

Preparing pre-service elementary teachers to teach about climate change

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Abstract: I find it concerning, as a former elementary teacher and now a teacher educator, that not much attention is given to the preparation of new teachers on the environmental and social crisis of climate change. I have taught in two teacher preparation programs at public universities in the United States and understand the complexities, barriers, and limitations that these programs must contend with when trying to implement something new into an existing curriculum. In this paper I will describe my first attempt in navigating through the process of trying to include climate change education into a teacher preparation program. The focus of this initial effort was to understand the climate change literacy and self-efficacy towards teaching about climate change of the students in my elementary science teaching methods course.

Keywords: Climate change education, pre-service teacher preparation, elementary science education, climate change literacy

Introduction and background of the issue

I teach in the elementary teacher preparation program at Salem State University in Salem Massachusetts. The campus is situated on the traditional and ancestral land of the Massachusett Tribe (Pioneer Village, n.d.). Salem is a port town, and its economic prosperity of the 17th and 18th centuries was tied directly to the slave trade (Murphy, 2008). I mention both of these things to contextualize where I work and highlight some facts that most of my students are not aware of because it has not been included in their traditional schooling experiences. The majority of my students grew up in the area and have a strong connection to the place but most lack a critical environmental and social justice lens that is necessary to teach about climate change. Environmental Justice (Skelton & Miller, 2016), which contends that environmental and social issues are explicitly linked, is not something that is typically part of a traditional teacher preparation program.

In fact, environmental education (EE), which has been around for half a century, is not something that many states in the US prioritize in schools. In 2015, as part of my dissertation research (Rosemartin, 2015) about the institutionalization of EE in teacher preparation programs, I found that although 34 states had some form EE plan or statute, they did not mandate schools to teach it. Only nine states had specific EE K-12 standards and just four had some form of EE requirement for teacher certification. These findings ignore the results of decades of international conferences focused on addressing increasing environmental problems, such as global warming and climate change, that have overwhelmingly acknowledged that education is a key factor to solving these environmental problems. In 1977 the first Intergovernmental Conference on EE convened in Tbilisi, Georgia and the 265 delegates and 65 representatives made explicit recommendations regarding implementing EE into teacher preparation. The final report recommended to Member States:

1. that environmental sciences and environmental education be included in curricula for pre-service teacher education;
 2. that the staff of teacher education institutions be assisted in this respect;
 3. that teachers should get appropriate environmental training relating to the area, either urban or rural, where they are going to work; and
 4. teachers in training should be given an understanding of the widest possible range of educational materials and aids, with special reference to low-cost materials and to opportunities for adaptation and improvisation according to local circumstances.
- (UNESCO, 1978, p. 35-36)

A major barrier to teaching about climate change in public schools has been the lack of training that pre-service teachers receive in teaching environmental or sustainability education (Foley et al., 2017). This is compounded by the misconceptions that many pre-service teachers have regarding climate change. Some teachers believe that climate change is happening because of natural causes or do not explicitly teach that it is being caused by human activity (Plutzer et al., 2016; Liu et al., 2015). Teachers' confusion and lack of knowledge about topics such as the water cycle, carbon cycle, greenhouse effect, and global warming has been documented for three decades, arguably contributing to these misconceptions (Dawson, 2012; Gowda, Fox, &

Magelky, 1997; Groves & Pugh, 1999; Khalid, 2001, 2003; Papadimitriou, 2004; Lombardi & Sinatra, 2013). This is problematic because teachers understanding of these concepts affects how they will teach about climate change to their students. Liu et al. (2015) point out that teachers' decisions on how to teach about climate change is related to their knowledge and attitude about it.

Institutional barriers

The elementary teaching licensure program that I work in is like most traditional teacher preparation programs at public universities in the United States, which is how 80% of public-school teachers get their education (National Research Council, 2010). Our program and courses are aligned to meet state licensing agency requirements which is managed by the state's department of education. Unfortunately, as mentioned previously, it is rare that a teacher preparation program is required to prepare students to teach about an environmental and social justice issue such as climate change. I am required, however, to prepare pre-service teachers to teach science lessons using the state's science education standards known as the *Massachusetts Science and Technology/Engineering Curriculum Framework* (Massachusetts Department of Elementary and Secondary Education, 2016). An analysis of these learning standards highlights how little attention is focused on environmental issues such as climate change. At the elementary school level, there are a few standards that focus on the impacts of human activity on the local environment, but it also notes that "An understanding of climate change is not expected in state assessment" (Massachusetts Department of Elementary and Secondary Education, pg.37, 2016). It is not until the eighth grade that there is a standard that specifically asks students to examine the role that humans have had in global warming. A further critical look at these standards also brings to light the lack of social justice connections in science education. I don't mean to suggest that environmental issues or climate change can only be taught in science classes. My reason for focusing on science is because my background is in elementary science education, I teach an elementary science teaching methods course, and I believe that climate change should be included in the elementary science curriculum.

Another institutional barrier is the extremely worrying trend of less science and social studies being taught in many elementary schools that many of my students are working at as student teachers. This is not a new phenomenon and has its roots in the No Child Left Behind Act (NCLB, 2002) era of the early 2000s. When I was an elementary school teacher, I saw how the shift towards more accountability through standardized testing in mainly reading and math pushed a lot of science teaching out of the main classroom and into specialized classes that were taught once a week by a different teacher. In my own teacher preparation program, we have only one science education course that our students are required to take. It is extremely difficult to teach foundational science education concepts as well as science teaching methodology in 16 weeks. The three hours of class time each week is barely enough time for my students to unlearn the misconceptions they have about what science is. The cumulative negative science learning experiences that my students have had has resulted in many students believing that teaching science is solely about content rather than the process of doing science, which instills critical thinking skills.

Research

I was hired to teach the science teaching methods course in the elementary teacher preparation program. This is one of the four content area teaching courses which includes science, literacy, math, and social studies. Unlike literacy and math, our pre-service teachers do not take separate foundational educational courses in science or social studies before the teaching methods course. They are however required to take general education college science and history courses. These courses typically focus only on one area of the field such as biology or early colonial history and lack the educational lens that help teachers understand what and how to teach these content areas.

Taking into consideration the barriers that I was facing to implement climate change education into my course such as limited class time, varied science education experiences, and lack of state-level education standards that focus on climate change, I decided to begin by collecting some baseline climate change literacy data from my students. I also thought it would be good to find out how my students felt about teaching climate change in elementary schools. If I wanted to use the limited class time effectively, I needed to know what my students knew and didn't know and if they felt it was something they wanted to teach.

I received a university summer research seed grant to help me develop and implement a study that examined the climate change literacy and self-efficacy towards teaching about climate change of the students in my science teaching methods course. I collected quantitative data from 70 students and qualitative data from three students during the three years of the study. The quantitative data was collected using a questionnaire that I developed after reviewing several climate change literacy and science teaching efficacy surveys (CIMSS, 2015; Leiserowitz, Smith, & Marlon, 2010; Leiserowitz et al., 2015; Riggs and Knochs, 1990) and discussions with climate change educators and scientists that I work with. The qualitative data was a result of three follow-up interviews that were conducted after students completed the questionnaires. The purpose of these interviews was to gain some insight about why students responded in certain ways to some of the items on the questionnaire.

The 25-item questionnaire survey was divided into seven themes: 1) Consensus about climate change; 2) Causes and drivers of climate change; 3) Effects of climate change; 4) Mitigation of climate change; 5) Fundamental concepts of climate science; 6) Self-efficacy towards teaching about climate change; and 7) Exposure and interest in learning how to teach about climate change. There were statements for each theme that participants responded to using a 5-point Likert scale, from strongly agree to strongly disagree. I analyzed the ordinal data with descriptive statistics to find out the frequency distribution of responses for each item.

The interviews were semi-structured with questions that focused on five themes: 1) Experiences with climate change education; 2) Climate change literacy; 3) Self-efficacy towards teaching about climate change; 4) Influential factors on climate change literacy; and 5) Barriers to teaching about climate change. I transcribed the interview responses and used a simple thematic analysis (King & Horrocks, 2010) to code and define overarching themes.

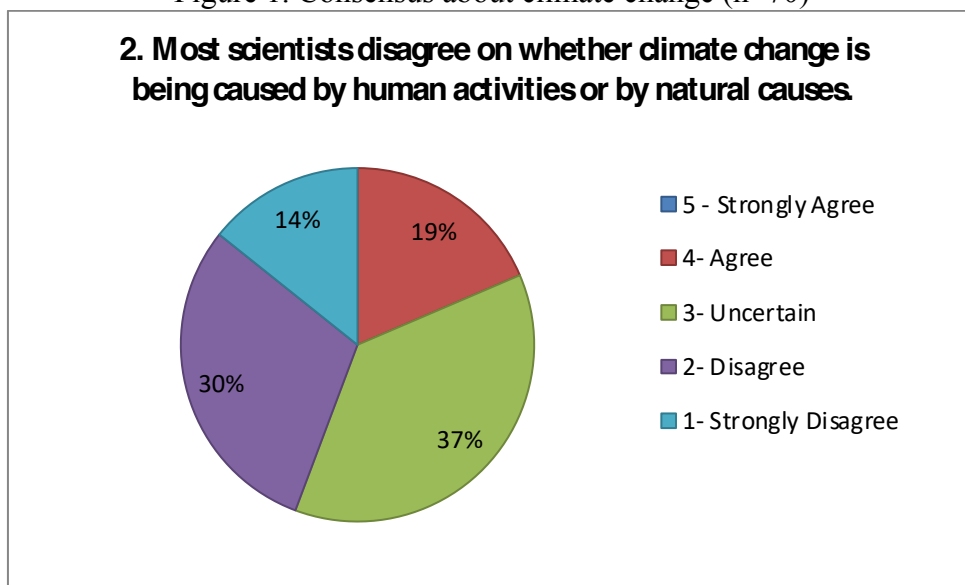
A comprehensive analysis of all the data collected using this sequential mixed-methods approach (Creswell, 2009) enabled me to answer three questions: 1) What are my pre-service teachers understanding of climate change? 2) What are my pre-service teachers' beliefs and

willingness towards teaching about climate change? and 3) Where are my pre-service teachers getting their knowledge/information about climate change?

What are my pre-service teachers understanding of climate change?

The first notable finding was that although 97% of the pre-service teachers in this study agreed that climate change is happening, less than half (44%) believed that there is consensus among scientists that it is being caused by human activities (Figure 1). The follow-up interviews revealed that a possible reason for this uncertainty could be the contradictory information that can increasingly be found on the internet. There have also been some well-funded efforts to mislead the public and science educators such as the packet of information that I received titled, “Why scientists disagree about global warming” which was sent out by the Heartland Institute to science teachers across the United States. (link to JSE article about the Heartland Institute climate change misinformation book http://www.susted.com/wordpress/content/deconstructing-free-enterprise-and-reconstructing-for-sustainability-cultural-ecological-propaganda-analysis-for-educators_2020_04/)

Figure 1. Consensus about climate change (n=70)



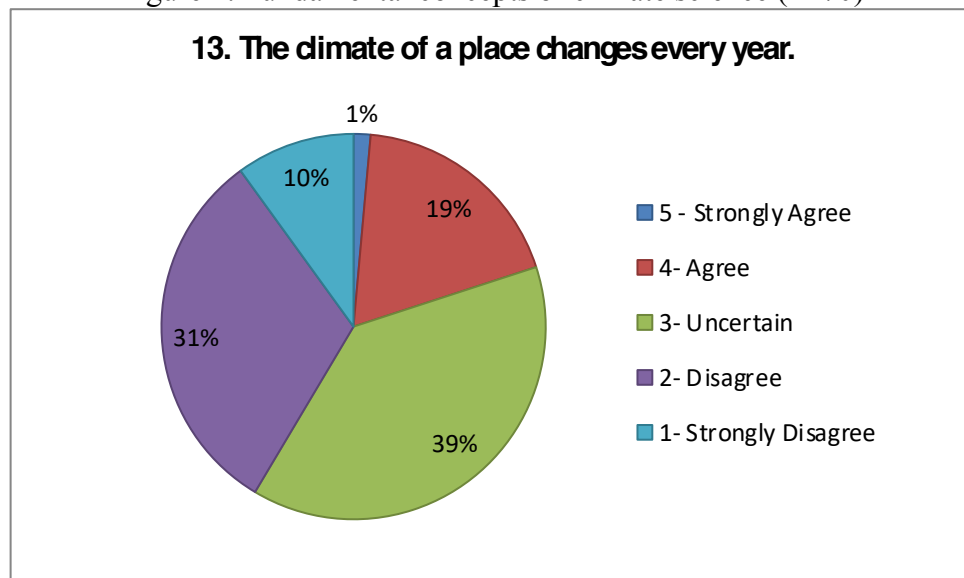
Overall, the pre-service teachers seemed aware of some of the causes and drivers of climate change. Eighty-four percent believed deforestation and increased emissions of greenhouse gases are causing climate change. Seventy-one percent understood that life, including microbes, plants, animals, and humans, is a major driver of the global carbon cycle and can influence climate change. Similarly, most had knowledge of some of the effects of climate change such as sea-level rise and increased forest fires (86%) and believed that climate change is causing serious problems to human health or livelihood (87%).

However, they were less aware of strategies to mitigate the impacts of climate change. While 76% understood that planting trees can help reduce the amount of carbon dioxide (a

greenhouse gas) in the atmosphere, only 45% realized that eating a more vegetarian diet can help reduce emissions of greenhouse gases into the atmosphere.

A second notable finding was related to my pre-service teachers' knowledge of fundamental concepts of climate science. While most of the pre-service teachers (80%) understood that climate and weather are not the same thing, less than half (41%) recognized that the climate of a place does not change every year (Figure 2). In follow-up interviews this was explained by the fact that many of them have witnessed how the climate of where they live has changed during their lifetime, which only spans the last two decades.

Figure 2. Fundamental concepts of climate science (n=70)



What are my pre-service teachers' beliefs and willingness towards teaching about climate change?

Only about half of the pre-service teachers (49%) felt that they could do a good job of teaching about climate change to elementary school students. Not surprisingly, even less (32%) felt confident that they would be able to answer their elementary students' questions about climate change.

Follow-up interviews revealed three themes related to this lack of self-efficacy towards teaching about climate change. The first theme was *multiple concepts*. Many of the participants responses were focused on the difficulty in learning about and understanding all the different concepts and systems related to climate change. A second theme was *grade appropriateness*. The participants felt that an additional challenge to learning the climate change concepts was how to discern which concepts were appropriate to teach at each grade level. The third theme was *fear of not knowing the answers*. This is an extension of the first theme but directly connected to another common concern of pre-service teachers; not being able to answer a student's question. Respondents were worried that the questions might be too hard to answer, they might now be knowledgeable enough about the facts or data, and in general they had a sense of fear about any question related to climate change that their students might ask.

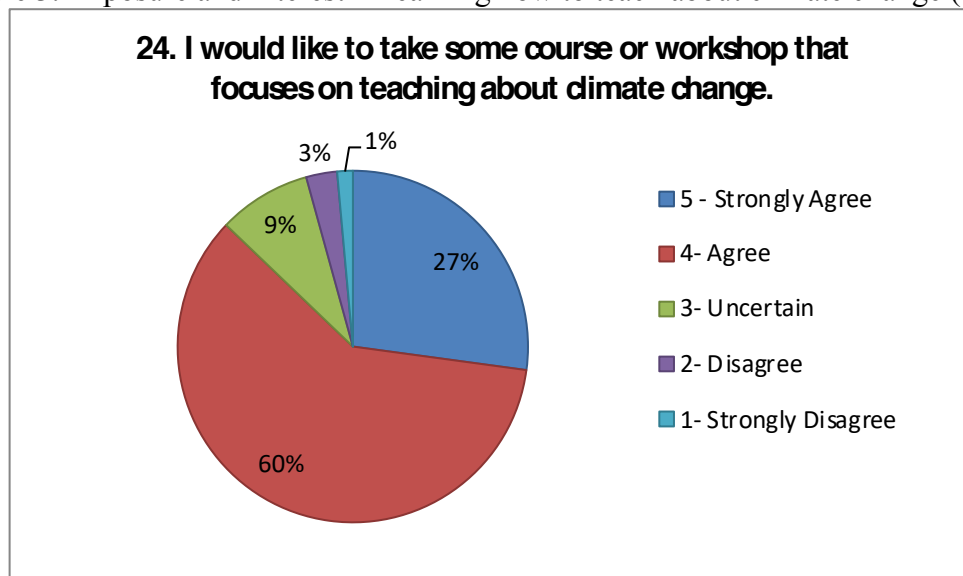
When the interviewees were asked about perceived barriers to teaching about climate change, the two themes that emerged were *education standards* and *climate change deniers*. In respect to education standards, the concern was that it seemed difficult enough to try to teach to all the different content area standards and if they did not include climate change it probably would not get taught. Their concern about climate change deniers was that maybe some of the parents would be upset that their children were being taught about climate change in a way that did not match their beliefs. They also felt that it did not help that many politicians, including President Trump, did not believe that climate change was a human caused problem.

Where are my pre-service teachers getting their knowledge/information about climate change?

The large proportion of the pre-service teachers feeling a lack of confidence in teaching about climate change may be attributed to the fact that very few (31%) felt that they were adequately educated about climate change. Many of them (73%) stated that climate change had been discussed in very few of their college courses. In follow-up interviews, the pre-service teachers cited documentaries, such as *An Inconvenient Truth* starring Al Gore in 2006, as one of the most influential factors in their understanding of climate change. They also acknowledged that a lot of their information about climate change comes from social media through postings that their friends share. A very telling finding about this generation of students is the fact that they have been learning about climate change by living through this climate crisis for their entire lives. They have grown up seeing increasing droughts, wildfires, heatwaves, hurricanes, and wonder why we haven't done anything about it.

A final notable finding addresses the pre-service teachers concern about their inadequate education about climate change. The majority (87%) of them said that they would like to take some course or workshop that focuses on teaching about climate change (Figure 3).

Figure 3. Exposure and interest in learning how to teach about climate change (n=70)



Discussion

The findings from this research enabled me to step back and rethink how to include climate change education into a teacher preparation program. There are three overarching questions that I believe can be answered through some targeted strategies: 1) How can climate change literacy and self-efficacy towards teaching about climate change be addressed in a pre-service teacher preparation program? 2) What is essential knowledge for teaching about climate change in elementary schools? and 3) What are good pedagogical practices for teaching about climate change?

How can climate change literacy and self-efficacy towards teaching about climate change be addressed in a pre-service teacher preparation program?

I found similar results to previous studies that examined pre-service and in-service teachers' climate change literacy (Dawson, 2012; Gowda, Fox, & Magelky, 1997; Groves & Pugh, 1999; Khalid, 2001, 2003; Papadimitriou, 2004; Lombardi & Sinatra, 2013). The pre-service teachers in the teacher preparation program that I teach lack some fundamental climate science concepts and have some misconceptions that will impact how and what they teach their students.

I agree, as others have suggested (Dal, Alper, Özdem-Yılmaz, Öztürk & Sönmez, 2015), that climate change literacy needs to be addressed in pre-service teacher preparation programs so that the misconceptions that they have are not carried into their future classrooms where they will pass them along to their students. The logical first step towards addressing any lack of climate change knowledge and misconceptions is to develop some method to assess climate change understanding, knowledge, and misconceptions. It can be a questionnaire similar to what I used for this study but that will only reveal some general information about what pre-service teachers know or don't know. What is additionally needed are some discussions to critically reflect on and examine why they lack some of this knowledge and where these misconceptions may come from. During one such discussion, the pre-service teachers in my class and I sat in a circle on the floor to discuss the merits of learning about climate change through watching films such as the 2006 documentary *An Inconvenient Truth* and the 2016 documentary *Before the Flood*. They all agreed that although the films were good for some overall general knowledge, they could also lead to some misunderstanding or confusion of climate change if they did not follow up on the climate science concepts that were presented. There was also some debate of whether the use of actors such as Leonardo DiCaprio strengthened or weakened the validity of the information being presented.

The lack of confidence that my pre-service teachers have toward teaching about climate change comes from their fear of not knowing enough knowledge about climate science which is similar to their fear about teaching science in general. Some of this fear can be alleviated by learning more climate science, but I also think that focusing on the emotion of fear itself might be more beneficial. Lombardi and Sinatra (2013) discussed how a feeling of hopelessness about climate change can be a barrier to teaching about it so these emotions should not be ignored. The sense of hopelessness my students feel mainly focuses on teaching about climate change rather than the actual impacts of it. This anxiety can be addressed by focusing on two things: 1) understanding that teaching is not about always knowing all the answers and 2) what are some

pedagogical strategies that can be used when you don't have an answer to a student's question? One strategy is to acknowledge that it is a good question, admit that you don't have an answer, discuss possible answers, and then create a lesson activity that enables the students to co-construct the answer to the question with the teacher.

After assessing the pre-service teachers' climate change literacy and addressing their fears about teaching climate change, it is advantageous to examine teaching access points such as state science learning standards. One of the concerns to teaching about climate change that the pre-service teachers pointed out was the lack of inclusion of it in the education standards. Teaching about climate change might not be explicitly stated in the standards but fundamental climate science concepts such as weather, climate, the water cycle, and the carbon cycle certainly are.

What is essential knowledge for teaching about climate change in elementary schools?

I find it very concerning that my pre-service teachers' misconception about climate science supports similar findings from research of the past two decades (Dawson, 2012; Gowda, Fox, & Magelky, 1997; Groves & Pugh, 1999; Khalid, 2001, 2003; Papadimitriou, 2004; Lombardi & Sinatra, 2013). Are the misconceptions of my 20-year-old pre-service students a result of a continuous cycle of bad climate science education? If so, what needs to be done to stop this cycle?

It is essential that pre-service teachers understand some basic fundamental climate science concepts such as the difference between weather and climate. Without this understanding, misconceptions about severe weather events can lead to inaccurate claims that climate change and global warming is not happening. An example of this is how some people misinterpret severe winter weather as evidence that global warming is not occurring. It is also important to comprehend how the Earth's greenhouse effect works in order to understand how burning fossil fuels contributes to global warming.

An important fact that needs to be made clear is that scientists are not in disagreement about whether climate change is happening or if it is being caused by human activity. There seems to be some confusion about how scientific findings are reviewed for accuracy that leads to the misconception that scientists don't agree about climate change. There are certainly new climate change research studies that have disputed or altered previous scientific findings but the consensus of 97% of climate scientists is that anthropomorphic climate change is happening (National Aeronautics and Space Administration, n.d.).

What are good pedagogical practices for teaching about climate change?

I think using a place-based and project-based approach helps increase understanding of climate science concepts as well as climate change impacts. I have done two pilot activities with my pre-service teachers which use this approach and focus on the impacts of climate change on local plants and coastal communities. In the first activity, they learned how to participate in a citizen science program called Nature's Notebook, developed by the USA National Phenology Network, by observing and collecting data about the phenophases of some of the trees around the building where our class was being held. They regularly recorded the date, temperature, and details about the trees during the spring semester. For example, they noted when the first leaves

appeared, when the first flower buds appeared, and when the first flowers opened. The purpose of doing this was to understand how temperature affects the timing of a plant's life cycle events. This also enabled the pre-service teachers to understand that weather patterns, such as temperature, are part our regional climate. Additionally, by observing a real example of how climate change will impact plants, they were able to start having conversations about how this would also impact everything that depends on plants.

In the second activity the pre-service teachers used a model of the coastline where we are situated and discussed possible ways to mitigate the impacts of recent severe storms and projected sea level rise. The model was designed to simulate sea level rise by adding water after the students had placed markers for the locations of residential and business buildings. They discussed what they observed and made plans for addressing the impacts of flooding on the buildings. I intentionally selected both learning activities because they highlight the process of using data collection, data analysis, and scientific modeling as evidence to make claims. I wanted to emphasize how scientific claims about climate change are based on this process and not motivated by political or social pressure as they sometimes hear in various forms of media.

Conclusion

Ennes (2021) found the primary barrier to teaching about climate change that teachers reported was the lack of time. I have similarly concluded that the barrier which has impeded me the most to including climate change education into my teacher preparation program has been insufficient time. It is difficult to implement consistent lessons or activities that focus on climate change education into my science methods course the way it is currently structured. I have had to make tough decisions about what to prioritize in a 16-week semester and unfortunately there are external mandates that sometimes supersede my choices. Therefore, I have argued for at least one additional science education foundations course to be added to our teacher preparation program. I have learned that the process for changing or adding courses in a university curriculum requires patience, persistence, and good timing. As a consequence of a larger effort to revise our elementary education program, I was recently given the responsibility to develop two new science education courses. The new courses have an environmental and social justice framework which will include climate change as a major theme. I am looking forward to the opportunity to address many of the issues I have discussed in this paper through the new courses.

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Author photo



Image for article (my pre-service teachers making observations in a wetland ecosystem next to our university campus)

