Measuring Students' Climate Change Knowledge: Instrument Development and Validation

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Objectives

Climate change is an environmental socioscientific issue that presents both a challenge to our society (NRC, 2012) and an opening for meaningful instruction due to its recent inclusion in K-12 science education standards (NGSS, 2013). Many science topics are described as complex but coordinated systems of components and dynamic processes (Hmelo-Silver & Azevedo, 2006) that students often view as a litany of unrelated facts (Svihla & Linn, 2012). Climate change is a prime example of this complexity. This topic is challenging for students to learn due to numerous prevalent alternative conceptions (Shepardson, et al., 2012) and for educators to teach as a result of the lack of formal preparation (Hestness, McDonald, Breslyn, McGinnis, & Mouza, 2014; Plutzer, et al., 2016). Yet this complex system is ripe for instruction due to the high interest and everyday relevancy of this socioscientific topic. However, no instrument is currently available to measure climate change knowledge that is both appropriate for middle and high school students and has been empirically established as reliable and valid. This poster shares the development process for the Climate Change Assessment (CCA) and examines it through psychometric analysis using classical test statistics. The purpose of this work was to design an assessment that measures climate change related content knowledge and to explore the validity and reliability of the measure with middle school students.

Theoretical Perspective

The standards-based education movement, especially the *Next Generation Science Standards* (NGSS) and its advocacy for three-dimensional instruction, has promoted the use of alternative and performance assessments (NGSS, 2013; NRC, 2012). However, these assessment types often prove to be cumbersome for teachers to use in most science classrooms. Therefore, multiple-choice assessments still have an important role to play in current approaches to assessment (Haladyna, Downing, and Rodriguez, 2002) provided that they are reliable, valid, and easy to use.

During the construction and validation of the CCA, we sought to develop a measure that will provide accurate and useful information to classroom teachers and to educational researchers about the current normative understandings and prevalent misconceptions held by their students both before and after instruction.

Research Context

This work is part of a larger NSF funded project focused on climate change education and assessment in the Mid-Atlantic region. A main component of this project is a year-long professional development (PD) program for teachers to enhance their climate change knowledge along the four content constructs of the *greenhouse effect mechanism, effects of human activity, climate change impacts, and mitigation and adaptation approaches*. The PD also sought to strengthen teachers' familiarity with pedagogical approaches for teaching climate change to their middle and high school students. As part of the PD, teachers developed and implemented climate change topics within diverse curricula across multiple grade levels and state settings.

Three teachers (one 6th grade and two 8th grade) were recruited to collect student data related to content knowledge on climate change topics prior to and following the enactment of the teacher-designed lessons. In total, the assessment was administered to 279 middle school students as a pre- and post-test.

Development Process

To develop the assessment, we first determined the big ideas of climate change and grade-level appropriate expectations of content knowledge from NGSS, state curricula, AAAS literacy maps, and the NOAA climate literacy principles (USGCRP, 2009). Additionally, we conducted an extensive review of relevant research literature to identify common alternative or misconceptions around key climate change concepts. Next, we created a framework for climate change understanding with four underlying constructs: **the mechanism of the greenhouse effect, the impacts of human activity, climate change effects, and mitigation and adaptation approaches**. Items were then written for each construct. Those items represented different and increasing levels of complexity. Additionally, item distractors incorporated common misconceptions, a practice established by other educational research teams (e.g. Anderson, et al., 2002; Lee, et al., 2011; Sadler, 1998).

A priori efforts to ensure content validity included an expert panel review of the items by faculty members not affiliated with our research team but familiar with the overall project. The purpose of the review was to enhance item accuracy and clarity of science content ideas. Additionally, to enhance item appropriateness and clarity of language and vocabulary for students in grades 6-12, all items were reviewed by a group of middle and high school teachers involved in a climate change professional development program. Suggested modifications that resulted from both review iterations were incorporated into the subsequent versions of the assessment. One of the modifications was an inclusion of the phrase 'Why is your choice the best answer?' to allow students the opportunity to more fully display their thinking in writing and to support efforts to establish the validity of the multiple choice questions.

Sample Test Statistics	Desired Value	Actual Value
Mean Item Difficulty	~63.0%	70.0%
Mean Item Discrimination	.40	.52
Cronbach's Coefficient Alpha	.7<x<.9	.803

Results

See above for test statistics related to the item difficulties, item discrimination indices, and scale reliability. These results are well within the recommended values for a valid and reliable assessment.

The student interview transcripts (N=11) were evaluated for the number of correct and incorrect or alternative conception utterances. These scores were compared to the student's achievement on the CCA. The two scores were strongly correlated for each student. When employing a repeated measures t-test, **no statistically significant difference was found between the students' performance** on the CCA and the longer one-on-one interview conditions.

Comparison of Assessment Scores to Interviews		
Mean Assessment Score	68.70	
Mean Interview Correct Utterances	63.40	
Correlation between Scores	r=.853	p=.001
Repeated Measures t-test	t(10)=1.957	p=.079

Findings

Results from this work indicate that the CCA is both reliable and valid for examining middle school students' thinking on climate change topics.

Additionally, the factor analysis results indicate that these items load onto a single factor. This suggests that **climate change knowledge is highly intertwined across the four underlying constructs, specifically the greenhouse mechanism, the role of human activity, the local and global effects of climate change and the approaches taken towards mitigation and adaptation.** These results also suggest there may not be one single trajectory, nor separate parallel progressions of the different climate change constructs. Instead, it is likely that developing an understanding of climate change requires an intertwining path among these complex concepts and relevant underlying constructs. Overall, the instrument is appropriate for pre and post instructional use to identify student knowledge, as well as their progression toward scientifically accurate understanding and the prevalence of misconceptions in students' thinking.

Key Contributions

The work reported here demonstrates that the CCA is sensitive to the multiple interwoven dimensions of the complex topic of climate change. This assessment allows learners to show how their knowledge is integrated across sub-constructs by encouraging them to draw on different aspects of their understanding to adequately explain their answer choices. This work also shows that the CCA performed comparatively to a one-on-one interview as a method for exploring student thinking. This is an especially important contribution as the CCA is easy to use with larger groups of students and easy to score and analyze. It also allows educators to better understand initial student thinking and changes in student knowledge through the purposeful, distractor driven multiple choice items and subsequent explanation spaces. The CCA enables teachers and researchers to investigate the development of their students' thinking over time and as a result of instruction.

As an assessment instrument, the CCA aligns with important climate change ideas but it is not dependent on a specific instructional approach or curriculum. This enables the use of the assessment across various educational interventions related to climate change. This flexibility is especially important because of the diverse approaches to teaching climate change that are utilized by K-12 teachers and investigated by educational researchers. Therefore, future research use of the CCA instrument could also support the iterative improvement of climate change education for students and climate change PD for teachers.

For Full Text of the Climate Change Assessment (CCA) developed, please contact Andrea Drewes, adrewes@udel.edu

For more information on this project, go to www.madeclear.org

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