# Preliminary Findings:
# Teacher Candidates' Reflections on Science Teaching During a Sustainability-Infused Elementary Science Methods Course

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## Setting, Participants, and Data Source

To gain insight into the research question: *"Does integrating the theme of sustainability into science teacher education influence teacher candidates' thinking about their future science teaching practice?,"* my colleague and I examined data collected from three sections of an Elementary Science Methods course that incorporated the theme of sustainability. Participants (N=66) were undergraduate teacher candidates in the fourth and final year of their Elementary Education program. The data examined were participants' written responses to an online learning module (http://www.climateedresearch.org/EDCI372/) focused on local sea level rise projections and impacts. With their research team, the course instructors (McGinnis and Hestness) designed the module for the purpose of introducing pre-service teachers to the sustainability topic of climate change. Completed midway through the semester, the module was one of several interventions in the course that incorporated the theme of sustainability. Upon completion of the module, participants responded to a set of three reflection questions. Written responses, approximately two to five sentences in length, were saved into a web-based spreadsheet. A colleague and I used inductive and deductive methods to code participants' responses to the reflection question: *"How might you teach your students about locally-relevant issues related to environmental sustainability (e.g., climate change and its local impacts)?"*. Since this question related to participants' thinking about sustainability and its role in their future science teaching, I believed that the data had the potential to provide insights relevant to the research question.

## Coding Approaches

### Inductive Approach

During first-cycle coding, my colleague and I independently coded the written reflections using inductive methods. Our initial coding and categorization had many features in common (see Appendix Tables 1 and 2). We each included categories for learning activities that participants intended to use in the science classroom, as well as specific sustainability topics they envisioned themselves addressing. Likewise, we each created a category encompassing resources that participants could use to support their teaching, though we bounded the category somewhat differently. While my version was restricted to informational resources, my colleague defined resources more broadly, including codes such as *students' personal experiences* and *local nature areas* as examples of resources to support sustainability teaching. I included codes similar to these in my initial coding scheme, but categorized them differently. Seeing similar codes parsed into categories differently raised my awareness of the diversity of possibilities for categorizing. Another area of discrepancy appeared in my inclusion of a category that my colleague did not include: participants' attention to the affective dimensions of sustainability teaching, such as *student interest* and *student choice*. My attention to this dimension may relate to my background in informal science education, a field that generally views affect as an important priority in science learning. This could be an example of bias I bring to my reading of the data, and may highlight the value of engaging more than one researcher in coding and negotiating differences.

The inductive approach to coding presented a number of advantages. Inductive coding appeared to capture the richness of the data and the diversity of ideas that participants expressed. As we coded the data, my colleague and I were not constrained by the need to fit the data into pre-established categories – if a previously established code could not appropriately describe a participant's statement, we were free to create a new code that better encapsulated it. This resulted the coding of some interesting piece of information in nearly every sentence of the data. Despite these advantages, there were several disadvantages to coding inductively. First, the process itself was time-consuming, and required further post-coding analysis in order to consider how codes could be combined into categories for more concise reporting. This left considerable space for inter-rater discrepancy. Though we each generated some similar categories, those that were different required negotiation of our interpretations. It appeared that some of the differences in our coding and categorization may have been a product of our biases; both my colleague and I were influenced by our different experiences working with pre-service teachers and interpreting what we thought they meant in their statements. Here, a member-check with participants would have been useful, however this was not feasible since we no longer had access to participants.

**Deductive approach**

Using a deductive approach, my colleague and I each coded the written reflections using a coding scheme derived from the Maryland Environmental Literacy Standards (Maryland State Department of Education, 2011). The *Sustainability* standard included six topics and indicators for student performance. I developed analogous indicators for teacher performance, which served as our coding scheme (Appendix Table 3). In comparing my use of the codes to my colleague's, it was interesting to examine the frequencies with which we applied each code (Appendix Table 4), and whether we applied them to the same data. There are a variety of possible explanations for the discrepancies that appeared in our coding. One possible factor could be the redundancy of some of the codes. I coded some of the data using multiple codes (e.g., *Interconnectedness of Systems* (WB) and *Limits of Ecological Systems* (ENV) codes). My colleague engaged in less of this multiple coding. A conversation to develop a shared understanding regarding instances in which each or both codes were warranted might have alleviated these discrepancies. In our discussion after coding, my colleague and I also noted some overlap between the *Action Component* code (TA) and the *Intergenerational Responsibility* (RDA) code. We decided that the codes were somewhat redundant, and might be better clustered into one code. Finally, the discrepancy in our use of the *Influence of Social/Cultural systems* code appeared to be related to our different interpretations of the code. In this case, we should have had a more detailed conversation prior to coding, and developed a shared understanding of its meaning.

Like the inductive coding process, deductive coding presented several advantages. The pre-established coding scheme provided my colleague and I with a common lens for examining the data. The deductive coding process was less time-consuming than inductive coding, and there was less post-coding work to be done—we started and ended with a small number of codes, rather than having the number of codes grow over time and require collapsing. A particularly interesting affordance of the deductive codes was their effectiveness in highlighting aspects of sustainability teaching that were missing from participants' responses. If a code was used only a few times, it prompted us to consider possible explanations. For example, we rarely used the code describing human impacts on the environment. Did this mean that participants were unaware of human impacts on the environment? Was it a product of the intervention? The process of coding deductively raised questions about the data that the inductive process did not. Despite these advantages, there were a number of disadvantages to the deductive approach. Because much of the data did not fit the pre-established codes, large sections of data had no codes assigned. Thus, it seemed that the deductive codes may have missed aspects of participants' thinking. If the research question had been oriented to evaluating the effectiveness of an intervention for changing participants' thinking regarding the Maryland Environmental Literacy Standards in particular, the deductive coding scheme may have been more useful.

**Second cycle codes and translation to themes**

After the first cycle coding process, I reflected on the affordances of the categories that emerged from the inductive and deductive coding processed. In an effort to capture the richness of the data that each of these approaches had helped to elucidate, while moving toward a concise reporting of findings, I developed a set of four second cycle codes: resources, relevance, connections, and responsible actions. These codes encompassed the clustered and collapsed codes from the first cycle coding processes (Appendix Table 5). To ensure that the codes appropriately described the data, I engaged in a second cycle of coding. Finally, these four codes were translated into themes for reporting preliminary findings.

## Preliminary Findings

Participants' responses to the online module question: *"How might you teach your students about locally-relevant issues related to environmental sustainability?"* provided insight into the ways in which pre-service teachers thought about their future teaching practice during their sustainability-infused Elementary Science Methods course. Four key themes emerged from the data. First, most participants identified activities and resources they could use to support their science teaching—some of which clearly support the infusion of sustainability, and some that appeared to represent more general teaching strategies. Second, many participants appeared to see value in making sustainability personally relevant to their students, and identified strategies for connecting with students' lives and interests. Third, some participants identified ways they would emphasize the connections between social, economic, and environmental systems through sustainability-focused teaching. Finally, some participants identified ways they would engage students in thinking about responsible actions. Next, I discuss each of these four themes in turn.

### Teaching Activities and Resources

In responding to the online module prompt, nearly all pre-service teacher participants identified activities and resources they could use in their future science teaching. Given their current roles as part-time interns in schools, participants' attention to concrete approaches to working with students is not surprising. In examining the kinds of activities and resources participants suggested, it is interesting to consider the extent to which participants' ideas might support the infusion of sustainability into their future science teaching.

While some activities and resources that participants mentioned appeared to support the targeted integration of sustainability into science education, others appeared to represent vague or generalized approaches to science teaching. For example, one participant stated,

> *"I would allow my students to do their own research and find evidence to support their claims."* (Miriam, online module response)

Helping students engage in argument from evidence is a highly valued practice in science education. As such, it is a desirable takeaway for a pre-service teacher in an Elementary Science Methods course. However, such a statement gives little insight into how the sustainability focus itself might have influenced the ways in which the participant thought about her future teaching. By contrast, other participants' statements connected specifically to the course's sustainability focus, and suggested that participants had ideas about how they might integrate sustainability into their own science teaching. For example, one participant stated:

> *"I could show them the causes and effects of the issue. I can show them before and after maps, similar to the interactive map about sea level rise, and the damage it can cause the more it rises."* (Meghan, online module response)

This statement presents a clearer example of how the participant conceptualized connections between sustainability and science teaching, and provides an example of the ways in which the intervention itself – the online sea level rise module – may have influenced participants' thinking about infusing sustainability into science education.

While most participants mentioned activities and resources similar to those modeled in the course, a few offered examples of pedagogical thinking extending beyond what was modeled. For example, in contrast to the virtual investigation presented in the online sea level rise module, one participant suggested providing community-based investigation experiences:

> *"Students can talk to local business owners and community members and see what they know about climate change and see what steps they are taking to minimize their impact."* (Stacey, online module response)

This example suggests that some participants were able to extend their thinking about sustainability teaching to consider activities and resources beyond those explicitly modeled.

**Relevance**

Because participants were specifically prompted to discuss how they might teach about locally-relevant issues related to sustainability, participants attended frequently to the notion of making sustainability relevant to their students. The theme of relevance that emerged in the data suggested that most pre-service teacher participants saw value in making science relevant to students in general, and gave insight into how they saw themselves connecting the concept of sustainability to students' lives and interests.

Three key explanations of the value of making topics personally relevant to students emerged from participants' responses: that relevant topics foster learning, provide a hook to engage students and spark their curiosity, and inspire them to care about the problems presented. A few participants described how connecting to students' prior knowledge and experiences – a central tenet of constructivism – could facilitate learning. For example, one participant stated,

> *"By…showing examples that they can relate to, learning the broader topic would be easier."* (Lisa, online module response)

Such a comment provides little information about the potential influence of the sustainability focus in particular, and appears to reflect the kinds of rhetoric to which participants are generally introduced in teacher preparation.

The modeling of a sustainability issue – sea level rise – in the online module, and its effects in two local areas – Rehoboth Beach, DE and Assateague Island, MD – appeared to influence participants' ideas about strategies for engaging students in learning by making it relevant to their lives. One participant reflected that,

> *"If they're familiar with the area you're talking about (I got excited when I saw Rehoboth Beach!), they're more likely to stay engaged and be interested in the lesson. If you ask questions that they can relate to (i.e. "Have you ever eaten crabs when you were at Rehoboth Beach/Ocean City?"), they're already invested in the lesson more than they would be if you just jumped right in to talking about coastline erosion, for example."* (Alexandra, online module response)

As illustrated in this statement, many participants suggested making connections between sustainability and activities their students enjoy. For many, it appeared that these connections had the goal of getting students to care about sustainability, by seeing how sustainability issues posed a potential threat to their valued ways of life (e.g. vacation destinations, food choices).

Many responses reflected the idea that highlighting the ways in which sustainability issues had the potential to change students' lives could be effective in leading students to care. Examples included such statements as:

> *"By showing how sea level rise can affect THEIR vacation or THEIR family, you can really connect on its importance."* (Steve, online module response)

It is possible that this type of thinking may have been a product of the module's approach, in which participants considered impacts of sea level rise in two well-known vacation destinations. Nevertheless, participants appeared to view the local, place-based approach as a potentially valuable hook for introducing sustainability into their science teaching, and making issues *real*.

**Connections**

Another theme present in participants' responses to the online sea level rise module was that of connections – particularly the ways in which integrating the sustainability theme into science education might illuminate connections between social, environmental, and economic systems – widely recognized dimensions of sustainability. This is potentially related to the approach modeled in the online module, in which participants were asked to consider sea level rise projections and the potential impacts for human health, ecosystems, and tourism.

Some participants focused on negative environmental impacts or effects, but did not specify the connections these might have for other systems. For example, one participant stated:

> *"I could show students videos of the effects that were happening because of issues such as climate change."* (Maria, online module response)

Here, effects on humans, economy, or ecosystems may be implied, but the participant's intention is somewhat unclear. While these types of statements were fairly common, the most frequent explicit connection participants made between systems related to the impacts of environmental systems (i.e., changes to environmental systems) on human communities (i.e. changes to social systems). For example, participants made such statements as:

> *"[Students] may… have relatives in New Jersey that were affected by Hurricane Sandy, so they can understand why these issues are important."* (Amy, online module response)

A number of participants extended such statements to indicate a connection between environmental changes, human systems, and economic systems; that is, when social systems are affected, so too are economic systems. As one participant stated,

> **"***I am from a very rural town that experienced a lot of flooding during Sandy one year ago. I could show students the impact of that flooding (crops being destroyed, livestock being limited to a small area, etc.)"* (Melissa, online module response)

In addition to economic effects on agriculture, participants highlighted potential economic impacts of environmental change in describing effects for tourism, coastal business owners [in the event of sea level rise], and fisheries. Such examples provided evidence that participants considered how they might communicate the potentially wide-reaching social and economic impacts of changes to environmental systems.

The reverse perspective – that social or economic systems impact environmental systems – was less evident in participants' responses. This is notable, as much environmental education rhetoric has traditionally highlighted the negative impacts of humans and economic development on the environment. One of the few participants who took this perspective stated,

> *"I feel a great way to teach student about sustainability is to give them an image of what the [Chesapeake Bay] ecosystem looked like before humans had left much of any mark on it. The Chesapeake Bay originally had crystal clear waters that you could see through for feet. [There] were almost mountains of oysters coming out of the water and they were all bigger than you hands. Images such as these allow students to see the splendor and limits of the natural system when humans don't interfere. By comparing those untouched images to the issues of today's Bay, students begin to see that the resources aren't endless and eventually they will run out."* [Natasha, online module response]

There are several potential explanations for the relative scarcity of such responses. It is possible that participants were influenced by approach modeled in the module, which focused more on the effects of sustainability challenges than on their causes. However, an understanding of potential impacts of human actions for the environment emerged more clearly as some participants discussed ways to engage students in responsible actions to promote sustainability.

**Responsible Action**

As with the relatively limited discussion of the impacts of humans on environmental systems, fewer participants included discussion of responsible human action into their sustainability-infused science teaching. However, responsible action was a theme that appeared within some participant responses. Participants who did consider incorporating discussion or activities related to responsible actions provided a variety of suggestions for including this perspective. Several participants discussed getting their students involved in service-learning activities, such as direct service or advocacy, stating:

> *"Students may be asked to develop a perspective on the changes occurring and develop a potential solution to be delivered to the class, and possibly to a person in the community (such as a representative, legislator), who can help make those changes happen."* (Carolyn, online module response)

In such statements, participants conceptualized ways to engage students in service to promote sustainability, though specific actions or curricular connections were not stated. Other participants focused on encouraging students to change their everyday habits. For example,

> *"I would design lessons that would teach students things they can do in everyday life to reduce their impact on the environment."* (Jamilah, online module response)

As in the service learning examples, the few participants who focused on encouraging students to be mindful of their everyday actions were not specific about what they would encourage students to change. One possible explanation is that participants might prefer suggested lifestyle changes to be student-generated, rather than imposed by teachers.

Rather than engaging students in direct action or behavior change, a few participants focused instead on engaging them in discussion about responsible decision-making. In some cases, these participants appeared primarily concerned with raising students' awareness that people can make a difference in addressing sustainability concerns. For example,

> *"I could teach my students about locally relevant issues related to environmental sustainability, such as climate change and its local impacts, by discussing why action needs to be taken."* (Jenna, online module response)

In cases like this, it was unclear whether participants had specific ideas for action, or who should be responsible for taking action. In some other cases, where discussion was intended to lead to student action, it was likewise unclear whether participants had ideas about the kinds of actions might be feasible. For example, one participant stated,

> *"I could take students to a nearby body of water and have them take samples of the water, look at water pollution, research the species in the area, and get ideas for how we could make a difference in our environment… By going to a local body of water students can get a hands on experience and be able to solve the issue on their own."* (Emma, online module response)

This statement calls to question the ways in which the participant conceptualized the complexity of sustainability issues, in suggesting that students might be able to “solve” them through one intervention. Nevertheless, such statements suggested that some of the participants saw student engagement in action as an important part of integrating sustainability into science education.

**Summary of Findings**

The four themes presented here—resources and activities, relevance, connections, and responsible action—provide preliminary insights into the research question “*Does integrating the theme of sustainability into science teacher education influence teacher candidates’ thinking about their future science teaching practice?”*. I noted potential influences of the course’s approach to sustainability education on participants’ thinking about how they might integrate sustainability into their own science teaching. I also noted ways in which the course’s approach may have limited the ways in which participants thought about their future science teaching practice. Finally, in a smaller number of cases, I noted the ways in which participants extended their thinking beyond the approaches modeled in the course to imagine unique approaches to integrating sustainability into their science teaching. Future research might employ interviews or focus groups to examine teacher candidates’ retrospective thinking about the sustainability-infused methods course and its influence on their conceptualizations of science teaching during subsequent student teaching and induction-year science teaching experiences.

## References

Maryland State Department of Education (MSDE). (2011). Maryland Environmental Literacy Standards. Retrieved from http://www.msde.maryland.gov/NR/rdonlyres/EC79EC27-40BF-4017-894B-63A12A89A3D1/31625/MD_ELIT_STANDARDS.pdf

APPENDIX

**Inductive Coding Process**

**Table 1.** Inductive coding: Colleague's first cycle codes and categories

| **Categories** | **Codes included** |
|---|---|
| 1. Types of projects or activities | • Service Learning<br>• Research Projects<br>• Develop questions |
| 2. Sustainability topics | • Erosion<br>• water conservation<br>• recycling<br>• sea level/climate change<br>• animal impact/climate change<br>• temp ranges |
| 3. Materials and resources | • local example: nature location<br>• local example: school<br>• general personal experience<br>• Graphs<br>• Videos<br>• Maps<br>• Websites/online resources<br>• demonstration<br>• historical resources<br>• field trips |
| 4. Rationale for materials or resource choice | • shows effect<br>• interesting/engaging<br>• whole picture |

**Table 2.** Inductive coding: Author's first cycle codes and categories

| **Categories** | **Codes included** |
|---|---|
| 1. Learning activities | • Research<br>• Use evidence to support claims<br>• Examine all sides<br>• Taking action<br>• Using data<br>• Make predictions<br>• Outdoor education<br>• Hands-on<br>• Form opinions<br>• Field trips<br>• Discussion |
| 2. Sustainability issues | • Recycling<br>• Water conservation<br>• Erosion<br>• Pollution<br>• Sea level rise<br>• Extreme weather<br>• Climate change<br>• "Issues" (vague) |
| 3. Teaching resources | • Videos<br>• Websites<br>• Local news<br>• Technology<br>• Guest speakers |
| 4. Relevance to students | • Local examples<br>• Negative impacts<br>• Student experiences<br>• Examining local changes (before/after)<br>• Firsthand observation<br>• Personal relevance<br>• Real world |
| 5. Affective dimensions | • Student interest<br>• Student choice<br>• Care<br>• Affect |

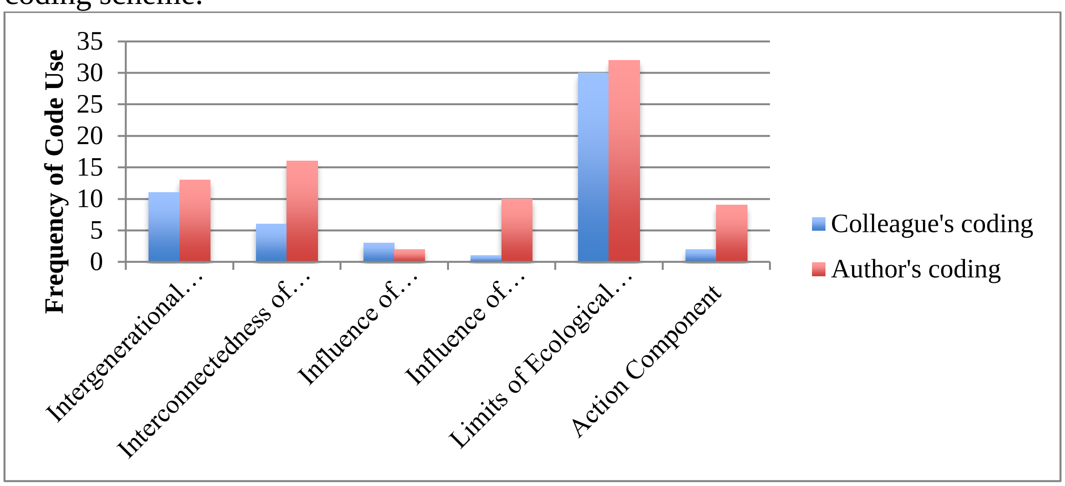
APPENDIX

**Deductive coding**

**Table 3.** Deductive coding scheme derived from indicators for Standard 8 (Sustainability) from the Maryland Environmental Literacy Standards (MSDE, 2011)

| **Topic defined in Standard 8: Sustainability** | **Code** | **Description** |
|---|---|---|
| A. Intergenerational responsibility | RDA – Reason about responsible decisions or actions | Participants discuss how they will ***help students reason about decisions or actions*** that relate to sustainability |
| B. Interconnectedness of systems | WB – Wellbeing of individuals or communities | Participants discuss how they will help students recognize how ***individual or community well-being is linked to ecological, economic, or social well-being*** |
| C. Influence of economic systems on sustainability | ECON – Economy affects society or environment | Participants discuss their intention to talk about cause-effect relationships, in which an ***economic (e.g. business) change/problem*** leads to a social or ecological consequence |
| D. Influence of social and cultural systems on sustainability | SC – Society/culture affects economy or environment | Participants discuss their intention to talk about cause-effect relationships, in which ***social and cultural change/problem*** leads to an ecological or economic consequence |
| E. Limits of ecological systems | ENV – Environmental change affects economy or society | Participants discuss their intention to talk about cause-effect relationships, in which an ***ecological change/problem*** leads to a social/cultural or economic consequence |
| F. Action component | TA – Take action | Participants discuss their intention to ***engage students in service-learning activities*** to promote sustainability |

**Table 4.** Comparative frequency of author's and colleague's use of codes from the deductive coding scheme.



APPENDIX

**Table 5.** Second cycle codes, later translated to themes for reporting findings

| Code | Description | Data included |
|---|---|---|
| Activities and Resources (AR) | Participants describe resources they could use to support sustainability teaching | • General science activities<br>• Resources to support science teaching |
| Relevance (REL) | Making sustainability relevant to students' lives | • Relevance to students' lives (e.g., local focus)<br>• Rationale for relevancy focus<br>• Affective dimension (if related to relevance) |
| Connections (CON) | Interdisciplinary connections; connecting economic, social, environmental systems | • Interdisciplinary activities<br>• Connecting economy, society, environment |
| Responsible Action (RA) | Engaging students in (thinking about) responsible action | • Service-learning<br>• Talking about responsible decisions |