types of CC, *short term CC* and *long term CC*, further leading to the erroneous conclusion that the current CC is of a *short-term* type (and would potentially go away soon?), as opposed to CC over extended geological periods.

Finally, the review of CC representation in the NGSS reveals the limited suitability of a science curriculum to address the CC in a comprehensive way.

3. Analysis of Climate Change in the New Jersey Student Learning Standards

Climate change education in the NJSLS to the best of knowledge, is the first effort in the USA, and among the few worldwide, to develop a comprehensive CC curriculum that goes beyond the representation of CC in the Sciences. In June 2020, the State Board of Education adopted the “2020 New Jersey Student Learning Standards”, making New Jersey the first state in the USA to incorporate K–12 CC education across Content Areas (New Jersey Climate Change Education Hub, n.d.). The enactment of the new standards began in September 2022. The NJSLS CC curriculum is presented in Appendix 4, by CC core ideas and PEs, Grade Bands and Content Areas. The CC curriculum analysis presented hereby addresses key aspects, including: conceptualization and theoretical rational; use of terminology; content scoping, organization and progression; and DRR.

Notably, NJSLS adopts the NGSS as the curriculum for Science and Engineering. The previous section discusses the NGSS extensively. Thus, the analysis below focuses primarily on the other Content Areas of the NJSLS, excluding Science.

3.1. Conceptualization and Theoretical Rational

CC is conceptualized as a multidisciplinary topic appearing across all Content Areas in an approach identified by the NJSLS as a cross-curriculum approach (New Jersey Climate Change Education Hub, n.d.). The various parts of the contents making up the topic tend to be included in their relevant Content Areas. However, within each Content Area CC is perceived as multidisciplinary. The curriculum does not provide a rationale or justification for its cross-curriculum approach. It is not clear whether alternative approaches for inclusion were considered; and the extent to which the inclusion approach was substantiated theoretically and empirically.

Pedagogically, the curriculum advocates authentic learning experiences, consideration of a range of perspectives, and collective action. The curriculum states: “Districts are encouraged to utilize the NJSLS to develop interdisciplinary units focused on climate change that include authentic learning experiences, integrate a range of perspectives and are action oriented” (NJDOE, n.d.).

3.2. Use of Terminology

Overall, the curriculum attempts to keep the terminology consistent, using the term *CC*. With the current tendency of the mass media to use catchy, sensationalist terms, such as *climate crisis*, this curriculum may be commended for its overall consistency in CC terminology. However, two exceptions were found, where in one PE (Code: 7.1.NM.IPERS.6), CC contents are addressed by the term *climate* instead of *CC*; and in another PE (Code: 1.1.12adv.Cn10b), the term *global warming* appears instead of *CC*. However, these two minor deviations highlight the overall consistent use of the term *CC*.

3.3. Content Scoping, Organization, and Progression

Concerning content scoping, the curriculum does not outline the boundaries of CC as a field of knowledge and the scope of CC contents. The curriculum also presents limited internal organization.

Concerning internal organization, for most other fields, such as History or Biology, content organization is thematic, where themes are methodologically constructed across Grade Bands. When it comes to CC, some thematic organization is found in Social Sciences, mainly in Grade Band 9–12.

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In the other Content Areas (excluding Science), CC appears mostly by title, giving the reader the impression that CC is metaphorically *sprayed* across the curriculum, rather than being methodologically structured and constructed around specified contents. In these other Content Areas, where CC appears primarily as a title, it seems that teachers and students are left to select their own CC contents. This is a cause for concern because of the high level of sensitivity associated with CC, and the risk it poses to student well-being and potential development of climate anxiety. Furthermore, by leaving students to select their own CC content from the media, the curriculum may be contributing to two media-related risks: developing inaccurate CC conceptions and developing CC anxiety. This approach seems counterproductive as it enhances the negative effects of the media, rather than placing schools in a remedial role. To achieve this, CC content needs to be carefully selected and delivered through evidence-based practices, rather than exposing students to unsupervised content randomly selected by the students themselves.

Lastly, the limited content scoping and internal organization across K–12 appear to result in limited attention to learning progression across Grade Bands and between Content Areas within grade bands. Appendix 5 presents the analysis of the curriculum by Grade Bands, focusing on the contents, organization, and progression across the Grade Bands.

3.4. Disaster Risk Reduction

A review of the curriculum reveals that DRR is addressed in Science through the NGSS, in Grade Bands 3–12. This is exemplified as follows: Grade Band 3–5, Science core idea states: "A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts" (NJSLS, 2020). Accordingly, PE 3-ESS3-1 states: "Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard" (NJSLS, 2020). Grade Band 6–8 Science core idea states: "Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events" (NJSLS, 2020). Accordingly, PE MS-ESS3-2 states: "Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects" (NJSLS, 2020). Grade Band 9–12 PE HS-ESS3-1 states: "Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards and changes in climate have influenced human activity" (NJSLS, 2020).

The analysis of DRR inclusion in the curriculum suggests that the curriculum primarily focuses on addressing Dimensions 1 and 3 of the five essential dimensions outlined by UNESCO and UNICEF (2014). Dimension 2: "Learning and practicing safety measures and procedures" (p. 11), is not addressed. In my view this missing Dimension is the most important of the five, because it directly deals with preparing students to take safety measures that may save lives in hazardous events. From this perspective, the curriculum focuses on the content knowledge related to hazards, neglecting critical skills, mental and physical preparation of students through drill exercises and other educational methods. The omission of practical preparation to take lifesaving measures during CC-related hazards is a concern and needs to be addressed in future CC curriculum development.

3.5. Summary

The analysis of the NJSLS reveals two distinct approaches for including CC. The first is pronounced primarily in the NGSS-based Science, and to a lesser degree in Social Science, where CC contents are specified and there is apparent learning progression, where ideas become more complex across Grade Bands. The second approach is apparent across all other Content Areas, where CC appears as a title, devoid of content. This type of CC appearance lacks learning progression, and the PEs do not seem age appropriate. It was suggested that this approach may be putting young students at psychological risk.

4. Discussion of Critical Gaps in Climate Change Curriculum Development

The literature review revealed critical gaps in literary approaches to developing CC curriculum. These were further elucidated in the analysis of CC in the two curricula, NGSS and NJSLS. Taken together, the analysis suggests that there are six key issues in CC curriculum development that require in-depth problematizing. These include CC inclusion through a cross-curricular approach unproblematized; key socio-economic-political concepts underpinning CC not articulated; lack of thematic organization; the importance of non-linear CC thematic organization; terminological consistency; insufficient consideration given for learning progression and selection of age-appropriate content; and DRR—a neglected theme.

4.1. Problematizing the Cross-Curriculum Approach to Climate Change Curricular Inclusion – Climate Change Needs to Be a Subject in Its Own Right

The cross-curriculum approach for including CC in the curriculum is the most advocated approach (European Commission, 2022; Mulvik et al., 2022; UNESCO, 2021a, b). However, theoretical and empirical evidence clearly indicate its ineffectiveness. This idea may be traced back to the suggestion that if CC is a multidisciplinary field of knowledge, it follows that it needs to be implemented in multiple school subjects. This conceptualization is problematic in two ways. First, by giving the false impression that multidisciplinary is a distinguishing epistemological descriptor of CC, and second, by assuming that effective teaching of multidisciplinary knowledge is by dispersing it across the curriculum.

The fact is that multidisciplinarity is a non-distinguishing epistemic characteristic of knowledge. This is because most knowledge produced by humans is essentially multidisciplinary. Science, History, Civics—they all can be characterized as multidisciplinary, and thus multidisciplinarity on its own is not helpful in characterizing CC as a body of knowledge and distinguishing it from other bodies of knowledge. Regardless, while we do not approach the teaching of History or Science by dispersing them across the curriculum, there seems to be an agreement that this approach is a good idea when it comes to CC. This form of fragmentation and dispersal of CC across the curriculum was criticized for posing a range of hindrances for effective teaching and learning, including challenges to curriculum design and implementation, resource development, teaching and teacher knowledge, and learning (Eilam, 2022).

In fact, disciplinary curricular structures are particularly suitable for addressing complex knowledge such as CC. For this reason, in upper secondary subjects, where knowledge becomes more complex, the curricular organization tends to be more disciplinary based compared to that in the lower grades. For a curriculum to be effective in achieving its educational goals, its structure must be intimately connected to the structure of knowledge and its acquisition. For knowledge to be processed effectively it needs to be systematically structured and organized, where key concepts and the connections between them are identified (California State Board of Education Policy on the Teaching of Natural Sciences, 2018). The dispersal of CC content across the curriculum violates this basic principle of knowledge acquisition.

Empirically, it was found that regardless of the advocacy of the cross-curriculum approach, few countries apply this approach in their curricula, and when they do so, it scarcely filters down into actual implementation (European Commission, 2022; UNESCO, 2021b). The current study supports these findings. The review of the NJSLS reveals that while at the declarative level, the aim was to include CC in a cross-curriculum approach, effectively, only the Science curriculum presented truly meaningful CC contents, with Social Studies lagging behind and presenting limited CC content, mostly in a disorganized way. No other Content Area presented CC content. Instead, CC appeared across most areas of the curriculum by title only. When addressing the discrepancy between cross-curriculum advocacy and poor implementation success, the literature commonly lays the blame on the curricula, schools, and teachers for not trying hard enough (UNESCO 2021a, b). However, this lack of success is grounded in educational theories and is the most likely expected outcome. Consequently, the complexity of CC and the high level of systems interactions calls for implementing

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CC as a subject on its own right with dedicated teachers trained to deal with the complexity in a systematic way.

4.2. Key Socio-Economic-Political Concepts Underpinning CC—Not Articulated

The literature review and the curricula analysis consistently revealed that key concepts in the humanities basis of CC are mostly missing. This is contrary to the science basis of CC, where key concepts are identified and presented in a relatively organized way. To develop a complete CC curriculum, it is essential to identify and organize key concepts in humanities. This is because the humanities basis of CC is the only basis that could provide valid explanations for the state of CC and its trajectories. The science on its own cannot provide explanations for many aspects concerning CC.

Concepts form important foundations in curricular structures, in characterizing and explaining phenomena. They provide the cognitive tools for unpacking complexity and understanding the principles of knowledge assemblage, production, verification and evaluation. Some concepts are governed by natural laws, such as the concept of *atom* or the process of *conduction*. However, some concepts in the humanities describe typifying characteristics of operation or relationships, such as the concepts of *free market* and *democracy*. Fields of knowledge are made up of concepts, each having its own explanatory power. Understanding concepts allows the learners to generalize and explain phenomena. For example, understanding the concept of *free market* provides a framework for explaining other phenomena, such as why the growth in nations' Gross Domestic Product is accompanied with the growth of inequality.

The lack of key concepts in humanities is a critical omission from CC curricula, leaving it incomplete and not fit for purpose. For example, to understand the exponential rise in global CO_2 emissions since the second half of the twentieth century there is a need to understand the economic paradigm shift occurring at this period, from the Keynesian economy to the neoliberal economy of the Chicago School of Milton Friedman (with its roots in the Mont Pèlerin Society) (Laybourn-Langton & Jacobs, 2018). Among the various impacts of this shift was the opening of markets for free trade and governments stepping back from their regulatory roles, consequently creating the conditions that allowed CO_2 emissions to rise unabatedly.

Curricula reliance on science alone evades critical questions in CC. The following NGSS statement is an example of this oversight: "Changes in the atmosphere due to **human activity have increased** carbon dioxide concentrations and thus affect climate" (NGSS, 2013, HS-ESS2-6). The empty statement "human activity has increased …" does not explain why emission growth was slow for over a century post the Industrial Revolution and had quadrupled by 1990 (Ritchie & Roser, 2020). While science does not hold the answer to this question, understanding the economic paradigm shift and its wider implications does hold the answer.

Another example of the need to develop a fully conceptualized CC curriculum that goes beyond the science, relates to explaining the thirty-year time lag in implementing measures to curb emissions. By 1992 when world leaders gathered at the Earth Summit in Rio de Janeiro, the science of CC was clear and consensual—the massive burning of carbon-based fuels is destroying the climate balance and threatening Earth life support systems (United Nations, 1992). However, thirty years later emissions are still rising. This begs the question: Why? Arguably, if the matter was only an issue of understanding the science, then CC could have been dealt with as effectively as dealing with the ozone depletion. Here again, science does not hold the answers, yet the social sciences do. To understand the thirty-year time lag we need to draw upon social science explanations about the ways in which the fossil fuel companies organized and strategically orchestrated deception and manipulation campaigns to prevent action on CC; and understand the economic political structures that allowed the denial industry to propagate unaccounted for within enabling legal frameworks.

These two examples highlight the need to position CC education on its appropriate footings. CC is not an issue only in the natural sciences, but also in the social sciences and humanities. Nor can it be explained on a science basis only. Scientific explanations form only a limited subset of concepts constituting CC. Thus far, the vast number of CC concepts related to the humanity aspects of CC have not been articulated sufficiently in CC literature, nor in curricula. Instead, the humanity aspects are

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presented as an amorphous un-explicated notion often disguised under ambiguous explanations such as: "Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior …" (NGSS Lead States, 2013, MS-ESS3-5). Together, the assumption that CC is predominantly a field of science, and the critical lack of explication of key humanity concepts, hinder effective CC curriculum development.

4.3. Lack of Thematic Organization

When we think about school curricula, such as in Science, Geography or History, a common feature is the thematic organization of content. Thematic organization is a key curricular instrument for organizing information for teaching and learning. It allows the breaking down of complexity into smaller units. Within these themes we usually find key concepts that form the building blocks of the themes, and often there is a narrative connecting the concepts within themes. In this way, key concepts are used as steps that assist in constructing meaning and explanations as students develop their understanding along the thematic narrative. Such thematic organization may be demonstrated in the Science curriculum. Table 1 presents the thematic organization of the NGSS. Here each branch of the sciences is broken down into themes and sub-themes (referred to as Disciplinary Core Ideas and Sub-Ideas). For example: the theme PS1 Matter and Its Interactions includes three sub-themes: PS1A Structure and Properties of Matter; PS1B Chemical Reactions; and PS1C Nuclear Processes. In History, thematic curriculum organization may consist of historical periods or the history of different regions or areas.

Contrarily, the analysis of CC curricula revealed only one theme—the science theme. All other matters concerning CC are bundled amorphously on the edges of the science theme, lacking concept specification and thematic narratives. When it comes to the humanities aspects of CC, concept specification and thematic organization are critically important. This is because they provide inroads into the unspecified knowledge often bundled under generic descriptors, such as humanity: 'is causing', 'affected by', and 'needs to solve' CC. The absence of thematic and conceptual organization leaves students to assume that the given packaged knowledge is the only option. It is up to students and teachers to unpack the bundled humanities aspect of CC, with all its complexity, a task which is difficult for experts, and much more so for teachers and students.

When it comes to understanding complexity—the evidence suggests that students require explicit, thematically organized instruction to support their conceptual development (Goldman et al., 2016; Sweller et al., 2019). Organized CC information is required to enable students to effectively integrate multiple concepts in Science and Humanities into coherent epistemic explanations in CC. Thus far there is a dearth of information in scholarly work proposing thematic organization for CC curricula. Eilam et al. (2020) proposed a thematic organization of CC along eight thematic narratives. The above discussion concerning DRR adds a ninth important contribution to CC themes. Further research is urgently required in identifying relevant themes and their underlying concepts for CC curriculum development.

4.4. The Importance of Non-Linear Climate Change Thematic Organization

A word of caution is required against the tendency to organize CC curricula in a cause–effect linear form, causing the flattening of the CC body of knowledge and reducing its complexity. It seems to be a common practice to organize CC content along a linear, more-or-less cause–effect, and somewhat chronological narrative. This would commonly take the form of: Causes of CC >>> CC Processes >>> Effects and Impacts >>> Solutions (mitigation and adaptation). This highly simplistic linear organization is reductionist in the sense that it ignores the multiple thematic narratives that are co-operative in the system in multiple directions and influences, creating meanings and trajectories. Such a linear thematic organization would mostly focus on the science aspects only, while ignoring other narratives. For example, under Effects and Impacts, the discussion of impacts on humans may take the following form:

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Coastal regions will be impacted by rising oceans and according to some studies a possibility of more frequent hurricanes (Trenberth, 2005). Prolonged heat waves and drought conditions will stress water and food resources and cause more heat-related deaths (Intergovernmental Panel on Climate Change [IPCC], 2007b). Hotter days will result in poorer air quality and increased ozone alerts (Mickley et al., 2004). … people may be required to change their lifestyles and practices to mitigate global warming, and communities may need to become climate ready, preparing for increased flooding and storm and drought conditions, which may require changes in zoning, land use practices, and agriculture (Pielke et al., 2007). (Shepardson et al., 2012, p. 335).

These projections are reflective of a science-based theme. However, other themes may have different stories to tell, in which the full story can only emerge when viewed across multiple themes in a non-linear form. For example, the economic theme may tell the story of the "Tragedy of the Commons" described by Hardin in 1968. The idea suggests that in the absence of strict regulations and enforcement, common resources such as air, water and soil are destined for depletion. The neo-liberal free market economic paradigm created the perfect conditions for the CC tragedy to unfold, where many common resources ceased to be common through privatization, and the corporates were permitted to freely exploit both privatized and the commons, through favoring governmental regulations. Here the discussion of effects and impacts would include the impacts of unequal distribution and reduced social resilience on withstanding CC calamities.

Finally, to demonstrate the importance of developing non-linear thematic organization of CC curricula, it may be helpful to think of what other subjects might have looked like if such an organizational approach was applied to them. Imagine, for example, organizing the subject of Biology as follows: Cells >>> Organisms >>> Ecosystems. Evidently critical aspects of Biology become lost in this simplistic cause–effect, linear organization.

4.5. Terminological Consistency

The analysis of the NGSS revealed terminological inconsistency and incoherency. This finding is not surprising given the epistemological vagueness of this body of knowledge (Eilam, 2022). Some national policy documents and scholarly research use the terms Climate Education or Climate Literacy (Bieler at el., 2017; USGCRP, 2009). CC also seems to be associated with terms such as Carbon Literacy (Government UK Department of Education, 2022); Climate Crisis (Ángel & Cartea, 2020); and Climate Science Literacy (Busch & Román, 2017). Additionally, it is commonly conceived as a theme within multiple other fields such as Education for Sustainable Development (UNESCO, 2021a, b); and Global Citizenship Education (UNESCO, 2020).

The use of terms such as *climate education* or *climate literacy* rather than *climate change education* in government policies is somewhat surprising, as climate *per se* is studied within the framework of the discipline of Climatology. Using the term *climate education* may give the erroneous impression that CC is equivalent to Climatology. While CC includes climatological concepts, it goes beyond Climatology. Thus, the term presents a reductionist view of CC. Overall, there is a need to address CC through consistent and unified terminology. The term used by the Intergovernmental Panel on Climate Change (IPCC) is *climate change* (IPCC, n.d.). This is the most scientifically accurate name that curricula should be using.

4.6. Learning Progression and Selection of Age-Appropriate Content

Learning progression forms an important aspect in curriculum development, where the progression of students from novice to expert advances along conceptual progression (Busch et al., 2019). Within curricula, learning progression identifies signposts for aligning standards, instruction, and assessment (Duschl, et al., 2011). Additionally, it plays an important role in ensuring age-appropriate delivery, where the concepts taught are appropriate for students' levels of conceptual development (King & Kirchener, 2004).

Regardless of the important roles of learning progression, this issue is only scarcely addressed in the literature in relation to CC curriculum (e.g., Shepardson et al., 2012).

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The curricula analysis revealed duality in relation to implementing learning progression. The findings revealed clear learning progression in the NGSS Science curricula. This progression was retained in the NJSLS in relation to the application of the NGSS in Science. The decision by the NGSS not to include CC in primary-school may be underlined by epistemic considerations. As primary-school students may lack the required cognitive maturity to deal with the complex CC mechanisms and feedback loops, as well as insufficient emotional preparedness to deal with the enormity of the threat. However, in all other Content Areas, there was no identifiable conceptual progression. Contrarily some of the standards for the early grades were clearly not age-appropriate. This form of curriculum organization is inappropriate and in the case of CC may be harmful for students' well-being (See elaboration in Appendix 5). It is imperative that concepts be built on existing concepts and not appear disconnected and un-explicated. To ensure that CC content is delivered systematically, using age-appropriate pedagogies, future CC curriculum development needs to identify learning progression for each of its themes.

4.7. Disaster Risk Reduction

The literature rarely addresses DRR as a CC theme. Mapping of global DRR integration into education curricula in 30 case studies by UNESCO/UNICEF reveals that DRR is mostly included in curricula through "infusion," by which DRR topics appear in various subjects (Selby & Kagawa, 2012). The present analysis reveals that DRR is only included in Science, in the NGSS, and in the Science curriculum of the NJSLS. There was no indication for Selby & Kagawa's (2012) notion of *infusion*. Furthermore, while the Standards touch upon CC hazards, they are not presented as such in the Science curriculum. Further work is required in developing DRR in CC in a more integrated and purposeful way.

5. Conclusions

In concluding this critical analysis, a set of recommendations are offered for consideration in further development of CC curriculum:

- CC is not a field of Science. CC is a comprehensive, interconnected body of knowledge extending beyond the boundaries of Science, and thus, it should not be conceptualized as a field of Science.
- The cross-curricular approach to including CC is theoretically unsubstantiated and empirically ineffective. CC should be taught as a subject or a topic on its own right.
- CC curriculum development needs to identify thematic narratives and their constituting concepts. There needs to be organization across themes and within themes. Concepts within themes need to be organized along selected narratives. The NRC framework (NRC, 2012) provides a good example for thematic organization in Science. A similar approach may be applied in CC curriculum development.
- DRR needs to form part of CC curricula, most likely as a theme. Students of all ages need to participate in exercise drills preparing them to protect themselves from hazardous CC events. I suggest that drill exercises as a stand-alone learning activity could be applied across all Grade Bands.
- A complete CC curriculum needs to identify learning outcomes related to both content and skill acquisition, set performance expectations, and present forms of assessment.
- There is a need to develop learning progression across themes and/or within themes, as appropriate.
- Carefully consider age-appropriate content. CC appears to be an inappropriate subject for primary-school students. It is beyond the scope of this study to discuss the issue in-depth. However, it is evident that CC is probably one of the most complex fields of knowledge taught at school and requires sufficient cognitive and emotional epistemic development and preparedness prior to addressing this high level of complexity. However, primary years are important in forming the conceptual foundations for later understanding of CC. Such knowledge basis may include, for example, weather and climate, forms of governance and more.

- Curricula need to use one consistent term in addressing CC. It is suggested to follow the IPCC and use *climate change* as the agreed term describing the school subject.

Further Research

The present paper focused on tackling the problem of CC curriculum content identification and organization, as a priority. However, a complete CC curriculum needs to address additional aspects, which are beyond the scope of this position paper. These include, for example, identifying CC values, relevant skills, and pedagogies for teaching. A CC curriculum also needs to consider the critical question of how to teach students about the evident calamities of CC, while at the same time maintain students' well-being. Teachers need to be equipped with effective pedagogical tools for preventing the development of climate anxiety and addressing it, if arises. The present position paper aimed to contribute to some aspects involved in CC curriculum development, however, further research is required for addressing the various open questions concerning CC curriculum development and implementation.

Appendix 1. Acronyms

CC	climate change
DCI	Disciplinary Core Idea
DRR	Disaster Risk Reduction
IPCC	Intergovernmental Panel on Climate Change
NGSS	Next Generation Science Standards
NJDOE	New Jersey Department of Education
NJSLS	New Jersey Student Learning Standards
NRC	National Research Council
PE	Performance Expectation
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USA	United States of America
USGCRP	United States Global Change Research Program

Appendix 2

Table A1. The positioning of ESS3.D: Global Climate Change within the Next Generation Science Standards (NGSS), by Disciplines, Disciplinary Core Ideas (DCIs) and sub-Ideas.

Physical Science	Life Science	Earth and Space Science
PS1 Matter and Its Interactions PS1A Structure and Properties of matter PS1B Chemical Reactions PS1C Nuclear Processes **PS2 Motion and Stability: Forces and Interactions**	**LS1 From Molecules to Organisms: Structures and Processes** LS1A Structure and Function LS1B Growth and Development of Organisms LS1C Organization for Matter and Energy Flow in Organisms	**ESS1 Earth's Place in the Universe** ESS1A The Universe and Its Stars ESS1B Earth and the Solar System ESS1C The History of Planet Earth **ESS2 Earth's Systems**

PS2A Forces and Motion PS2B Types of Interactions PS2C Stability and Instability in Physical Systems **PS3 Energy** PS3A Definitions of Energy *PS3B Conservation of Energy and Energy Transfer* PS3C Relationship Between Energy and Forces PS3D Energy and Chemical Processes in Everyday Life PS4 Waves and Their Applications in Technologies for Information Transfer **PS4 Waves and Their Applications in Technologies for Information Transfer** PS4A Wave Properties PS4B Electromagnetic Radiation PS4C Information Technologies and Instrumentation	LS1D Information Processing **LS2 Ecosystems: Interactions, Energy, and Dynamics** LS2A Interdependent Relationships in Ecosystems *LS2B Cycles of Matter and Energy Transfer in Ecosystems* LS2C Ecosystem Dynamics, Functioning, and Resilience LS2D Social Interactions and Group Behavior **LS3 Heredity: Inheritance and Variation of Traits** LS3A Inheritance of Traits LS3B Variation of Traits **LS4 Biological Evolution: Unity and Diversity** LS4A Evidence of Common Ancestry LS4B Natural Selection LS4C Adaptation LS4D Biodiversity and Humans	ESS2A Earth Materials and Systems ESS2B Plate Tectonics and Large-Scale System Interactions ESS2C The Roles of Water in Earth's Surface Processes *ESS2D Weather and Climate* ESS2E Biogeology **ESS3 Earth and Human Activity** *ESS3A Natural Resources* *ESS3B Natural Hazards* *ESS3C Human Impacts on Earth Systems* ***ESS3D Global Climate Change***

Note. From "How to Read the Next Generation Science Standards (NGSS)", by NGSS Lead States, 2013, p. 3. DCIs and sub-ideas which are potentially related to CC are highlighted by italics.

Appendix 3

Table A2. NGSS High-School Level Framework: Science Domains and their Topics.

Physical Sciences	**Life Sciences**	**Earth and Space Sciences**
Structure and Properties of Matter	Structure and Function	Space Systems
Chemical Reactions	Matter and Energy in Organisms and Ecosystems	History of Earth
Forces and Interactions		Earth's Systems
Energy	Interdependent Relationships in Ecosystems	Weather and Climate

Waves and Electromagnetic Radiation	Inheritance and Variation of Traits Natural Selection and Evolution	Human Sustainability

Note. Adapted from NGSS Lead States, 2013. https://www.nextgenscience.org/overview-topics.

Appendix 4

Table A3. Climate change Core Ideas and Performance Expectation in the 2020 New Jersey Student Learning Standards (NJSLS), by Grade-Bands and Content Areas.

Core Ideas/ Enduring Understanding	Performance Expectations
Kindergarten through Grade 2	
Visual and Performing Arts	
As dance is experienced, all personal experiences, knowledge and contexts are integrated and synthesized to interpret meaning.	1.1.2.Cn10b: Using an inquiry-based set of questions examine global issues, including climate change as a topic for dance.
Artist's appreciation of media artworks is influenced by their interests, experiences, understandings, and purposes. Identifying the qualities and characteristics of media artworks improves the individual's aesthetic and empathetic awareness.	1.2.2.Re7b: Identify, share and describe a variety of media artworks created from different experiences in response to global issues including climate change.
As theater is created and experienced, personal experiences and knowledge are synthesized to interpret meaning and analyze the way in which the world may be understood.	1.4.2.Cn11a: With prompting and support, identify similarities and differences in stories and various art forms from one’s own community and from multiple cultures in a guided drama (e.g., process drama, story drama, creative drama) experience about global issues, including climate change.
People develop ideas and understandings of society, culture and history through their interactions with and analysis of art.	1.5.2.Cn11b: Describe why people from different places and times make art about different issues, including climate change.
Comprehensive Health and Physical Education	
People in the community work to keep us safe.	2.1.2.CHSS.4: Describe how climate change affects the health of individuals, plants and animals.
Science	

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All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.	K-LS1-1: Use observations to describe patterns of what plants and animals (including humans) need to survive.
Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.	K-ESS2-1: Use and share observations of local weather conditions to describe patterns over time.
Sunlight warms Earth's surface.	K-PS3-1: Make observations to determine the effect of sunlight on Earth's surface. K-PS3-2: Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.
Plants and animals can change their environment. Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things.	K-ESS2-2: Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.	K-ESS3-1: Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.
Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things.	Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things.
Plants depend on water and light to grow.	Plants depend on water and light to grow.
A situation that people want to change or create can be approached as a problem to be solved through engineering.	A situation that people want to change or create can be approached as a problem to be solved through engineering.
Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	K-2-ETS1-2: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

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Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	K-2-ETS1-3: Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
Social Studies	
Physical and human characteristics affect where people live (settle).	6.1.2.GeoPP.1: Explain the different physical and human characteristics that might make a location a good place to live (e.g., landforms, climate and weather, resource availability).
Environmental characteristics influence the how and where people live.	6.1.2.Geo.HE.1: Explain how seasonal weather changes, climate, and other environmental characteristics affect people's lives in a place or region.
	6.1.2.Geo.HE.2: Describe how human activities affect the culture and environmental characteristics of places or regions (e.g., transportation, housing, dietary needs).
	6.1.2.Geo.HE3: Identify cultural and environmental characteristics of different regions in New Jersey and the United States.
	6.1.2.Geo.HE.4: Investigate the relationship between the physical environment of a place and the economic activities found there.
When all members of the group are given the opportunity to participate in the decision-making process, everyone's voice is heard.	6.3.2.CivicsPD.1: With adult guidance and support, bring awareness of a local issue to school and/or community members and make recommendations for change.
Global interconnections occur between human and physical systems across different regions of the world.	6.3.2.GeoGI.1: Investigate a global issue such as climate change, its significance, and share information about how it impacts different regions around the world.
	6.3.2.GeoGI.2: Collect data and consider sources from multiple perspectives to become informed about an environmental issue and identify possible solutions.
Computer Science and Design Thinking	
Individuals collect, use, and display data about individuals and the world around them.	8.1.2.DA.1: Collect and present data, including climate change data, in various visual formats.

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Computers store data that can be retrieved later. Data can be copied, stored in multiple locations, and retrieved.	8.1.2.DA.2: Store, copy, search, retrieve, modify, and delete data using a computing device.
Data can be used to make predictions about the world.	8.1.2.DA.3: Identify and describe patterns in data visualizations. 8.1.2.DA.4: Make predictions based on data using charts or graphs.
Engineering design is a creative process for meeting human needs or wants that can result in multiple solutions.	8.2.2.ED.1: Communicate the function of a product or device. 8.2.2.ED.2: Collaborate to solve a simple problem, or to illustrate how to build a product using the design process. 8.2.2.ED.3: Select and use appropriate tools and materials to build a product using the design process.
Limitations (constraints) must be considered when engineering designs.	8.2.2.ED.4: Identify constraints and their role in the engineering design process.
Career Readiness, Life Literacies, and Key Skills	
There are actions an individual can take to help make this world a better place.	9.1.2.CR.1: Recognize ways to volunteer in the classroom, school and community. 9.1.2.CR.2: List ways to give back, including making donations, volunteering, and starting a business.
Critical thinkers must first identify a problem then develop a plan to address it to effectively solve the problem.	9.4.2.CT.1: Gather information about an issue, such as climate change, and collaboratively brainstorm ways to solve the problem (e.g., K-2-ETS1-1, 6.3.2.GeoGI.2). 9.4.2.CT.2: Identify possible approaches and resources to execute a plan (e.g., 1.2.2.CR1b, 8.2.2.ED.3). 9.4.2.CT.3: Use a variety of types of thinking to solve problems (e.g., inductive, deductive).
Young people can have a positive impact on the natural world in the fight against climate change.	9.4.2.DC.7: Describe actions peers can take to positively impact climate change (e.g., 6.3.2.CivicsPD.1).
Digital tools and media resources provide access to vast stores of information that can be searched.	9.4.2.IML.1: Identify a simple search term to find information in a search engine or digital resource.

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Digital tools can be used to display data in various ways.	9.4.2.IML.2: Represent data in a visual format to tell a story about the data (e.g., 2.MD.D.10).
A variety of diverse sources, contexts, disciplines, and cultures provide valuable and necessary information that can be used for different purposes.	9.4.2.IML.3: Use a variety of sources including multimedia sources to find information about topics such as climate change, with guidance and support from adults (e.g., 6.3.2.GeoGI.2, 6.1.2.HistorySE.3, W.2.6, 1-LSI-2)
Digital tools have a purpose.	9.4.2.TL.1: Identify the basic features of a digital tool and explain the purpose of the tool (e.g., 8.2.2.ED.1). 9.4.2.TL.2: Create a document using a word processing application. 9.4.2.TL.3: Enter information into a spreadsheet and sort the information. 9.4.2.TL.4: Navigate a virtual space to build context and describe the visual content. 9.4.2.TL.5: Describe the difference between real and virtual experiences. 9.4.2.TL.6: Illustrate and communicate ideas and stories using multiple digital tools (e.g., SL.2.5.).
Grades 3 through 5	
Visual and Performing Arts	
As dance is experienced, all personal experiences, knowledge, and contexts are integrated and synthesized to interpret meaning.	1.1.5.Cn10b: Use an inquiry-based set of questions to investigate global issues, including climate change, through a variety of dance genres, styles, and cultural lenses.
An artist's appreciation of media artworks is influenced by their interests, experiences, understandings, and purposes. Identifying the qualities and characteristics of media artworks improves the individual's aesthetic and empathetic awareness.	1.2.5.Re7b: Identify, describe, explain and differentiate how various forms, methods and styles in media artworks affect and manage audience experience when addressing global issues including climate change.
As theater is created and experienced, personal experiences and knowledge are synthesized to interpret meaning and analyze the way in which the world may be understood.	1.4.5.Cn11a: Identify, respond to and investigate connections to global issues, including climate change and other content areas in a dramatic/theatrical work.

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People develop ideas and understandings of society, culture and history through their interactions with and analysis of art.	1.5.5.Cn11b: Communicate how art is used to inform others about global issues, including climate change.
Comprehensive Health and Physical Education	
Community professionals and school personnel are available to assist and address health emergencies as well as provide reliable information.	2.1.5.CHSS.2: Describe how business, non-profit organizations and individuals can work cooperatively to address health problems that are affected by global issues, including climate change.

Science	
Populations live in a variety of habitats and change in those habitats affects the organisms living there. When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.	3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.	3-ESS2-2: Obtain and combine information to describe climates in different regions of the world.
A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.	3-ESS3-1: Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.
Energy and fuels that humans use are derived from natural sources and their use affects the environment in multiple ways. Some resources are renewable over time and others are not.	4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.	4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes and climate change have on humans.

The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers". Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.	5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.	5-ESS2-1: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can	3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time or cost.

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be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	
Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.	3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Social Studies	
Human activities affect environmental characteristics of places or regions resulting in positive and negative impacts.	6.1.5.GeoHE.1: Use a variety of sources from multiple perspectives, including aerial photographs or satellite images to describe how human activity has impacted the physical environment during different periods of time in New Jersey and the United States. 6.1.5.GeoHE.2: Cite examples of how technological advances have changed New Jersey and the United States (e.g., energy, transportation, communications). 6.1.5.GeoHE.3: Analyze the effects of catastrophic environmental and technological events on human settlements and migration.
Regions form and change as a result of unique physical characteristics conditions, economies, and cultures.	6.1.5.GeoPP.2: Describe how landforms, climate and weather, and availability of resources have impacted where and how people live and work in different regions of New Jersey and the United States.
A nation's economy is influenced by its government, human and physical capital,	6.1.5.EconNM.2: Use data to describe how the resources and regions in New Jersey and other

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availability of resources, and technological progress.	regions of the United States have impacted economic opportunities.
Interactions between humans has led to the spread of cultural practices, artifacts, languages, diseases, and other positive and negative attributes as well as changes in environmental characteristics.	6.1.5.GeoGI.4: Explain how cultural and environmental characteristics affect the distribution and movement of people, goods and ideas.
In an interconnected world, increased collaboration is needed by individuals, groups and nations to solve global issues.	6.3.5.GeoGI.1: Use technology to collaborate with others who have different perspectives to examine global issues, including climate change and propose possible solutions.
Through participation in the decision-making process (e.g., voting, petitions, contacting elected officials, serving in their community) people can initiate change.	6.3.5.CivicsPD.1: Develop an action plan that addresses issues related to climate change and share with school and/or community members.
Human activities affect environmental characteristics of places or regions resulting in positive and negative impacts.	6.3.5.GeoHE.1: Plan and participate in an advocacy project to inform others about the impact of climate change at the local or state level and propose possible solutions.
World Languages	
Learning a language involves interpreting meaning from listening, viewing, and reading culturally authentic materials in the target language.	7.1.NM.IPRET.5: Demonstrate comprehension of brief oral and written messages found in short culturally authentic materials on global issues, including climate change.
Interpersonal communication is the exchange of information and the negotiation of meaning between and among individuals.	7.1.NM.IPERS.6: Exchange brief messages with others about climate in the target regions of the world and in one's own region using memorized and practiced words, phrases, and simple, formulaic sentences.
Presentational communication mode involves presenting information, concepts, and ideas to an audience of listeners or readers on a variety of topics.	7.1.NM.PRSNT.6: Name and label tangible cultural products associated with climate change in the target language regions of the world.
Computer Science and Design Thinking	
Individuals can select, organize, and transform data into different visual representations and communicate insights gained from the data.	8.1.5.DA.3: Organize and present collected data visually to communicate insights gained from different views of the data.

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	8.1.5.DA.4: Organize and present climate change data visually to highlight relationships or support a claim.
The technology developed for the human designed world can have unintended consequences for the environment. Technology must be continually developed and made more efficient to reduce the need for non-renewable resources	8.2.5.ETW.5: Identify the impact of a specific technology on the environment and determine what can be done to increase positive effects and to reduce any negative effects, such as climate change.
Engineering design is a systematic and creative process of communicating and collaborating to meet a design challenge. Often, several design solutions exist, each better in some way than the others.	8.2.5.ED.1: Explain the functions of a system and its subsystems. 8.2.5.ED.2: Collaborate with peers to collect information, brainstorm to solve a problem, and evaluate all possible solutions to provide the best results with supporting sketches or models. 8.2.5.ED.3: Follow step by step directions to assemble a product or solve a problem, using appropriate tools to accomplish the task.
Engineering design requirements include desired features and limitations that need to be considered.	8.2.5.ED.4: Explain factors that influence the development and function of products and systems (e.g., resources, criteria, desired features, constraints). 8.2.5.ED.5: Describe how specifications and limitations impact the engineering design process. 8.2.5.ED.6: Evaluate and test alternative solutions to a problem using the constraints and trade- offs identified in the design process.
Career Readiness, Life Literacies, and Key Skills	
Collaboration with individuals with diverse perspectives can result in new ways of thinking and/or innovative solutions.	9.4.5.CI.1: Use appropriate communication technologies to collaborate with individuals with diverse perspectives about a local and/or global climate change issue and deliberate about possible solutions. 9.4.5.CI.2: Investigate a persistent local or global issue, such as climate change, and collaborate with individuals with diverse

	perspectives to improve upon current actions designed to address the issue.
Digital engagement can improve the planning and delivery of climate change actions.	9.4.5.DC.8: Propose ways local and global communities can engage digitally to participate in and promote climate action.
Grades 6 through 8	
Visual and Performing Arts	
As dance is experienced, all personal experiences, knowledge and contexts are integrated and synthesized to interpret meaning.	1.1.8.Cn10b: Employ a variety of research methods to inform the development of original dances about global issues, including climate change. Articulate ways the research deepened understanding of the topic and how big ideas are expressed metaphorically through dance.
An artist's appreciation of media artworks is influenced by their interests, experiences, understandings and purposes. Identifying the qualities and characteristics of media artworks improves the individual's aesthetic and empathetic awareness.	1.2.8.Re7b: Compare, contrast and analyze how various forms, methods and styles in media artworks affect and manage audience experience and create intention when addressing global issues including climate change.
As theater is created and experienced, personal experiences and knowledge are synthesized to interpret meaning and analyze the way in which the world may be understood.	1.4.8.Cn11a: Research the story elements of a staged drama/theater work about global issues, including climate change, and discuss how a playwright might have intended a theatrical work to be produced.
People develop ideas and understandings of society, culture and history through their interactions with and analysis of art.	1.5.8.Cn11b: Analyze and contrast how art forms are used to reflect global issues, including climate change.
Comprehensive Health and Physical Education	
Advocacy for personal, family, community, and global health can influence and change the interaction of people and their health.	2.1.8.CHSS.7: Collaborate with other students to develop a strategy to address health issues related to climate change.
Science	
Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers	MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

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recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	
Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.	MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.	
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	
All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.	MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization and precipitation, as well as downhill flows on land.	MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
The complex patterns of the changes and the movement of water in the atmosphere,	MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of

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determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.	air masses results in changes in weather conditions.
Because these patterns are so complex, weather can only be predicted probabilistically.	
Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.	MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms and living things. These interactions vary with latitude, altitude and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.	
The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time and globally redistributing it through ocean currents.	
Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.	MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.	MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the	MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused climate change over the past century.

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understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	
The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.	MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. Models of all kinds are important for testing solutions. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool or process such that an optimal design can be achieved.

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Social Studies	
The physical and human characteristics of places and regions are connected to human identities and cultures.	6.2.8.GeoHE.4.b: Use geographic models to determine the impact of environmental modifications made by earlier civilizations on the current day environmental challenges.
In a democratic government, there are multiple processes by which individuals can influence the creation of rules, laws, and public policy.	6.3.8.CivicsPR.4: Use evidence and quantitative data to propose or defend a public policy related to climate change.
Economic decision involves setting goals, weighing costs and benefits and identifying the resources available to achieve those goals.	6.3.8.EconET.2: Assess the impact of government incentives and disincentives on the economy (e.g., patents, protection of private property, taxes).
World Languages	
Learning a language involves interpreting meaning from listening, viewing, and reading culturally authentic materials in the target language.	7.1.NM.IPRET.5: Demonstrate comprehension of brief oral and written messages found in short culturally authentic materials on global issues, including climate change.
Interpersonal communication between and among people is the exchange of information and the negotiation of meaning.	7.1.NM.PRSNT.6: Name and label tangible cultural products associated with climate change in the target language regions of the world.
Presentational communication involves presenting information, concepts, and ideas to an audience of listeners or readers on a variety of topics.	7.1.NM.PRSNT.6: Name and label tangible cultural products associated with climate change in the target language regions of the world.
Computer Science and Design Thinking	
Computer models can be used to simulate events, examine theories and inferences or make predictions.	8.1.8.DA.6: Analyze climate change computational models and propose refinements.
Resources need to be utilized wisely to have positive effects on the environment and society. Some technological decisions involve trade- offs between environmental and economic needs, while others have positive effects for both the economy and environment.	8.2.8.ETW.4: Compare the environmental effects of two alternative technologies devised to address climate change issues and use data to justify which choice is best.
Career Readiness, Life Literacies, and Key Skills	
Gathering and evaluating knowledge and information from a variety of sources, including	9.4.8.CI.1: Assess data gathered on varying perspectives), and determine how the data can

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global perspectives, fosters creativity and innovative thinking.	best be used to design multiple potential solutions.
Multiple solutions often exist to solve a problem.	9.4.8.CT.1: Evaluate diverse solutions proposed by a variety of individuals, organizations, and/or agencies to a local or global problem, such as climate change and use critical thinking skills to predict which one(s) are likely to be effective. 9.4.8.CT.2: Develop multiple solutions to a problem and evaluate short- and long-term effects to determine the most plausible option (e.g., MS-ETS1-4, 6.1.8.CivicsDP.1).
Digital technology and data can be leveraged by communities to address effects of climate change.	9.4.8.DC.8: Explain how communities use data and technology to develop measures to respond to effects of climate change (e.g., smart cities).
Sources of information are evaluated for accuracy and relevance when considering the use of information.	9.4.8.IML.7: Use information from a variety of sources, contexts, disciplines, and cultures for a specific purpose (e.g., 1.2.8.C2a, 1.4.8.CR2a, W.5.8, 6.1.8.GeoSV.3.a, 6.1.8.CivicsDP.4.b, 7.1.NH. IPRET.8). 9.4.8.IML.8: Apply deliberate and thoughtful search strategies to access high-quality information on climate change (e.g., 1.1.8.C1b).
Grades 9 through 12	
Visual and Performing Arts	
As dance is experienced, all personal experiences, knowledge and contexts are integrated and synthesized to interpret meaning.	1.1.12prof.Cn10b: Research global issues, including climate change, using multiple research methods to inform original dances expressed through multiple genres, styles and varied cultural perspectives. 1.1.12acc.Cn10b: Collaboratively investigate global issues, including climate change, to inform the development of an original dance project. 1.1.12adv.Cn10b: Investigate and present ways in which dance can be used to communicate

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	new perspectives and/or realizations about global issues, including global warming.
An artist's appreciation of media artworks is influenced by their interests, experiences, understandings and purposes. Identifying the qualities and characteristics of media artworks improves the individual's aesthetic and empathetic awareness.	1.2.12prof.Re7b: Analyze how a variety of media artworks affect audience experience and create intention through multimodal perception when addressing global issues including climate change. 1.2.12acc.Re7b: Analyze how a broad range of media artworks affect audience experience, as well as create intention and persuasion through multimodal perception when addressing global issues including climate change. 1.2.12adv.Re7b: Survey an exemplary range of media artworks, analyzing methods for managing audience experience, creating intention and persuasion through multimodal perception and systemic communications when addressing global issues including climate change.
People develop ideas and understandings of society, culture and history through their interactions with and analysis of art.	1.5.12prof.Cn11b: Describe how knowledge of global issues, including climate change may influence personal responses to art. 1.5.12acc.Cn11b: Compare uses of art in a variety of societal, cultural and historical contexts and make connections to global issues, including climate change. 1.5.12adv.Cn11b: Assess the impact of an artist or group of artists on global issues, including climate change.
Comprehensive Health and Physical Education	
Local, state, and global advocacy organizations provide accurate and reliable resources and strategies designed to address common health and social issues.	2.1.12.CHSS.8: Investigate how local, state and global agencies are addressing health issues caused by climate change and share this information in an appropriate setting.
Science	
The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption,	HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can

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storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.	create feedbacks that cause changes to other Earth systems.
The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.	HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	
Resource availability has guided the development of human society.	HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards and changes in climate have influenced human activity.
All forms of energy production and other resource extraction have associated economic, social, environmental and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.	HS-ESS3-2: Evaluate competing design solutions for developing, managing and utilizing energy and mineral resources based on cost-benefit ratios.
When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics and to consider social, cultural and environmental impacts.	
The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations and biodiversity.
Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.	HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.

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When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics and to consider social, cultural and environmental impacts.	
Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict and manage current and future impacts.	HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics and to consider social, cultural and environmental impacts.	HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability and aesthetics as well as possible social, cultural and environmental impacts.
Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to	HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	
Social Studies	
Economic globalization affects economic growth, labor markets, human rights guarantees, the environment, resource allocation, income distribution and culture.	6.1.12.EconGE.3.a: Analyze how technological developments transformed the economy, created international markets and affected the environment in New Jersey and the nation.
Political and economic decisions throughout time have influenced cultural and environmental characteristics of various places and regions.	6.1.12.GeoHE.6.a: Compare and contrast issues involved in the struggle between the unregulated development of natural resources and efforts to conserve and protect natural resources during the period of industrial expansion.
Human settlement activities impact the environmental and cultural characteristics of specific places and regions.	6.1.12.GeoHE.5.a: Generate/make an evidence-based argument regarding the impact of rapid urbanization on the environment and on the quality of life in cities. 6.1.12.GeoHE.8.a: Determine the impact of the expansion of agricultural production into marginal farmlands and other ineffective agricultural practices on people and the environment.
Political and economic decisions throughout time have influenced cultural and environmental characteristics.	6.1.12.GeoHE.13.a: Construct an argument on the effectiveness of environmental movements, their influence on public attitudes and the efficacy of the government's environmental protection agencies and laws. 6.1.12.GeoHE.14.a: Evaluate the impact of individual, business and government decisions and actions on the environment and climate change and assess the efficacy of government policies and agencies in New Jersey and the United States in addressing these decisions.
Long-term climate variability has influenced human migration and settlement patterns,	6.1.12.GeoHE16.a: Explain why natural resources (i.e., fossil fuels, food, and water) continue to be a source of conflict and analyze

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resource use and land use at local-to-global scales.	how the United States and other nations have addressed issues concerning the distribution and sustainability of natural resources and climate change.
Resources impact what is produced and employment opportunities.	6.2.12.EconET.3.a: Determine how, and the extent to which, scientific and technological changes, transportation and new forms of energy brought about social, economic and cultural changes in the world.
Understanding the interrelated patterns of change by examining multiple events allows for a clearer understanding of the significance of individuals and groups.	6.2.12.HistoryCC.3.b: Explain how industrialization and urbanization affected class structure, family life, the daily lives of men, women, and children and the environment.
Economic globalization affects economic growth, labor markets, human rights guarantees, the environment, resource allocation, income distribution and culture.	6.2.12.EconGE.5.a: Evaluate the role of the petroleum industry in world politics, the global economy and the environment.
Demographic shifts and migration patterns both influence and are impacted by social, economic and political systems.	6.2.12.GeoPP.6.a: Make evidence-based inferences to determine the global impact of increased population growth, migration and changes in urban-rural populations on natural resources and land use.
Human and civil rights support the worth and dignity of the individual.	6.2.12.CivicsHR.6.b: Make an evidence-based argument on the tensions between national sovereignty and global priorities regarding economic development and environmental sustainability and its impact on human rights.
Constitutions, laws, treaties and international agreements seek to maintain order at the national, regional and international levels of governance.	6.2.12.CivicsPI.6.a: Use historic case studies or a current event to assess the effectiveness of multinational organizations in attempting to solve global issues.
Global economic activities involve decisions based on national interests, the exchange of different units of exchange, decisions of public and private institutions and the ability to distribute goods and services safely.	6.2.12.EconGE.6.a: Evaluate efforts of governmental, non-governmental, and international organizations to address economic imbalances, social inequalities, climate change, health and/or illiteracy.

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Global interconnections create complex spatial patterns at multiple scales that continue to change over time.	6.3.12.GeoGI.1: Collaborate with students from other countries to develop possible solutions to an issue of environmental justice, including climate change and water scarcity and present those solutions to relevant national and international governmental and/or nongovernmental organizations.
World Languages	
Learning a language involves interpreting meaning from listening, viewing, and reading culturally authentic materials in the target language.	7.1.NH.IPRET.8: Demonstrate comprehension of brief oral and written messages using contextualized culturally authentic materials on global issues, including climate change. 7.1.IL.IPRET.6: Using contextual authentic cultural resources, identify reasons for climate change in the target culture and in students' own community. 7.1.IM.IPRET.9: Use information gathered from culturally authentic resources to identify possible solutions to the effects of climate change. 7.1.IH.IPRET.8: Collect, share and analyze data related to global issues including climate change. 7.1.AL.IPRET.10: Collect, share and analyze data related to global issues including climate change.
Interpersonal communication between and among people is the exchange of information and the negotiation of meaning. Speakers and writers gain confidence and competence as they progress along the proficiency continuum.	7.1.NH.IPERS.6: Using information from brief oral and written messages on global issues and exchange information with classmates and others about global issues, including climate change. 7.1.IL.IPERS.6: Exchange information with classmates and with native speakers of the target language about the effects of climate change on the target language region(s) of the world and suggest a few possible solutions.

	7.1.IM.IPERS 6: Exchange information from a variety of resources with classmates about global issues, including climate change. 7.1.IH.IPERS.6: Compare and contrast global issues in a group discussion, with emphasis on climate change and its impact on the target language regions of the world and the people who live in those areas. 7.1.AL.IPERS.6: Converse with members of the target culture with understanding about contemporary global issues, including climate change.
Presentational communication involves presenting information, concepts and ideas to an audience of listeners or readers on a variety of topics. Speakers and writers gain confidence and competence as they progress along the proficiency continuum.	7.1.NH.PRSNT.6: Tell or write a few details about the impact of climate change in the target language regions of the world and compare those impacts with climate change in the student's community and/or different regions in the United States. 7.1.IL.PRSNT.5: Compare and contrast global issues facing the target language regions of the world and those facing the students' own regions. 7.1.IM.PRSNT.7: Compare cultural perspectives regarding the degradation of the environment of the target culture(s), including the effects of climate change, with those of students' own culture. 7.1.IH.PRSNT.6: Explain cultural perspectives of the target language people regarding climate change and compare and contrast those perspectives with ones held by people in the students' own culture. 7.1.AL.PRSNT.6: Analyze how cultural perspectives about climate change over time and compare with changing perspectives in one's own culture.
Computer Science and Design Thinking	

Individuals select digital tools and design automated processes to collect, transform, generalize, simplify and present large data sets in different ways to influence how other people interpret and understand the underlying information.	8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.
Development and modification of any technological system needs to take into account how the operation of the system will affect natural resources and ecosystems. Impacts of technological systems on the environment need to be monitored and must inform decision-making. Many technologies have been designed to have a positive impact on the environment and to monitor environmental change over time.	8.2.12.ETW.3: Identify a complex, global environmental or climate change issue, develop a systemic plan of investigation and propose an innovative sustainable solution.
Engineering design is a complex process in which creativity, content knowledge, research and analysis are used to address local and global problems.	8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
Decisions on trade-offs involve systematic comparisons of all costs and benefits and final steps that may involve redesigning for optimization.	8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback. 8.2.12.ED.3: Evaluate several models of the same type of product and make recommendations for a new design based on a cost benefit analysis. 8.2.12.ED.4: Design a product or system that addresses a global problem and document decisions made based on research, constraints, trade-offs and aesthetic and ethical considerations and share this information with an appropriate audience.
Engineering design evaluation, a process for determining how well a solution meets requirements, involves systematic comparisons	8.2.12.ED.5: Evaluate the effectiveness of a product or system based on factors that are related to its requirements, specifications, and constraints (e.g., safety, reliability, economic

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between requirements, specifications, and constraints.	considerations, quality control, environmental concerns, manufacturability, maintenance and repair, ergonomics). 8.2.12.ED.6: Analyze the effects of changing resources when designing a specific product or system (e.g., materials, energy, tools, capital, labor).
Career Readiness, Life Literacies, and Key Skills	
Network connectivity and computing capability extended to objects, sensors and everyday items not normally considered computers allows these devices to generate, exchange and consume data with minimal human intervention. Technologies such as Artificial Intelligence (AI) and blockchain can help minimize the effect of climate change.	9.4.12.DC.8: Explain how increased network connectivity and computing capabilities of everyday objects allow for innovative technological approaches to climate protection.
Solutions to the problems faced by a global society require the contribution of individuals with different points of view and experiences.	9.4.12.GCA.1: Collaborate with individuals analyze a variety of potential solutions to climate change effects and determine why solutions may work better than others (e.g., political, economic, cultural).
In order for members of our society to participate productively, information needs to be shared accurately and ethically.	9.4.12.IML.5: Evaluate, synthesize and apply information on climate change from various sources appropriately. 9.4.12.IML.6: Use various types of media to produce and store information on climate change for different purposes and audiences with sensitivity to cultural, gender and age diversity.
Accurate information may help in making valuable and ethical choices.	9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.

Note. From https://www.nj.gov/education/standards/climate/learning/gradeband/index.shtml Copyright n.d. by New Jersey Department of Education.

Appendix 5. Analysis of CC Inclusion in the New Jersey Student Learning Standards, by Grade Bands

The analysis addresses the contents, organization, and progression across the Grade Bands. Science is excluded from the analysis.

Grade Band K–2. This Grade Band lacks CC content scoping and information organization. Instead, CC appears as a title only, scattered, undefined and unspecified. This was found across all Content Areas. For example, Social Science Performance Expectation (PE) 6.3.2.GeoGI.1 states: "**Investigate a global issue such as climate change**, its significance, and share information about how it impacts different regions around the world" (NJSLS, 2020), while in Computer Science and Design Thinking, Performance Expectation 8.1.2.DA.1 states: "Collect and present data, including **climate change data**, in various visual formats" (NJSLS, 2020). In Career Readiness, Life Literacies, and Key Skills, Performance Expectation 9.4.2.CT.1 it states: "**Gather information about** an issue, such as **climate change**, and collaboratively **brainstorm ways to solve the problem**" (NJSLS, 2020).

Taken together, The PEs lack contents, and are unlikely age-appropriate. These PEs appear to leave young children to navigate CC on their own, according to their own level of incidentally constructed everyday knowledge. This approach suggests that at best, children are put at risk of developing inaccurate conceptions about CC, and at worst, they are put at risk of developing CC-anxiety from being exposed to unsupervised, potentially threatening content. As a foundation for further acquisition of structured CC education, this approach seems more harmful then beneficial.

Grade Band 3–5. In this Grade Band CC continues to appear by title only across the Content Areas, in a similar way to its appearance in Grade Band K–2, at times repeating the same standards. Here too, the curriculum refrains from selecting CC content in an age-appropriate way, often presenting Standards that are evidently not age-appropriate and disconnected from their affiliated Core Ideas. For example, Comprehensive Health and Physical Education, PE 2.1.5.CHSS.2 states: "Describe how business, non-profit organizations and individuals can work cooperatively to address health problems that are affected by global issues, including **climate change**" (NJSLS, 2020). It is highly unlikely that children in Grades 3–5 would be capable of addressing such a complex question without having developed the necessary foundational knowledge required for dealing with this multi-system global issue. Furthermore, this PE seems vastly remote and disconnected from its associated modest core idea, stating "Community professionals and school personnel are available to assist and address health emergencies as well as provide reliable information" (NJSLS, 2020). Similarly in the other Content Areas, CC appears by title only, content-devoid, and decontextualized.

Grade Band 6–8. In this Grade Band CC content knowledge continues to be unspecified, with overly complex standards, disregarding students' preparedness and age-appropriateness. For example, Expectation Performance 6.3.8.CivicsPR.4 requires the application of complex considerations of climate science and technology, economy, and climate policy to effectively meet the expectation to: "Use evidence and quantitative data to propose or defend a public policy related to climate change" (NJSLS, 2020). The curriculum does not specify the foundational content that would allow students to perform according to this expectation. Performance Expectation 8.1.8.DA.6 brings this idea to absurdity when putting forward the expectation that students "Analyze climate change computational models and **propose refinements**" (NJSLS, 2020). It is unlikely that students in Grades 6–8 have sufficient mathematical and computational knowledge to understand how CC models are produced, let alone **refine** them.

Grades 9–12. In this Grade Band Social Studies outlines contents in the social aspects of CC, while Science addresses the science aspects of CC in depth and details. The CC contents in Social Studies include: Economic and social globalization, economic growth, labor markets, human rights, environment, resource and income distribution, and culture; political and economic decisions affect the environment; the expansion of agricultural production into marginal farmlands; CC in the public sphere and in government decisions; effect on public attitudes; government efficacy in relation to CC: natural resources as a source of conflict; the effect of science and technology on social, economic, and cultural changes; effects of industrialization and urbanization; the role of the petroleum industry in politics, economy and the environment; population growth, migration and urbanization; national sovereignty and global priorities regarding economic development and environmental sustainability and its impact on human rights; constitutions, laws, treaties and international agreements. With the exception of Science and Social Studies, across the other Content Areas CC continues to appear as a title mostly devoid of content.

In summary, in the New Jersey CC curriculum, the early Grade Bands are dedicated to establishing foundational scientific and social studies knowledge, mainly through the application of the NGSS, where specific CC contents are gradually introduced in Grade Band 6–8, becoming more detailed and specific in Grade Band 9–12 in Science and Social Studies. However, there is no clear thematic organization, limited identification of thematically related key concepts, and lack of learning progression.

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