HSSE Online 2(1) 28-35

Advancing a framework for climate change education in Singapore through Teacher Professional Development

Chew-Hung Chang

National Institute of Education
Nanyang Technological University, Singapore

Cities like Singapore have implemented numerous planning norms and policies that are aimed at addressing rapid urbanization. These efforts, however, have largely been state-driven and state-led. In other words, important behavioral norms such as the reduction of consumption of materials and energy have not necessarily been inculcated or accepted (Ministry of Environment and Water Resources, Singapore, 2008). For instance, while there have been many public events and campaigns through mass media aimed at raising awareness, such campaigns only galvanize a small portion of the population to change their behavior in order to mitigate climate change. Schools, however, provide a favorable environment whereby environmental measures such as recycling activities can be put in place to promote positive attitudes and behaviors toward climate change. Formal lessons, in addition, can help to reinforce the concept of climate change and this in turn may influence students' knowledge, attitude, and behavior towards climate change.

While climate change education (CCE) exists in pockets within the formal curriculum in Singapore (Goh, Tan, Chang, & Ooi, 2009), how this is implemented and enacted depends largely on the key stakeholder – the teacher. When teachers consider teaching about climate change, they commonly focus on changing human behavior to mitigate the effects of human-induced climate change. This, however, may not be effectively carried out because relatively few educators and students are able to articulate the importance of climate change or the best ways to understand the topic of climate change.

There is, in fact, no explicit pedagogical content knowledge articulated for climate change education. In this paper, I argue that in order to inspire active learning, it is necessary to first foster critical thinking. Before we can develop a robust approach to teaching about climate change, educators must first have a good conceptual understanding of *what* and *how* a topic should be taught. To this end, a workshop was developed to allow geography teachers to build capacity through concept mapping and to understand the conceptual lens through which climate change education can be framed.

Prior to the workshop, an expectations-building exercise was conducted through email correspondence. Key areas of concern for the participants included learning how to be able to introduce climate change as a topic, learning how to engage students, and educating students to realize the large scale impact and consequences of climate change.

Levels of Cognitive Engagement

Due to time constraints, the workshop, based largely on cognitive engagement theories, focused on the curriculum content for climate change. Historically, educators within a behavioral paradigm considered knowledge to be stored in the learner's memory when something was learned. The theories regarding learning conditions, however, have evolved to incorporate cognitivist psychology theories. More specifically, cognitivist theories point to an information-processing model of cognition in which external conditions in the learner's

environment influence internal processes (Gagné, 1985).

When thinking about the conditions that are required for some capabilities to be learned, Gagne (1985) suggested that it is not simply identifying what is to be learned but appropriately structuring learning experiences to help students accomplish things they could not previously carry out on their own. Desired capabilities or learning outcomes, then, are performance categories that can help teachers consider the kinds of learning experiences and conditions that would be most favorable for student achievement. This concept is aligned with the instructional objectives proposed in "The Taxonomy of Educational Objectives, Handbook I: Cognitive Domain" (Bloom, 1956) which presented a classification of how content might be processed.

For example, in the context of climate change education, we might refer to a student having learned the "Carbon Cycle" or the "Impact of global warming." However, when we say that a student is learning the 'Carbon Cycle', we imply that the student might be learning how to define the carbon cycle, what the components of the carbon cycle are and how carbon can be stored or released as different forms in different parts of the natural environment or cycle. Students may be required to explain their definitions, analyze different components or apply their understanding to a new situation.

Implicit in this definition is that there are specific outcomes of learning that can be classified and used as specific instructional objectives for curriculum planning. However, it was Gagné who explicitly proposed levels of learning outcomes. In the modified and improved Gagné and Driscoll (1988) system, cognitive, affective and psychomotor domains were incorporated into differentiating learning outcomes. Krathwohl (2002) also suggested a critique and revision of Bloom's original taxonomy: instructional objectives were constructed around descriptions of intended learning outcomes arising out of the prescribed instruction. Krathwohl's cognitive dimension includes remembering, understanding, applying, analyzing, evaluating and creating. We can further extend this cognitive taxonomy into the domains of attitudes, beliefs and actions, as climate change issues require an active response rather than a passive arm-chair critique of events.

The proposed taxonomy of learning outcomes provides a vocabulary to help teachers describe what they want students to learn about climate change. This taxonomy can also help teachers consider to what extent students have learned by focusing on their abilities to apply, analyze, evaluate, and create knowledge about climate change. In other words, we have a structure with which to describe and discern the extent to which education on climate change has provided the necessary conditions for developing a better-informed citizenry that can better manage climate change issues in the future. To illustrate, we can describe the learning outcomes of any climate change learning task using this framework; whether learning has simply resulted in remembering to turn off the light before leaving the room or the ability to analyze and critique the latest Intergovernmental Panel on Climate Change (IPCC) report.

Subject Matter Knowledge

Despite having a framework with which to describe the learning outcomes of student learning about climate change issues, the subject-matter knowledge about climate change itself has to be first understood. Concepts of climate change, global warming and the greenhouse effects (GHE) are commonly misunderstood. The natural greenhouse effect for example does not result in global warming (Global Greenhouse Warming, 2010). Indeed, climate change as a learning construct is largely misunderstood at many levels and there is often no distinction between learning about the science of climate change and how to mitigate the impact of climate change. Indeed, macro concepts of causality-consequence-management can be used to frame the understanding of the subject matter knowledge of climate change. It is first important to understand the causes of climate

change, both human-induced and natural, before one can appreciate how that change impacts human lives. Subsequently, students can then learn how this impact can be managed either through mitigation or adaption strategies.

Teachers are required to understand the definition of climate change and point out to students if it is equivalent to global warming. To provide the background to the activity, the teachers were asked to study the syllabus document on the topic of weather and climate, focusing on the definitions and the key concepts highlighted. Teachers were then asked to brainstorm what it means to teach climate change based on a conceptual framework of CCE. To facilitate the brainstorming process several guiding questions were asked, including:

1. What is the distinction between weather and climate?

2. What does it mean when we say the climate has changed?

3. What are the causes of climate change? Are they the result of human activity?

4. How does climate change affect human beings?

5. What can we do about it?

Throughout the brainstorming session, questions were also raised by the teachers to clarify or affirm what they understand about the topic. Some examples of the questions asked included:

1. Is CO2 the only Greenhouse gas that matters? I read somewhere that the other greenhouse gases are insignificant in their contribution to global warming. Is this true?

2. I read about the conspiracy that green-technology industry has fabricated the claim that climate change is natural. Is this true?

3. How do I explain to my students that Ozone is not a greenhouse gas?

These questions were then explained and clarified. In order to illustrate the nature of explanations, the three questions are answered here:

1. Although CO2 is a main contributor of GHE, its contribution is not as significant as water vapor. In addition, the other greenhouse gases, whether natural or man-made add to the GHE. With addition of all these gases and introduction of new greenhouse gases to the earth's atmosphere, we are dealing with an enhanced GHE. So the question really is what has caused this increase in both concentrations and types of greenhouses gases?

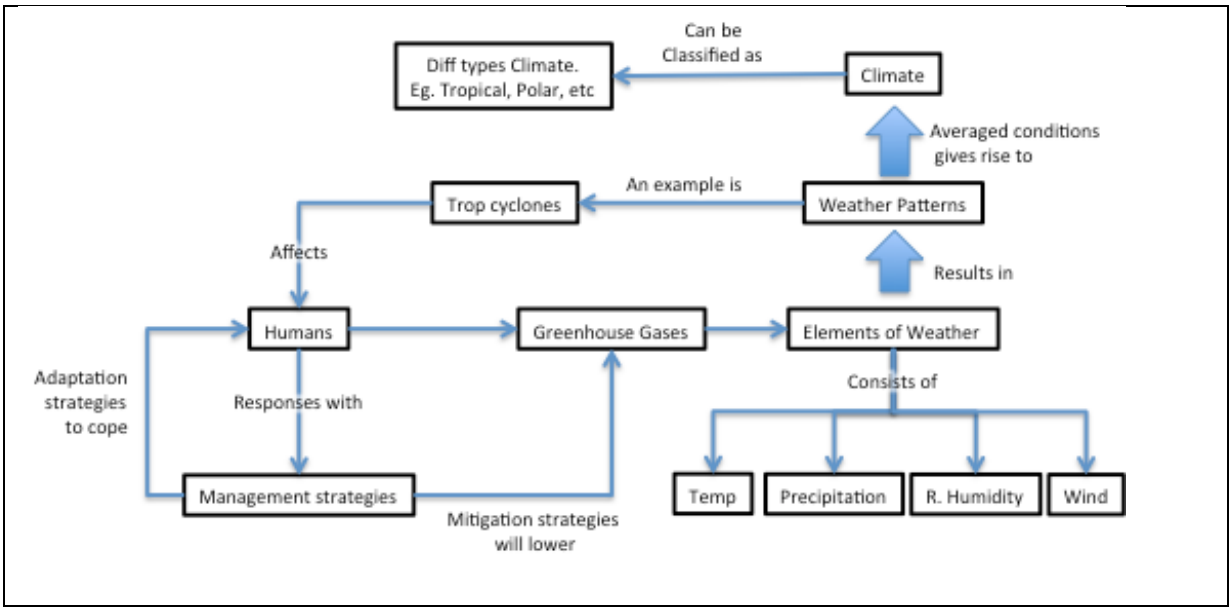
2. Whether the claims made by green-technology industry are motivated by a hidden agenda or not, Earth has experienced episodic climate change through geologic history. This was ascertained long before green-technologies came into being. As early as 1350 to 1850 AD, people noticed that they were living in a "little ice age" and this was documented in a study by 1935. Therefore climate change is a regular feature in Earth's geologic history. A relevant question, therefore, is whether human activity has attenuated or exacerbated the rate of climate change.

3. Ozone is a greenhouse gas. The confusion students have is between the Ozone that is found in the upper atmosphere (about 25 km from the ground – or the stratosphere) and the ozone that is found near the surface of earth (in the troposphere). Stratospheric ozone forms a protective "layer" that blocks out harmful UV radiation. Industrial activity and photo-chemical activity causes Ozone to form in the troposphere, which then acts as a greenhouse gas. It is important to distinguish these two as the confusion stems from the topic on Ozone depletion in the stratosphere.

Based on this brainstorming activity and the question and answer session, the teachers had a set of statements about what they need to teach on this topic.

The figure below shows an example of how a concept map of the ideas looks like.

Figure 1: An example of a simple concept map of the topic.



To get a good consolidation of ideas, teachers were asked to get into groups of four. Individually, they were tasked to think of 20 words about climate change. Next, they distilled their 20 words down to 15 words with a partner, then come together as a group of four and distill the 15 words down to 10 best words that were related to climate change. This distillation process gave the teachers an opportunity to identify the key concepts that helped define climate change.

Based on this exercise, the teachers came to a conclusion that climate is a long-term average state of atmosphere where change in average values may not reflect all changes in frequency, duration and intensity of events. In addition, climate change education involves causes, impacts/consequences and management. The teachers also noted that climate change education involves developing knowledge, skills, and attitudes.

In addition to having a macro-framework to organize the participants' subject-matter knowledge, the workshop was designed to engage teachers in mapping the relevant topics from syllabus documents across subjects and levels. Examples from across the curricula were provided as a start of this process. Teachers from the workshop then provided some comments and responses as part of their reflection on what to teach.

For instance, both the primary 3 and primary 6 social studies curricula included the topic "How people adapt to and change their environment." Several teachers felt that this topic did not focus on environmental management but focused primarily on land-use. However, the big ideas of human environment interaction and stewardship are clearly included in the curriculum. Other examples include Civics and Moral Education (upper primary). This subject addresses the issue of protecting the environment. Students learn about the irreversible damage to the

environment if they do not protect it and learn that protecting the environment will allow them to continue living in a healthy environment (Goh, Tan, Chang, & Ooi, 2009).

At the secondary school levels, CCE is addressed at all levels. For example, in Secondary 2 Geography, the topic "Managing the changing environment" focuses on the "impact of human activities on the environment at local, regional and global scales, justifying the need for protection and conservation of the environment at different levels [CPDD (Curriculum Planning and Development Division), 2005].

Similar topics can be found in other subjects such as science. Focusing on the topic of energy, students are made aware of how they can help to save electricity at home and in school by switching off lights and electrical appliances when not in used (CPDD, 2007). They are also taught to use more energy-efficient appliances, for instance, to set their thermostats in air conditioners at a higher temperature (Heywoth, 2008).

Within social studies, the Secondary 1 and 2 Normal Technical Social Studies topic "Caring for our environment" teaches students how to explain the causes and effects of environmental problems and describe effective ways to manage the environment (CPDD, 2006). The content of the unit revolves around land, water, and air pollution. The issue of climate change is featured in the concluding unit of curriculum. Students learn about the causes and impacts of global warming and are taught how to describe and evaluate the measures adopted to reduce the impact of global warming and climate change. This provides numerous opportunities for teachers to move students from an awareness phase into an action-taking phase (Chang, 2012). Finally, the upper secondary level Social Studies topic "Sustaining Singapore's economic development" teaches students how to balance our economic development with environmental management.

Teachers need to be able to link the science of climate change to its impact and management. It is therefore important to draw on the concepts uncovered in understanding the science of climate change from the previous section, and reflect on the impact to the atmosphere, hydrosphere, biosphere, and society:

1. What are the changes to the weather patterns when we talk about climate change in the last 30 years? Do they vary across regions?

2. How do the changes in climate affect the amount of water in the hydrologic cycle? Does it affect the amount of water in the oceans?

3. How will changes in climate affect plant and animal life? Do these changes vary across regions?

4. How do changes in climate affect our everyday lives?

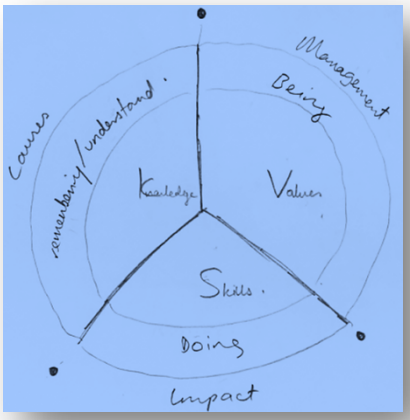
After understanding the key impact of climate change on human lives and the environment, teachers should then consider and evaluate different management strategies, including adaptation and mitigation strategies. Adaptation refers to living with climate change while mitigation translates into doing something about climate change. While both sets of strategies help people manage climate change as an issue, there is a need to clarify the nature of management so that it students can analyze the strategies and see if they are effective. More specifically, each management strategy needs to be evaluated for its effectiveness and to this end, some of the suggestions that came out of this discussion were to use graphic organizers to help students structure their evaluation.

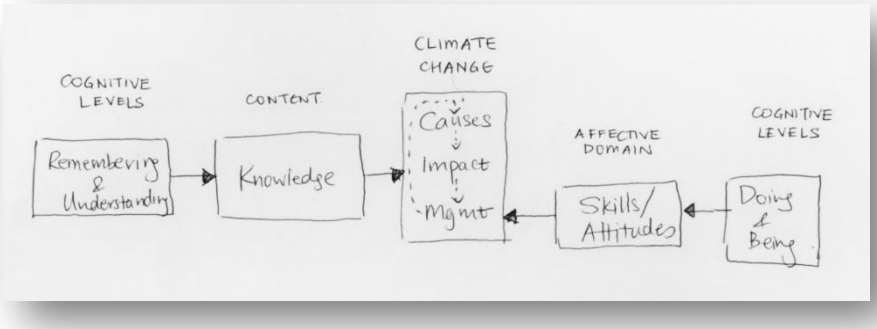
Conceptualizing Teaching Climate Change

Next, the teachers generated a visual depiction of how they organized the various concepts of cognitive engagement, subject-matter knowledge and the domains of causes, impact and management. The graphic organizers

produced by the teachers showed that there are different ways to conceptualize CCE.
Figure 2 shows samples of frameworks were drawn during the workshop by teachers to create a better understanding of what to focus on whilst teaching the students on climate change

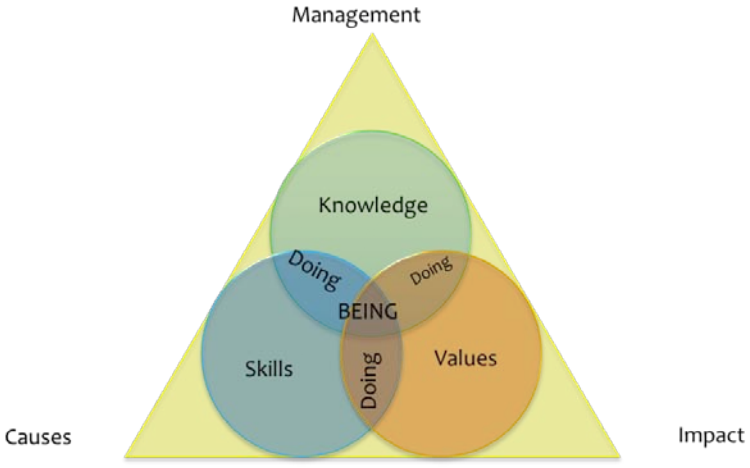
Figure 2: Examples of frameworks produced by teachers.





While all the frameworks produced by the participants showed various possible conceptions of CCE, one teacher's contribution was particularly interesting (see Figure 3).

Figure 3: Another example of framework produced by teachers.



This framework situates the learning of climate change causes, impact and management as the context of learning. While the various cognitive and affective domains of learning – knowledge, skills and values - are represented as circles within this context, the intersections indicate action will only result from students being able to combine content knowledge with a strong belief in the necessity of mitigating the environmental situation. Teachers should factor this when designing instruction.

During the workshop, the teachers were asked to consider not just the knowledge domain but also the cognitive engagement required as an outcome of that topic. Consequently, a teacher should conceptualize the way the lesson is carried out and the type of assessment that can help her/him determine if the student has learnt the skill as well as the knowledge required.

Given the increased focus on the need to respond to changing climate (Hussain, 2007), climate change education has become increasingly important in many countries. This workshop suggests that Singapore teachers will need to consider their own subject-matter knowledge about climate change and to consider the relationship between the different cognitive and affective domains of learning. In sum, there is certainly a need to educate the future generation of Singapore to ensure that we have a sustainable future (Tan & Chang, 2008). Consequently, as educators, we should not just aim to raise students' environmental awareness (Tan, Lee, & Goh, 1998) but focus, instead, on providing deeper and more relevant learning experiences.

Bibliography

Bloom, B. (1956). Taxonomy of Educational Objectives, the classification of educational goals – Handbook I: Cognitive Domain. (B. Bloom, Ed.) New York, NY: McKay.

Chang, C. (2012). A Critical Discourse of Singapore's School Geography for the Twenty-First Century. Literacy Information and Computer Education Journal , 3 (3).

CPDD (Curriculum Planning and Development Division). (2005). Social studies syllabus: Primary. Retrieved December 28, 2010, from Curriculum Planning and Development Division, Ministry of Education Singapore: http://www.moe.gov.sg

CPDD. (2006). Social studies: Secondary 2 Normal (Technical). Retrieved December 28, 2010, from Curriculum Planning and Development Division, Ministry of Education Singapore: http://www.moe.gov.sg

CPDD. (2007). Science syllabus: Lower secondary: Express/Normal (Academic). Retrieved December 28, 2010, from Curriculum Planning and Development Division, Ministry of Education Singapore: http://www.moe.gov.sg

Gagné, R. (1985). The conditions of learning and theory of instruction (4th ed.). NEw York, NY: Holt, Rinehart & Winston.

Global Greenhouse Warming. (2010). Climate Mitigation and adaptation. Retrieved 1 10, 2012, from Global Greenhouse Warming: http://www.global-greenhouse-warming.com/climate-mitigation-and-adaptation.html

Goh, K., Tan, K., Chang, C., & Ooi, G. (2009). Climate Change and Sustainable Development: The Response from Education - the case of Singapore. In J. Laessoe, S. Karsten, S. Breiting, & S. Rolls, The Joint National Reports on Climate Change and Sustainable Development: The Response from Education (pp. 240 -0291). Denmark: The International Alliance of leading Education Institutes.

Heywoth, R. (2008). New science discovery for lower secondary (2nd ed., Vol. 2). Singapore: Pearson Education.

Hussain, Z. (2007, April 23). Government preparing for possibility of rising sea levels. The Straits Times .

Krathwohl, D. (2002). A Revision of Bloom's Taxonomy: An Overview . Theory Into

Practice , 41 (4), 212 - 218.

Ministry of Environment and Water Resources, Singapore. (2008, March). Singapore's National Climate Change Strategy. Retrieved December 28, 2010, from Singapore's National Climate Change Strategy: http://app.mewr.gov.sg/data/ImgUpd/NCCS_Full_Version.pdf

School Examinations and Assessment Board. (2007). Geography: GCE Ordinary Level (Syllabus 2235). Retrieved January 19, 2009, from School Examinations and Assessment Board: http://www.seab.gov.sg/SEAB/oLevel/syllabus/2010_GCE_O_Level_Syllabuses/2235_2010.pdf

Tan, G., Lee, C., & Goh, K. (1998). A survey of environmental knowledge, attitudes and behaviour of students in Singapore. International Research in Geographical and Environmental Education , 7 (3), 181 - 202.

Tan, I., & Chang, C. (2008). Geography Education for sustainable development in Southeast Asia. International Research in Geographical and Environmental Education , 17 (4), 289 - 291