Climate Change Education: The Role of Pre-Tertiary Science Curricula in Ghana

Cecilia Boakye

Abstract

The study found out the role that some selected science curricula of the pre-tertiary level of education in Ghana played with respect to climate change education. Content analysis was used to analyze four science curricula of the pre-tertiary levels of education in Ghana, namely, the curriculum for primary, Grades 1 to 3 (age = 6-9 years); integrated science curriculum of primary, Grades 4 to 6 (age = 9-12 years); integrated science curriculum of the Junior High School (JHS; age = 12-13 years); and the integrated science curriculum of the Senior High School (SHS; age = 13-16 years). It was found that of the four curricula, it was only in the integrated science syllabuses of the SHS and that of the JHS that climate change as a topic for study had been stated categorically, but, even then, the teaching and learning methods needed to be improved on. It was practically non-existent in the natural science curriculum of Primary Grades 1 to 3. There were topics in some of the curricula such as “Ecosystems,” “Photosynthesis,” and “Energy” that can provide links to climate change education but were not linked to it. Some of the suggestions made to make these curricula play their roles in climate change education are that: (a) topics that lend themselves to climate change education in the various curricula could be linked to it in the teaching and learning situation to reinforce learning and (b) teaching and learning methods should be improved upon for effective attitudinal and behavioral changes to help mitigate climate change and its impact.

Keywords
climate change, action-oriented teaching, education

Introduction

Climate change with its associated global warming is an environmental issue that is most dreaded and poses a lot of threat to the very existence of human beings, and all efforts are being made to curb it (Borenstein, 2009; Cherry, 2011; Pettenger, cited by Feirabend & Eilks, 2010). Different methods are being used to find solutions to this menace. Education is one of the methods that have been recommended (Anderson, 2010; Cherry, 2011; Sharma, 2012; Stanford University, 2011). Although there are many advocates of having climate change education incorporated in the educational system, there are counter arguments against that (Fortner, 2001; Tomasevic, 2013). The reasons given by the opposers are: (a) the real cause of climate change is not known, so why teach students what is not fully established (Conger, 2013; Tomasevic, 2013), (b) overloading of school curricula (Smith, 2013), and (c) it is not man-made (Conger, 2013). For example, in the United States, the controversial nature of its inclusion led to the slashing off of some of the content of climate change from the science curriculum and emphasis on its anthropogenic nature was also reduced (Tomasevic, 2013). United Kingdom removed it from its curriculum (Tomasevic, 2013) but has brought it back (Smith, 2013).

Literature reveals that opposition to climate change education comes mainly from non-scientists and are found in non-refereed journals and are often funded by special interest (Cherry, 2011; Tomasevic, 2013). The controversies surrounding the inclusion of climate change in school curricula has made it difficult for its integration in the curricula of some schools (Tomasevic, 2013). That notwithstanding, it has been included successfully in the curricula of some schools (Roehrig, Campbell, Dalbotten, & Varma, 2012) because it equips the young who have more years to live and therefore will have longer exposure to the effects of climate change. Although recent research has shown that knowledge about climate change does not automatically mean concern toward it (Battistoni, 2012), the reasons for learning about climate change far outweigh the reverse. This is also because there is evidence that students equipped with such knowledge show concern for it (Cherry, 2011).

1University of Cape Coast, Ghana

Corresponding Author:
Cecilia Boakye, Institute of Education, University of Cape Coast, Cape Coast, Ghana.
Email: pomboakye@gmail.com
For climate change education to be effectively implemented in schools, there is the need to find out the extent of its integration into school curricula so that any deficiencies can be addressed. Research into the extent of integration of climate change in school science curricula has been done in some countries (Dalelo, 2012; Republic of Kenya, 2012). In both cases, content analysis was used to analyze curricula and syllabi. Findings from both studies stated abysmal integration of climate change in the curricula of the schools and the non-action-oriented nature of the teaching and learning methods. Action-oriented methods make students active participants in the lesson or have the potential to sensitize students to take action (Carboschools Consortium, 2010; Filho, Pace, & Manolas, 2010). There is the need to do the same for the curricula of other countries so that climate change education can be integrated effectively in school curricula. In this study, I also sought to find out the extent of integration of climate change into science curricula of pre-tertiary schools in Ghana so that if there was a need for improvement, this could be done to promote effective climate change education in Ghana. This is necessary because Ghana is experiencing the impact of climate change, and she needs to educate her citizens to help mitigate climate change and its effects.

**Context of the Study**

There have been reported cases of environmental catastrophes in Africa due to climate change (AllAfrica, 2013; Ofie-Nkansah, 2013; Wikimedia Foundation Inc., 2013; The World Bank Group, 2013), and Ghana has her fair share of it (Badu-Agyei, 2012; Boadi, 2013; GhanaCentric, 2010; Kunateh, 2013; Müller-Kuckelberg, 2012). Climate change has posed a lot of problems in Ghana such as (a) change in rainfall patterns, (b) a rise in the incidence of pests and diseases of crops and livestock, (c) reduction in crop yield, and (d) destruction of lives and property caused by floods and droughts (Kunateh, 2013). All these have negative effect on income generation activities. Some of the human activities that contribute to the climate problems in Ghana are deforestation caused by bush burning and the use of wood as fuel and charcoal making (GhanaCentric, 2010). This situation has demanded that efforts must be made in Ghana to combat climate change. To this end, a National Climate Change Policy (NCCP) has been made, and it has been approved by parliament to help combat the effects of climate change in Ghana (OmgGhana, 2013). The University of Ghana on its part has introduced two post-graduate programmes in climate change and sustainable development for the 2012-2013 academic year. The aims of the programmes “are to contribute to the development of expertise in Ghana and Africlimate change and development issues and to promote research on climate change impact assessment, adaptation and mitigation” (University of Ghana, 2013, p. 1). The president of Africa University College of Communication (AUCC) also expressed the desire to restructure its curriculum to integrate climate lessons to equip their students so that they can educate ordinary citizens, including farmers (OmgGhana, 2013). Ghana needs to integrate climate change education into the curricula of the basic to the tertiary levels of education after reviewing them (GhanaCentric, 2010). This according to GhanaCentric, will produce the local expertise to manage crisis and reach out to the entire population. Also as a signatory to the Kyoto Protocol, it is also obligatory for Ghana to control her own greenhouse emission (GhanaCentric, 2010).

In Ghana, the pre-tertiary education consists of preschool, followed by 3 years of lower primary and 3 years of upper primary. The next level is the Junior High School (JHS) that is of 3-year duration. Successful candidates enter the Senior High Schools (SHSs). At all these levels, science is taught except at the pre-school level. One objective for the teaching and learning of science at these levels is to equip the students to solve environmental problems. Is climate change, which is a very important environmental problem, factored into the science curricula at these levels? Knowing the state of climate change education in the pre-tertiary curricula is important so that it can be made more effective if there is that need. Students can be better equipped in that way so that they, in turn, can educate the populace.

The purpose of the study was, therefore, to find out the extent of integration of climate change education in the pre-tertiary science curricula and to make suggestions if necessary. The study answered specifically the following questions:

**Research Question 1:** To what extent is climate change integrated in the science curricula at the pre-tertiary levels of education, if at all?

**Research Question 2:** If climate change has not been integrated, how can it be improved upon?

**Literature Review**

**The Need for Climate Change Education**

Although natural phenomena such as ocean currents, emissions from volcanoes, or normal climate variability can influence climate change to a great extent, it is also influenced by some of these activities of humans: deforestation, intensive farming, and intensive use of fossil fuels (Sharma, 2012). The anthropogenic nature of global climate change has support in the literature (Semper, 2010; Sharma, 2012; Stanford University, 2011). There is, therefore, the need for something more than technology to address it. Sharma argued that if it were the consequences of individual actions, as shared by Pettenger, cited by Feirabend and Eilks (2010), then the logical thing to do to address global climate change was to educate individuals to behave in environmentally responsive ways. As a social solution, Sharma suggested that the preparation of students in schools should equip them with a better understanding of climate change to enable them to
act in ways that will sustain the environment. According to CarboSchools Consortium (2010), Sharma (2012), Stanford University (2011), and United Nations Educational, Scientific and Cultural Organization [UNESCO] (2009), education is an indispensable component of any program to combat climate change and its effects. For example, if one considers “adaptation” and “mitigation,” which are the two current approaches in responding to climate change (Ofei-Nkansah, 2013), not much can be done to combat climate change and its effects without education.

The need for education is clarified by Dyster (2013):

Education is the most powerful tool and can engage young people in the debate, prepare them for working with the green economy, and give the definitive science and facts about the biggest issue facing young people. To quote H.G. Wells: “Human history becomes more and more a race between education and catastrophe.” (p. 3)

Research shows that pupils are empowered to do something about climate change and feel positive and less worried about it when they are given accurate information about it (Bryan, 2011). Examples abound in the literature where education has been helpful in addressing issues with respect to climate change such as: (a) when a 15-year-old student opposed the removal of climate change from the geography curriculum of the United Kingdom by writing eloquently about the dangers of its removal. Thirty thousand signatures supported her petition in a matter of weeks (Dyster, 2013) (b) pupils made a great impact in their communities regarding the reduction of global warming gas emission with resultant great monetary savings through school carbon reduction initiatives (Cherry, 2011) and (c) The League of Conservation Voters Education Fund found in a study that it was information from educational materials that their children brought home from school that even environmentally minded citizens received most of their “green” information. Moreover, it was pressure from their children that caused them to act in a responsible way toward their environment (Cherry, 2011).

Although children are vulnerable, they are agents of change in climate change issues (Anderson, 2010; UNICEF, 2012). Thus, if children are empowered by providing them with the necessary education on disasters and climate change in a conducive environment, their vulnerability is reduced, and, at the same time, they contribute to sustaining the environment. Such knowledge and empowerment given to children through the school curriculum results in reduced vulnerability to risk, and, at the same time, it promotes the achievement of children’s environmental rights as is contained in the numerous articles of the Convention on the Rights of the Child (UNICEF, 2012).

Different definitions have been given to climate change education, but they mainly stress on knowledge, attitudinal, and behavioural change. One such definition is: climate change education is about helping learners understand and address the impacts of global warming today, while at the same time encouraging the change in attitudes and behavior needed to put our world on a more sustainable path in the future. (Matsuura quoted by UNESCO, 2009, p. 3)

Therefore, some of the characteristics of a climate literate person are that the person is: (a) knowledgeable enough about climate change to take informed decisions that will help mitigate climate change, and (b) has desirable attitude and behaviour towards climate adaptation and mitigation (Anderson, 2010; Semper, 2010). A successful climate change education should therefore move from awareness, to understanding, and finally taking action (Carboschools Consortium, 2010).

**Teaching and Learning Methods in Climate Change Education**

Because climate change education involves learning that should change attitude and behaviour, the teaching and learning method is very important. Literature supports active learning (Bryan, 2011; CarboSchools Consortium, 2010; Cherry, 2011; Prunoe, Grave, Bourque, & Langis, 2003; Roehrig et al., 2012). According to Bryan (2011), the teaching and learning methods should touch the heart as well as the mind. Cherry (2011), through her Young Voices on Climate Change project, used methods that touched the hearts as well as the minds of the young people, and this had a great impact in the community in which the young people lived. Cherry used motivational Young Voices on Climate Change films in which children were involved in activities to combat climate change.

With respect to climate change “the main emphasis of any educational campaign should be on learning not on teaching” (Filho et al., 2010, p. 144). CarboSchools Consortium (2010) recommended that to enable pupils to become active members of society in future, action skills in which a situation is created for pupils to experience the democratic process of thinking up, agreeing, implementing, and evaluating concrete changes individually and in a group should be used in climate change education.

**Climate Change Education and the Science Curriculum**

Some of the causes of climate change such as greenhouse effect, bush burning, and deforestation make it science related. According to Tomasevic (2013), climate change is science. Science lessons have been used to teach climate change and some of such lessons are found in the literature (Fries-Gaither, 2010; Smith, 2013). Some of the science topics that have been used in climate change lessons are energy (Climate Change Live, 2013; Fries-Gaither, 2010), photosynthesis (Mr. Green Lesson Plan, 2010), and the forest (Job...
Corps Lesson Plan, 2008; Kindlmannová & Semeráková, 2010). In the U.S. curriculum, climate change forms part of the science curriculum (Tomasevic, 2013). In Ethiopia, it is integrated into the Biology curriculum (Dalelo, 2012).

However, the literature reveals that science alone is not very effective in the teaching and learning of climate change. “Climate change science is one of the first science topics that social science physical science collaboration is required” (Semper, 2010, p. 8). Many suggestions have been given as to what should constitute a climate change curriculum. Some examples are that it should be (a) multidisciplinary/interdisciplinary (Roehrig et al., 2012; Semper, 2010) and (b) part of the science curriculum (Conger, 2013). The interdisciplinary approach to climate change education has been used successfully in the CYCLES approach. The approach blended integrative science, technology, engineering, and mathematics to teach climate change. That approach motivated the students and engaged them in meaningful problems within their communities. The conclusion drawn from the approach was that there is the need for new approaches to science teaching and learning that can promote the kinds of skills and critical thinking needed to address the global and multidisciplinary problems facing our planet (Roehrig et al., 2012).

Method

It was a content analysis research in which I purposively sampled and analyzed the natural and integrated science curriculum documents of the pre-tertiary institutions to find out to what extent climate change as a topic had been included. The documents were the syllabuses, the textbooks, and the teachers’ guides. The pre-tertiary documents selected for the lower primary to JHS were implemented in 2012 and those of the SHS were implemented in 2010. They are: (a) lower primary, Grades 1 to 3, natural science syllabus (Ministry of Education, 2012a); (b) lower primary, Grades 1 to 3, natural science teachers’ guides (Asiedu, Baah-Yeboah, & Domptey, 2012a, 2012b, 2012c, 2012d, 2012e, 2012f); (c) lower primary, Grades 1 to 3, natural science textbooks (Asiedu et al., 2012a, 2012b, 2012c); (d) upper primary, Grades 4 to 6, integrated science syllabus (Ministry of Education, 2012b); (e) upper primary, Grades 4 and 6, integrated science textbooks (Yeboah, Kwesi-Ahordjie, & Mensah, 2012a, 2012b, 2012c, 2012d); (f) upper primary, Grades 4 and 6, integrated science teachers’ guides (Yeboah et al., 2012a, 2012b, 2012c, 2012d); (g) JHS, Years 1 to 3, integrated science syllabus (Ministry of Education, 2012c); (h) JHS, Years 1 to 3, integrated science textbooks (Kom-Zuta, 2012a, 2012b, 2012c, 2012d, 2012e, 2012f); (i) JHS, Years 1 to 3, integrated science teachers’ guides (Kom-Zuta, 2012a, 2012b, 2012c, 2012d, 2012e, 2012f) and (j) SHS integrated science, Years 1 to 3, syllabus (Ministry of Education, 2010). I chose the natural science and integrated science curricula because they were core curricula. Other curricula in the Ghanaian pre-tertiary education that had some element of climate change are the (a) SHS biology, (b) SHS chemistry, and (c) SHS geography. However, they were elective curricula and besides, the aspect of climate change (greenhouse effect) and the teaching and learning methods were almost the same as those found in the science core curricula that I chose for this study. The curricula that had the potential to be used for the teaching and learning of climate change at the pre-tertiary level were the social studies curricula of the basic schools and SHSs. However, no element of climate change was incorporated in either of them. The textbooks and teachers’ guides that I used were based on the syllabuses. Because the syllabuses were teaching syllabuses, what they contained was not much different from how the curricula were enacted. The content of all the syllabuses that I used had been arranged in units (see the appendix). I also analyzed the West Africa Examination Council (WAEC) test items for Basic Education Certificate Examination (BECE), West Africa Senior Secondary School Certificate Examination (WASSCE), and Senior Secondary School Certificate Examination (SSSCE) to find out if climate change items were included. WAEC is the principal examining institution for the West African sub-region. BECE is the final examination at the end of basic school (primary and JHS) education that qualified one to enter the SHS. SSSCE and WASSCE are the examinations at the end of SHS education that qualified one to enter a higher (tertiary) institution. SSSCE has been phased out, and it has been replaced with WASSCE. For BECE, the papers I analyzed were from 1990 to 2012. Those of SSSCE and WASSCE were from 1993 to 2014. I used quantitative and qualitative methods in this study.

To establish the extent of the integration of climate change in each curriculum, I based my analysis on: (a) the proportion of climate change topic(s) in the syllabus, (b) the nature of the information the climate change topic(s) provided, (c) the nature of the teaching and the learning methods associated with the topics, (d) potential climate change topics that have not been related to it, and (e) the frequency of assessment based on climate change.

To establish the proportion of the curriculum that made up climate change, the units in the syllabuses served as units of analysis. I counted the units that contained climate change topics for each syllabus and proportions were established using percentages. The percentage was calculated by dividing the number of climate change unit(s) I identified by the total number of units in the syllabus and multiplied the result by 100. For the nature of the content, it was found out whether they promoted climate change education by providing knowledge about climate change that will help a person to make informed decisions with respect to adaptation and mitigation (Semper, 2010). Because climate change knowledge demands attitudinal change, teaching and learning methods must have the potential to foster that. I therefore analyzed the teaching and learning methods to see whether they were action-oriented by using methods that involve (a) active participation of the students (Bryan, 2011;
Kenya and other places where teaching and learning of climate curriculum in Ghana is worrisome. The situation is unlike issues. The absence of climate change in the primary school curriculum addressed directly or indirectly climate change (Kenya, 2012) where only 0.53% of the total secondary school curriculum content was higher than what was found in Kenya (Republic of Kenya, 2012a). That climate change was absent in the science curriculum of the lower primary level and beyond (Ministry of Education, 2012a). That climate change was absent in the science curricula of the lower and upper primary is worrisome. This is because children form a large part of millions of people needed to mitigate climate change and its impact (Cherry, 2011). This situation is not in conformity with the suggestion of Stanford University (2011) about children’s knowledge of climate change. Moreover, it is the opposite of what is being done in the American school system (Tomasevic, 2013).

Table 1 shows the integration of climate change in the four curricula.

Table 1. Climate Change Integration in the Pre-Tertiary Science Curricula.

| Curriculum   | Climate change information | Actual climate change topics stated | % of climate change in curriculum | Examples of potential climate change topics in curriculum |
|--------------|----------------------------|------------------------------------|----------------------------------|--------------------------------------------------------|
| Lower primary | Absent                     |                                    |                                  | Sunlight, Air, Seasons                                  |
| Upper primary | Absent                     |                                    |                                  | Energy, Air, Flooding                                   |
| JHS          | Present                    | Carbon cycle                       | 2.0                              | Vegetable crop production, Sources of energy, Conversion and conservation of energy, Light energy, Ecosystem, Water, Weather, Season and climate, Photosynthesis |
| SHS          | Present                    | Greenhouse effect and climate change | 2.0                              | Ecosystem, Energy, Photosynthesis                      |

Note. JHS = Junior High School; SHS = Senior High School.

Carboschools Consortium, 2010; Pruneau et al., 2003; Roehrig et al., 2012) and/or (b) methods that have the potential to promote active participation in the fight against climate change, such as observing other children involved in climate change activities (Cherry, 2011). The fourth criterion for the integration was whether there were topics that have the potential to be used to teach climate change and whether they have been used for that purpose. Relating such topics to climate change can have the potential to reinforce learning because of the repetition and also enhance adaptation and mitigation. For the fifth criterion that is on assessment, I analyzed WAEC test items for BECE (1990-2012), WASSCE, and SSSCE (1993-2014) to see whether students’ knowledge on climate change was assessed and the kind of knowledge that was assessed. I solicited the assistance of another colleague, science educator, to do the same analysis using the five criteria, and the two outcomes were reconciled so that the analyses were objective.

Results and Discussion

The Extent of Integration of Climate Change Into the Pre-Tertiary Science Curricula

Table 1 shows the integration of climate change in the four curricula.

The content analysis revealed that climate change was non-existent in the curricula of the lower primary, Grades 1 to 3, and upper primary, Grades 4 to 6, but was present in the JHS and SHS curricula.

As can be seen from Table 1, at both the JHS and SHS levels, the proportion of climate change integrated into both curricula were the same, 2%. The 2% climate change content of both the SHS and JHS leaves much to be desired considering the fact that there were potential topics in the curriculum that could have been related to it to reinforce learning. Nonetheless, the 2% is higher than what was found in Kenya (Republic of Kenya, 2012) where only 0.53% of the total secondary school curriculum addressed directly or indirectly climate change issues. The absence of climate change in the primary school curriculum in Ghana is worrisome. The situation is unlike Kenya and other places where teaching and learning of climate change start in the primary school (Cherry, 2011; Republic of Kenya, 2012). UNICEF (2012) actually supports the empowerment of children with climate change information.

Lower and upper primary curricula and climate change integration. Although climate change was not integrated into the curricula of the lower and upper primary, there were topics in both curricula that lent themselves to climate change as can be seen in Table 1. The science curriculum of the lower primary consisted of topics in the major branches of science. The purpose of the lower primary science curriculum was to provide a strong foundation for further study of science at the upper primary level and beyond (Ministry of Education, 2012a). That climate change was absent in the science curricula of the lower and upper primary is worrisome. This is because children form a large part of millions of people needed to mitigate climate change and its impact (Cherry, 2011). This situation is not in conformity with the suggestion of Stanford University (2011) about children’s knowledge of climate change. Moreover, it is the opposite of what is being done in the American school system (Tomasevic, 2013).

In the upper primary integrated science curriculum, the topic “Flooding” in the syllabus could have provided a good link to climate change, but content analysis of the syllabus, pupils’ textbooks, and the teacher’s guide revealed that that link was absent. Table 2 shows the teaching and learning activities and evaluation as given in the upper primary syllabus on the topic “Flooding.”

The role of climate change in flooding should have been included. Prevention of flooding was included in the content of the textbook, but it was not related to climate change. The preventive measures to flooding that were stated in the pupil’s textbook, such as not building in waterways are good, but it should not end there. Children must learn about climate change adaptation and how to be safe during disasters. Skills such as first aid, swimming, and water safety can be learned through simulation and drills. Then, through theater and music activities, they can educate their communities. Training children in disaster skills has been done in the Philippines and has proved useful. In Liloan and San Francisco villages, knowledge learnt that way saved both adults and children from a landslide (Anderson, 2010).
Junior secondary school and climate change integration. In the JHS syllabus, climate change was integrated in the JHS 2 under “carbon cycle.”

Content analysis of the pupil’s science textbook on “carbon cycle” showed that pupils were supposed to be introduced to the following terms: “greenhouse effect,” “greenhouse gas,” “climate change,” photosynthesis, combustion, atmosphere, carbon cycle, deforestation. This is good, because they are all related to climate change. They were also supposed to learn about the negative effects of climate change and the activities that can cut down on greenhouse emission such as the use of less fossil fuel, and the use of renewable sources of energy such as solar and wind power. Pupils were supposed to carry out a role-play to represent the carbon cycle. These activities can empower the pupils with knowledge on climate change as recommended by (Anderson, 2010; Semper, 2010; UNESCO, 2009). Moreover, such information in their notebooks/textbooks may sensitize others such as their parents who may read them as was reported by Cherry (2011). It can also empower them with some knowledge on mitigation. However, action-oriented teaching and learning methods where students learn by doing as suggested by Carboschools Consortium (2010) and used successfully by Cherry (2011) were lacking. This situation does not augur well for the acquisition of attitudinal and behavioural changes that are needed for combating climate change. The teaching and learning methods can be improved upon to help the pupils make more impact on their environment as was done by Cherry (2011) and learn adaptation methods as was reported by Anderson (2010). The evaluation activities and student activities in Table 3 are not action-oriented. There was one item in the science textbook that asked the pupils to find out how climate change may affect Ghana and how the impact could be reduced. This is good because it is sensitizing them to mitigation. It can however be improved upon, for example, by asking the pupils about the effect of climate change on their school compound and in the communities they live and the action they can take if there is a negative impact. Then students can be engaged in action-oriented activities. Although the climate change content in the JHS curriculum was 2%, it is higher than what was found in Ethiopia (Dalelo, 2012) and in Kenya (Republic of Kenya, 2012). One limitation in this study is that the textbook and teacher’s guide for Primary Grade 5 were not available to be analyzed. However, the syllabus reflected what should be in the textbook and teacher’s guide, because it was a teaching syllabus.

The analyses of the BECE test items revealed that from 1990 to 2012 it was only in 2011 that an item on climate change formed part of the assessment. That item demanded of the candidates to mention two ways in which the carbon cycle can be maintained and to state one environmental effect when the carbon cycle is disrupted. This formed two separate subsections of an item with four subsections. The indication from this observation is that climate change does not feature much in the assessment at the BECE level. This is to be expected because the BECE is based on the whole of the basic school syllabus in which the component of climate change is only 2% of the JHS curriculum.

Table 2. Teaching Natural Disaster.

| Unit | Specific objectives | Content | Teaching and learning objectives | Evaluation |
|------|---------------------|---------|----------------------------------|------------|
| Unit 3 Natural Disaster—Flooding | 5.3.1 Identify causes of flooding 5.3.2 List some effects of flooding | Causes of flooding Effects of flooding | Discuss the causes of flooding, e.g., excessive rain, poor drainage, building on waterways and choked gutters Collect pictures, video clips on flooding, and watch them List some of the effects [sic] flooding, e.g., loss of life and property and outbreak of disease Watch documentary on flooding in Ghana | What causes flooding in some parts of Ghana during rainy season? |

Source. Adapted from the Teaching Syllabus for Integrated Science (Upper Primary) by Ministry of Education (2012b, p. 34).

Table 3. Carbon Cycle in the JHS Syllabus.

| Unit | Specific objectives | Content | Teaching and learning objectives | Evaluation |
|------|---------------------|---------|----------------------------------|------------|
| Unit 1 Carbon Cycle | The pupil will be able to: 2.1.1 Describe how carbon is cycled in nature 2.1.2 Outline the importance of the carbon cycle 2.1.3 Describe ways the carbon cycle is disrupted | The carbon cycle Importance of the carbon cycle Ways by which the carbon cycle is disrupted | Let pupils: Discuss and illustrate the carbon cycle Identify and explain the stages in the carbon cycle Discuss the importance of the carbon cycle to humans and plants Gather information from library and the Internet on human activities which disrupt the carbon cycle Discuss ways by which the activities disrupt the cycle | Explain how the cycle is disrupted by humans Discuss ways to sustain the carbon cycle |

Source. Adapted from Ministry of Education (2012c). Note. JHS = Junior High School.
Table 4. Climate Change in the SHS Syllabus.

| Specific objectives | Content | Teaching and learning activities |
|---------------------|---------|----------------------------------|
| Identify the various regions of the atmosphere | Layers of the atmosphere: Troposphere, stratosphere, mesosphere, and thermosphere/ionsphere | Brainstorm to bring out the layers of the atmosphere |
| Outline the effects of human activities on the atmosphere | Human activities and their effects on the atmosphere | Describe the characteristics of each layer in terms of thickness, temperature, air quality and composition, pressure, and support for human activities |
| Describe the major pollutants of the atmosphere and their effects | Major atmospheric pollutants: Sources and effects | Gather information from the Internet and scientific journals on the effects of human activities on the atmosphere, i.e., air transport, defense, industrialization, agriculture, etc. |
| Explain Greenhouse effect on climate change | Greenhouse effect and climate change | Discuss the sources and the effects of the following pollutants: Oxides of lead, nitrogen and sulfur; ozone, halons (carbon and halogen compounds, etc.) |

SHS and climate change integration. The climate change component of the SHS integrated science syllabus is one unit out of 50 (2%) of the total content of the SHS integrated science teaching syllabus. It formed part of the SHS 1 syllabus under “interactions in nature.” Table 4 shows the content of the climate change in the SHS syllabus.

For the SHS, one limitation was that only the teaching syllabus was analyzed. The SHS syllabus is also a teaching syllabus, and it reflects the content to be taught in the curriculum. In the SHS syllabus, similar to the JHS, students were supposed to be equipped with knowledge on the effects of climate change. This is in line with Anderson (2010), Semper (2010), and UNESCO (2009). The suggested evaluations in the syllabus are: (a) differentiate between the troposphere and stratosphere in terms of the following: temperature, air composition, and pressure; and (b) outline five effects of climate change on biodiversity resources. In terms of action-oriented activities (Carboschools Consortium, 2010) that promote attitudinal and behavioral changes, these were lacking in the suggested evaluation. The latter evaluation on biodiversity is good but can be made better if students transfer the knowledge to their community by finding out the effect of climate change on biodiversity in their community. After that, they can be engaged in activities in their community to mitigate or prevent climate change and its impact depending on the outcome of their investigation. That will make it action-oriented (Bryan, 2011; Carboschools Consortium, 2010; Cherry, 2011; Pruneau et al., 2003; Roehrig et al., 2012). The topics that are related to climate change in the SHS curriculum (Table 1) can also be used to reinforce knowledge on climate change.

The analysis of the SSSCE and WASSCE items (1993-2014) showed that climate change was featured in (a) 1999, SSSCE; (b) 2000, SSSCE; (c) 2006, WASSCE; (d) 2011, WASSCE; and (e) 2014, WASSCE. Thus, within that period, items on climate change had been assessed in 4 out of the 14 years. This is to be expected because climate change forms only 2% of the SHS curriculum. The items mainly focused on the gas responsible for the greenhouse effect and how global warming can be minimized. The test items reflected the nature of the climate change content that was stated in the syllabus.

Conclusions and Implications

On the whole, the extent of integration of climate change into the pre-tertiary science curricula in Ghana leaves much to be desired. The content analysis of the four science curricula revealed that climate change is factored into the JHS and SHS curricula, but it is non-existent in the lower and upper primary curricula. Leaving the upper and lower primaries out cuts off children whom literature shows are very effective in the fight against climate change (Cherry, 2011). For the JHS and SHS curricula, climate change formed 2% in each case but there are topics in both curricula that lend themselves to climate change education some of which have been used in that respect in the literature (Climate Change Live, 2013; Fries-Gaither, 2010; Mr. Green Lesson Plan, 2010; Job Corps Lesson Plan, 2008; Kindlmannová & Semeráková, 2010). Probably, relating those topics to climate change may overload the curricula (Smith, 2013). The climate change content generally provides factual knowledge to the students which are not in line with the expectation of the nature of climate change education (Anderson, 2010; Carboschools Consortium, 2010; Semper, 2010). The teaching and learning...
activities are generally inadequate because they are not action-oriented as has been suggested in the literature (Bryan, 2011; Carboschools Consortium 2010; Cherry, 2011; Pruneau et al., 2003; Roehrig et al., 2012) and used effectively (Anderson, 2010; Cherry, 2011). They can help to provide students with knowledge about climate change but can hardly help the students in the adaptation and mitigation of climate change.

Climate change items are factored into the BECE and WASSCE/SSSCE. The implication is that it is deemed to be important and for that matter, the students must have knowledge on it. However, the frequency of the incorporation of the test items is higher at the WASSCE/SSSCE level than at the BECE level. This shows the less emphasis given to it at that level. This is to be expected because at that level, there is a total absence of climate change content at both the upper and lower primary curricula.

**Suggestions**

For the curriculum to play its role in climate change education properly and for Ghana to play a more effective role as a signatory to the Kyoto Protocol (GhanaCentric, 2010), there is the need to infuse climate change content into the curriculum of the lower and upper primary to make the students knowledgeable and be able to take part in debates and decisions on it (Dyster, 2013) and also equip them with the skills needed for mitigation and adaptation (Anderson, 2010; UNICEF, 2012).

The topics that lend themselves to climate change in the four curricula can be used for reinforcement of knowledge on climate change if that will not overload the curriculum (Smith, 2013). The “application” aspect of the Ghanaian pretertiary science lesson plan (Arhin & Asimah, 2006) where the knowledge gained in a lesson is applied to everyday life can be used for that purpose. That aspect takes up only 2 to 4 minutes of the lesson. The literature has lessons on science topics and how they are related to climate change, and teachers can avail themselves of such lessons.

The teaching and learning activities should be improved upon to provide opportunities for students to acquire skills for adaptation and mitigation with respect to climate change as has been done in other places (Anderson, 2010). All these have implication for facilities and resources. Facilities and resources must be made available to engage the students in activities that will give the students knowledge about climate change. Teachers who are the implementers of the curriculum must be knowledgeable about climate change and be prepared to engage students in action-oriented activities. Pupils can be engaged in greening activities on their school compound.

An interdisciplinary approach to the teaching and learning of climate change (Roehrig et al., 2012; Semper, 2010) can be adopted to effectively groom the students for adaptation and mitigation because the science curriculum alone cannot do that effectively. This has implication for research. Research can be done by analyzing all the Ghanaian basic and SHS curricula that lend themselves to climate change education so that a better approach to the teaching and learning of climate change that meets all the conditions specified in climate change education (Anderson, 2010; Semper, 2010) can be developed.

**Appendix**

**Table A1.** Structure and Organization of the SHS Integrated Science Syllabus.

| Sections       | SHS 1                                                                 | SHS 2                                                                 | SHS 3                                                                 |
|----------------|------------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------|
| Diversity of Matter | Unit 1: Introduction to Integrated Science | Unit 1: Acids, Bases, and Salts | Unit 1: Metals and Non-Metals |
|                | Unit 2: Measurement | Unit 2: Soil Conservation | Unit 2: Exploitation of Minerals |
|                | Unit 3: Diversity of Living and Non-Living Things | Unit 3: Water | Unit 3: Rusting |
|                | Unit 4: Matter | | Unit 4: Organic and Inorganic Compounds |
|                | Unit 5: Rocks | | |
| Cycles         | Unit 1: Air Movement | | Unit 1: Life Cycle of Pests and Parasites |
|                | Unit 2: Nitrogen Cycle | | Unit 2: Crop Production |
| Systems        | Unit 1: Skeletal System | Unit 2: General Principles of Farm Animal Production | Unit 2: Crop Production |
|                | Unit 2: Reproduction and Growth in Plants | Unit 1: Excretory system | Unit 1: Life Cycles of Pests |
|                | Unit 3: Respiratory System | Unit 2: Reproduction Systems and Growth in Mammals | Unit 2: Crop Production |
|                | Unit 4: Food and Nutrition | Unit 3: Circulatory System | |
|                | Unit 5: Dentition, Feeding and Digestion in Mammals | | |
|                | Unit 6: Transport-Diffusion, Osmosis, and Plasmolysis | | |
| Energy         | Unit 1: Forms of Energy and Energy Transformation | Unit 1: Electrical Energy | Unit 1: Light Energy |
|                | Unit 2: Solar Energy | Unit 2: Electronics | Unit 2: Heat Energy |
|                | Unit 3: Photosynthesis | Unit 3: Sound Energy | Unit 3: Electronics |
|                | Unit 4: Electronics | | |
| Interactions of Matter | Unit 1: Ecosystem | | Unit 1: Variation and Inheritance |
|                | Unit 2: Atmosphere and Climate Change | Unit 2: Forces, Motion, and Pressure | |
|                | Unit 3: Infections and Diseases | Unit 3: Safety in the Community | |
|                | | Unit 4: Endogenous Technology | |
|                | | Unit 5: Biotechnology | |
|                | | Unit 6: Work and Machines | |

Source. Adapted from the SHS Integrated Science Syllabus.

Note. SHS = Senior High School.
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Author Biography

Cecilia Boakye is a senior lecturer at the Institute of Education, University of Cape Coast, Ghana. She is a specialist in science education.