Investigating Educators' Understanding of Climate Change from a Computational Thinking Systems Perspective

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Exploring the Integration of Computational Thinking into Preservice Elementary Science Teacher Education (CT → PSTE)

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Introduction

There is a need to approach environmental education (EE) topics, such as climate change, with a framework that productively reflects its inherent complexity. This study investigates how computational thinking (CT), specifically systems thinking (ST), may prepare educators to teach climate change. As scientists increasingly rely on computational techniques in their studies of complex EE topics, it is incumbent on science education to provide learners with computational thinking opportunities. We investigated how elementary preservice teachers (PSTs) in a science methods course (N=35) adapted a curricular resource on the climate change topic of sea level rise to integrate the CT practice of ST.

Research questions

How does computational thinking, with an emphasis on systems thinking, support preservice elementary teachers' thinking about climate change, a complex environmental education topic?

How do preservice elementary teachers incorporate systems thinking in their proposed teaching of the environmental education topic of sea level rise?

Background and Theoretical Perspective

Our research is guided by a community of practice (CoP) framework (Lave & Wenger, 1991; Loughran, 2014; Parchmann et al., 2006). CoP seeks to gain insight into "elements that encourage teachers to change their practices, and more particularly, into the nature of teacher learning" (Loughran, 2014, p. 817). Situated within an undergraduate methods course, as part of a four-year teacher education program, and located within the larger education community, PSTs are in the process of moving from peripheral towards more active participation in teaching as a profession.

Context and participants

Participants were from of two sections of an undergraduate elementary science methods course. They were senior-level undergraduate students in their final year of the university's elementary teacher preparation program. Nearly all participants were women between the ages of 21-23 and were academically high performing. We did not collect data on participants' race/ethnicity; however, typically approximately 90% of the PSTs in the elementary education program were White.

Data collection and analysis

After completing an online sea level rise activity, PSTs' responses were coded using a taxonomy proposed by Weintrop (2016) for the presence of ST practices. In Table 1, below, each code category represents a systems thinking practice and includes our interpretation of the practice in the context of this study. The total below each column indicates the number of PSTs including the practice in their response.

Findings

For ST, even in a relatively short timeframe of a single science methods course, our PSTs developed a basic understanding for ST as a framework to understand and teach complex topics. Most went from being able to list only a few disparate elements of the climate system, to making causal connections between greenhouse gases, increasing global temperature, ice melt, and sea level rise. Most PSTs were able to describe how they could apply this new knowledge to a classroom setting in discussing how they would teach SLR, with 30/35 (86%) coded for including the practice *Understanding the Relationships within a System* and 20/35 (57%) for *Investigating a Complex System as a Whole*.

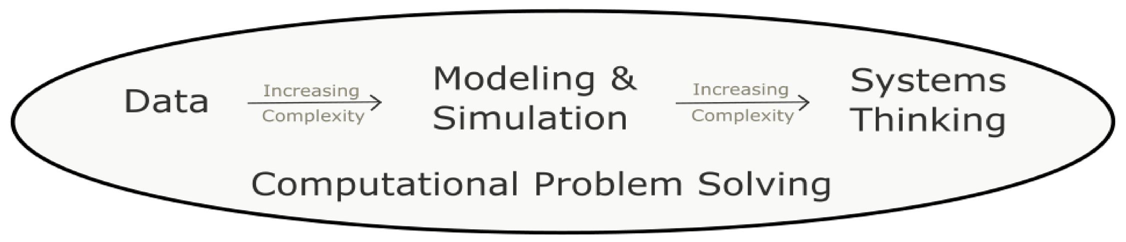
Findings (continued):

These findings were encouraging and suggested that ST could serve as an organizing framework for more connected and in-depth instruction on complex environmental topics.

Implications

Systems thinking, as a part of a continuum of CT practices, has the potential to support future elementary teachers' understanding and teaching of climate change, and other complex topics in the NGSS, that reflects its complexity.

Computational Thinking Practices Continuum



Especially at the elementary level, where science is often underemphasized and when taught focuses on a transfer of a body of information (Banilower et al., 2013), understanding how topics are interrelated is essential to prepare elementary students for middle and high school science learning.

Table 1: *Systems Thinking Practices in PSTs' Responses.*

Investigating a Complex System as a Whole	Understanding the Relationships within a System	Thinking in Levels	Communicating Information about a System	Defining Systems and Managing Complexity
In their teaching, PSTs address either major inputs or outputs of the climate system with an emphasis on SLR. Examples of inputs include deforestation, fossil fuel use, and release of other greenhouse gases. Outputs include the impacts on humans and ecosystems from climate change and SLR. Inclusion of migration/adaptation to climate change and sea level rise is also represented by this category.	*In their teaching, PSTs describe how the interactions between systems occur. Examples include CO_2 causing warming, warming causing ice melt (or thermal expansion), ice melt and thermal expansion causing sea levels to rise. Connections between humans and ecosystems and sea level rise also should be counted. This code represents the mechanistic aspects of climate change and SLR whereas Investigating a Complex System as a Whole represents the drivers and impacts.*	*PSTs approach climate change and sea level rise on several levels. For example, a micro level addressing the actions of individuals connecting to a macro level of increasing CO_2 concentrations and global warming. A further example would be teaching the micro level of the behavior of atoms leading to the thermal expansion of water and rising sea levels. Stating "thinking in levels" without providing an example does not constitute this code category.*	*PSTs provide opportunities for students to communicate their ideas about the systems involved in climate change and sea level rise and how these systems interact. Examples include creating visualizations, infographics, written works, or concept maps. It may also involve group and class discussions about sea level rise, the systems involved, and how the systems are related. Discussion should include student generated artifacts, research, or ideas from teaching activities.*	*PSTs provide opportunities for students to define the extent of the climate and sea level rise systems. PSTs actively participate in defining the boundaries of what to include (e.g., human activity, thermal expansion of water, etc.) and what can be excluded while still having a useful system/system model.*
Total: 20	Total: 30	Total: 0	Total: 8	Total: 0

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