Sustainability Education in Elementary Classrooms: Reported Practices of Alumni from a Pre-Service Teacher Course

Eileen G. Merritt, Leanna Archambault, and Annie E. Hale
Mary Lou Fulton Teachers College and Biodesign Institute, Arizona State University,
United States of America

Abstract

The article reflects results from a web-based survey of early career teachers who had taken a required, hybrid course focused on sustainability science. Many alumni reported early efforts to integrate sustainability topics and ways of thinking into their K-8 classrooms. Teachers reported modeling of classroom behaviors that promoted sustainability more than implementing sustainability into the curriculum. Read-aloud books and videos were used frequently, suggesting the need for available high quality children's books and videos on sustainability topics. Supports that were most helpful to teachers included school-wide initiatives, curricular and instructional resources, like-minded colleagues and supportive administrators. Lack of time and alignment with curricula were barriers that hindered some teachers' progress, suggesting the importance of systemic curricular reform that brings awareness to the Sustainable Development Goals.

Keywords: teacher education, elementary schools, education for sustainability, competencies, instructional practices.

New ways of thinking are needed in order to transform our education system and our society (Orr, 2004). Students need to understand complex problems facing our society today and be prepared to design and enact creative solutions. They also must be more aware of how their individual and collective actions impact the natural systems around us. Globally, few fifteen-year-olds are able to solve complex problems such as creating a sustainable fish farm, and only about 40% of students reported an interest in topics related to ecosystem services and sustainability (OECD, 2016). Exposure to engaging curriculum related to these topics is essential in advancing sustainability literacy. Sustainability literate individuals have the ability and dispositions to solve problems, make decisions, and take appropriate actions that promote sustainability (Nolet, 2009). Sustainability emanates from a concern for intergenerational equity – the idea that states should conserve and use the environment and natural resources for the benefit of present and future generations (World Commission on Environment and Development,

WCED, 1987). We must prepare the present and future generations for the challenges that lie ahead.

International calls for sustainability education over the past three decades have motivated various states and countries to integrate education for sustainability into educational programs and curricula (UNESCO, 2005, 2009; WCED, 1987). Many higher education institutions have responded by adding sustainability-focused concentrations, minors, and certificates (Vincent, Bunn, & Stevens, 2012). However, sustainability course work is much rarer in teacher education, and has only recently begun to emerge in the United States (McKeown, with USTESD Network, 2013). One such example is a course developed at Arizona State University (ASU) and launched in the fall of 2012 called *Sustainability Science for Teachers* (SSFT). This hybrid course incorporates the innovative use of online digital storytelling to teach sustainability content and then meets face-to-face to learn about pedagogical practices. As the course has evolved, we wanted to explore the experiences of our alumni and their pedagogical practices related to sustainability. This paper describes a study about the beliefs and teaching practices of SSFT alumni who are now kindergarten through eighth grade (K-8th-grade) educators.

Conceptual Framework

The United Nations sustainable development goals are broad and ambitious, including aims such as ending poverty in all its forms everywhere, and providing access to affordable, reliable, sustainable, and modern energy for all (United Nations, 2015). Most problems that fall under the domain of sustainability are considered "wicked problems" because they are not clearly bounded or formulated. The perception of these problems vary across stakeholders, and solutions are multi-faceted with broad and unpredictable consequences (Rittel & Webber, 1973). How will we know when learners are ready to tackle these wicked problems? Education for Sustainability (EfS) seeks to help students learn to understand and balance the environmental, social, and economic perspectives as they explore interdisciplinary problems and seek solutions (UNESCO, 2005).

Key competencies or literacies for learners in sustainability are "complexes of knowledge, skills, and attitudes that enable successful task performance and problem solving with respect to real-world sustainability problems, challenges, and opportunities" (Wiek, Withycombe, & Redman, 2011, p. 204). These competencies are challenging to conceptualize and measure in the field of sustainability. They need scaffolding and translation for pre-service teachers and their future K-12 students (Nolet, 2009; Warren, Archambault, & Foley, 2014; Wiek et al., 2011). Four ways of thinking (values, futures, strategic, and systems thinking) are integral to fostering sustainability literacy in teacher education and K-12 schools (Bertschy, Künzli, & Lehmann, 2013; DeHaan, 2006; Ostrom, 1990; Stibbe & Luna, 2009; Tilbury, 2011; Warren et al., 2014; Wiek et al., 2011). These ways of thinking provide a conceptual framework of overarching knowledge and skills that teachers can learn, model, and teach their students as they strive to create a more sustainable future for people and our planet (Warren et al., 2014). Each way of thinking is briefly described below.

Values Thinking

Values thinking requires students to consider how values influence decision-making and to acknowledge the diverse views of stakeholders that impact and are impacted by each sustainability problem. For example, who contributes to and profits from our current food systems, who has access to healthy foods, and who is food insecure? Values thinking necessitates active learning activities such as debates, role-plays, and discussions that bring in multiple perspectives (Warren et al., 2014).

Futures Thinking

Futures thinking emanates from the idea of anticipatory thinking, asking students to envision the future and imagine various scenarios based on choices we make today (Wiek et al., 2011). Students consider how our present is shaped by past actions, and how our decisions today will impact future generations (WCED, 1987). They consider how choices made by people have potential consequences, both positive and negative, and recognize that we must manage that activity to progress toward a more sustainable future.

Strategic Thinking

Strategic thinking means "being able to develop a strategy or a plan to achieve a particular vision" (Warren et al., 2014). Students must consider a variety of possible solutions with a critical lens, recognizing that each solution or strategy may yield unintended consequences or privilege one group over another. Students must learn about path dependency, the idea that our current state will automatically chart a path for the future, unless disrupted by intentional changes (Mahoney, 2000).

Systems Thinking

Systems thinking focuses on analyzing and understanding relationships within and between existing systems. Systems occur across different domains (society, environment, and the economy) and scales (local to global) (Wiek et al., 2011). Systems and system models are a crosscutting concept in the Next Generation Science Standards (National Research Council, 2012). Connections between human and natural systems are emphasized in NGSS and in the field of sustainability science. These four ways of thinking provide a foundation for the development of sustainability literacy.

Review of Related Literature

Sustainability education in the field of teacher education has both proximal and distal goals. First, students as learners must become sustainability literate themselves. They also must develop confidence and motivation to apply their new skills and knowledge to educate their students for sustainability. To accomplish these goals, pre-service teachers need to engage with the big ideas associated with sustainability, be exposed to tangible examples of sustainability concepts integrated across disciplines, and learn about available curricula and resources that they can use in their future classrooms

(Nolet, 2009). Most elementary teachers are interested in environmental topics, but have limited knowledge about the meaning of sustainability or topics such as renewable and non-renewable energy sources (Spiropoulou, Antonakaki, Kontaxaki, & Bouras, 2007; Yavetz, Goldman, & Peer, 2009).

Sustainability Education Courses for Teachers Around the World

Many countries, such as Germany, Australia, and Israel have designed sustainability education courses or modules for their teacher education programs (Andersson, 2017; Abramovich & Loria, 2015; Tomas, Girgenti, & Jackson, 2015). For example, James Cook University in Australia developed an Education for Sustainability (EfS) unit for first-year pre-service teachers. Researchers found that students made gains in their EfS self-efficacy and became more familiar with and interested in sustainability issues, and remained high in their beliefs about the relevance of sustainability (Tomas et al., 2015). Other studies have assessed impacts of sustainability courses or modules on pre-service teachers' knowledge, beliefs, and efficacy (Abramovich & Loria, 2015; Andersson, 2017; Buchanan & Crawford, 2015; Kennelly, Taylor, & Maxwell, 2008; Tomas et al., 2015). However, few programs report on what happened later, when teachers attempted to implement what they have learned through course work in their K-8 classrooms. One study surveyed graduates of an Israeli teacher education program who took a two-year EfS course (Abramovich & Loria, 2015). Researchers found that the majority of teachers exhibited understanding, values, and willingness to take action to protect the environment. However, only five out of 13 teachers surveyed were implementing sustainability activities with students and/or their families. More follow-up studies are needed to understand teachers' implementation after EfS courses, and this is the gap that the current study begins to address.

Sustainability and Teacher Education in the U.S.

Teacher educators in the United States have started to integrate sustainability modules and units into their curriculum (Buchanan & Crawford, 2015; Church & Skelton, 2010). To align with existing goals of teacher education, EfS must meet Interstate Teacher Assessment and Support Consortium (InTASC) standards and embed sustainability literacy development across courses and field experiences (Santone, Saunders, & Seguin, 2014). For example, students at one university learned about sustainability topics in their elementary social studies methods course. They indicated wanting to change some of their own consumer behaviors, but were not yet confident in their ability to educate for sustainability in their future classrooms (Buchanan & Crawford, 2015). With few courses in sustainability education in schools of education, can we expect to see integration of these concepts in K-12 schools?

Sustainability Education in K-12 Schools

Due to the complex systems and values that influence motivation to educate for sustainability, EfS practices are influenced by curriculum, policies, and sustainability literacy levels of teachers (Ferreira, Ryan, Davis, Cavanagh, & Thomas, 2009; Smith & Stevenson, 2017). National EfS K-12 student learning standards were outlined in the

United States in 2009 (U.S. Partnership for Education for Sustainable Development, USPESD, 2009). Outlining EfS standards is the first step in a long journey toward adopting more sustainable policies and practices. Recent curricular reform initiatives in the U.S. include the Common Core State Standards (CCSS), the Next Generation Science Standards (NGSS), and the College, Career and Civic Life (C3) framework for social studies (CCSS Initiative, 2010; National Council for Social Studies, 2013; NGSS Lead States, 2013). Each document has skills and concepts that align well with the goals of EfS, creating opportunities for K-12 educators to design EfS lessons and units across the curriculum.

Some states such as Vermont, Washington, and Maryland, have articulated student and teacher outcomes related to EfS (Agne, 2006; McKeown & Nolet, 2013; Maryland Department of Education, 2011; Professional Educators Standards Board, 2011). Since sustainability education must factor in local environmental, economic, and social factors, each program is unique and has different emphases and pedagogies (McKeown, 2002). Studies are needed that describe EfS practices in schools across a range of contexts to begin to paint a picture of EfS practices, both challenges and successes. Below, we summarize prior studies that describe existing studies in this area.

Modeling Sustainable Behaviors

Daily words and actions by teachers can shape students' behaviors in addition to covering concepts through curriculum (Regan & Berkeley, 2011). Specifically, modeling of sustainability practices can help children understand how to care for the earth and protect resources. High school students reported that role models at school influenced their behaviors. They learned about things such as driving a hybrid car, turning off classroom lights, wearing second hand clothes, and encouraging divergent opinions from teachers and staff (Higgs & McMillan, 2006).

Barriers and Supports to Education for Sustainability

Some school settings are more supportive of sustainability initiatives than others. One study explored barriers and supports identified by school leaders and staff in Australia as they strived to implement whole-school sustainability initiatives (Evans, Whitehouse, & Gooch, 2012). Researchers categorized three types of barriers encountered: grassroots barriers that are of concern to teachers daily (e.g., time, an over-packed curriculum, or discomfort teaching about controversial issues); administrative barriers such as program funding or a curriculum focused primarily on literacy and numeracy; and conceptual barriers, such as a lack of awareness of sustainability concepts or conflicts between sustainability education theory and practice. Another study categorized barriers to implementation as personal, institutional, stakeholder-related, environmental and training-related, and found that in-service teachers were more aware of barriers than pre-service teachers (Atmaca, 2017).

Teachers found specific supports helpful in their efforts to implement EfS initiatives. This included principals who provided administrative time focused on sustainability education and included a budget line devoted to sustainability initiatives. One school described sustainability as "core business on par with literacy and numeracy" (Evans

et al., 2012, p. 132). Principals also offered funding for professional development for teachers and enabled teachers by creating conditions which allowed them to develop initiatives and built trust with staff members. Other research has shown that leadership practices are critical to implementation of sustainability initiatives (Kadji-Beltran, Zachariou, & Stevenson, 2013; Smith & Stevenson, 2017).

Aim for Current Study

Given the challenges facing new teachers, and varied landscape of schools, we were interested in surveying alumni about their classroom experiences and practices. The following research questions guided our work: In a group of alumni from a teachers' college that provided a course on sustainability science for teachers, 1) To what extent do K-8 teachers report teaching about sustainability concepts and ways of thinking in their classroom? 2) How did teachers integrate sustainability concepts into their curriculum? 3) What barriers and supports do teachers report with regard to curricular implementation?

Methods

We conducted a web-based survey using Dillman's (2011) Tailored Design Method (TDM). Tailored Design is an ideal approach when it comes to survey procedures because it seeks to generate perceptions of higher reward, lessened cost, and trust among respondents. TDM involves five points of contact that are recommended to increase response rate. Accordingly, participants received an initial notification email and were subsequently emailed the survey three days later. Reminders were sent one week, three weeks, and four weeks after the original survey email. As an incentive, participants were mailed a $5.00 Starbucks gift card after completion of the survey.

Participants

We sent emails to a total of 428 alumni who had taken our course during the 2013 and 2014 academic years using university email addresses that were still on file. Of those, 205 opened the email, and 65 responded. As a result, we had a cooperation rate of 32%, which subtracts noncontacts and refusals from the sample of potential respondents (Blair & Blair, 2015). Respondents included teachers who had taught in pre-K (n =3), K-2 (n = 25), 3–5 (n = 26), grades 6–8 (n = 26), and two who had taught in high school (n = 2). Participants included 92% female (n = 57), 55% non-Hispanic white, 19% Hispanic/Latino, 6.6% African American, 6.6% native American and 3.2% Asian.

Program and Context

Alumni graduated from the Mary Lou Fulton Teachers College at ASU. They participated in a course called Sustainability Science for Teachers, which was required for all teachers working toward an elementary education (K-8) degree and teaching certification. An interdisciplinary team consisting of content experts in sustainability, pedagogy, and science and technology studies (STS) as well as instructional and graphic designers worked collaboratively to create the content, using digital storytelling as a

delivery mechanism for use in the online portion of a 15-week hybrid course. The following topics were addressed in order: sustainability, poverty, population, water systems, food systems, fossil fuels, new energy, ecosystem services, production, disposal, and enacting change. The online videos, quizzes, and assignments provided the course content, and in-person classes offered weekly discussion and activities related to each topic.

Measures

Our team, consisting of scientists and educators, created a 21-item survey focused on the teaching practices and contexts of our alumni. The team met to discuss key constructs based on a literature review and discussion of course goals, and the survey was developed in an iterative fashion. The survey consisted of three demographic questions, five questions about teaching experience and school context, two questions about barriers and supports, and five questions regarding teaching practices. Teachers were also probed about the extent to which they incorporated sustainability education into work with students, and whether or not they would have taught about sustainability if they had not taken the SSFT course.

Questions used a 4-point Likert scale ranging from "not at all" (1) to "to a great extent" (4). Several questions included space for an open-ended response. Wording for demographic measures was informed by the School and Staffing Survey (National Center for Education Statistics, 2011), while six questions on perceived relevance of education for sustainability were adapted from a survey developed by (Tomas, Girgenti, & Jackson, 2015). A few questions allowed for open-ended responses.

To establish an adequate level of content validity through expert review, several team members with extensive content and methodological knowledge reviewed the early draft and edited for clarity. After multiple rounds of revision, instrument items were verified to be complete, relevant, and arranged in an appropriate format (Creswell, 2003). In addition, we utilized a "think aloud" approach to help ensure content validity. This involved a prospective participant explaining what she was thinking as she went through each question of the instrument to ensure that the questions were easy to understand, arranged in a logical sequence, and were being interpreted as intended (Creswell, 2003).

Next, the survey was piloted on a randomly selected sample of alumni from the first semester that the course was offered (fall, 2012). We then administered the survey to alumni with ASU email addresses that were provided by the alumni association using Dillman's TDM (Dillman, 2011). It should be noted that this was a non-random, purposeful sample (Patton, 1990) used to gather as many responses as possible.

Limitations

As with all methodological approaches, there are inherent limitations to using a web-based survey. Because it relies heavily on self-report data, we are unable to verify the precision of the responses. In addition, many potential respondents who were emailed did not open or respond to the survey. Verifying the viability of the email address for our study was not possible, and therefore we recognize that many of the emails that were sent to participates were simply never received. The results reported here are from the alumni described who received the email, opened the email, and chose to participate in the survey.

Analytic Approach

Data were downloaded into an SPSS file, and descriptive statistics (means and standard deviations) and frequencies were calculated. Open-ended responses are also summarized by construct. Six respondents were not included in our final analyses because either they did not fully complete the survey or did not teach at the K-8 level. Results are reported in the following section.

Results

Eighty-two percent of teachers reported incorporating sustainability education into their teaching at least in small ways, which they noted was more than they otherwise would have done without taking the course. Teachers reported modeling classroom behaviors focused on sustainability to a greater extent than explicitly teaching sustainability concepts (e.g., modeled turning off the lights and computers to save electricity, how to recycle at school, how to reuse supplies, etc.).

Table 1 reports percentages of teachers in each category. One teacher said, "I model what I expect my students to do (i.e., recycle, turn off water when not using it, reuse "trash" for art projects, etc.)". Another said, "Having a personal interest in the concept helps the students see someone who cares about these things, and they often follow what they see!"

Table 1

Extent of Teaching about Sustainability and Modeling Sustainable Behaviors

	Not at all	A little	To some extent	To a great extent
Extent of teaching about sustainability currently	19% (11)	46% (27)	29% (17)	7% (4)
Extent of teaching about sustainability if you had not taken the course	53% (31)	37% (22)	9% (5)	2% (1)
Extent of modeling behaviors focused on sustainability	5% (3)	24% (14)	38% (22)	33% (19)

Teachers described which sustainability topics were being taught the most in their classrooms, and *how* they were teaching about each topic. Responses are summarized in table 2.

More than half of the educators reported teaching at least one lesson about each of these topics (in order of prevalence): water systems, ecosystem services, populations, poverty, food systems, disposal (e.g., landfills, recycling, etc.) and renewable and nonrenewable resources. Production (how products are made/produced) was taught less frequently with 17% (N = 21) reporting teaching about this topic. The most commonly reported pedagogical practices were showing a video and reading aloud a book related to a topic. Student projects and research were also reported by some teachers, especially on the topics of water systems, ecosystem services, and energy sources.

Table 2
Sustainability Topics and Teaching Strategies Reported by Teachers

Topics	Pedagogical Practices						Duration of Instruction	
	Read aloud	Video	Guest speaker	Field trip	Students conducted research	Students completed projects	Taught a lesson	Taught a unit
Population	13	19	0	6	6	8	21	5
Poverty	15	18	1	0	2	4	14	2
Food Systems	17	17	0	3	4	7	21	8
Water Systems	20	25	6	4	8	13	22	11
Ecosystem Services	18	20	1	5	9	10	19	10
Energy Sources	18	22	0	3	12	10	20	13
Production	12	9	0	0	4	5	11	4
Disposal	17	22	2	4	5	8	19	5

Note: n= 50 teachers who responded to this question

Table 3 summarizes the extent to which responding teachers explicitly taught each of the four ways of thinking into their curriculum. The most common response for all four ways of thinking was "a little." In order of frequency, teachers taught most about values thinking, followed by future thinking, strategic thinking, and systems thinking.

Table 3
Teaching about Ways of Thinking

Way of thinking	Not at all	A little	To some extent	To a great extent
Futures thinking	22% (13)	39% (23)	20% (20)	15% (9)
Values thinking	20% (12)	39% (23)	25% (15)	12% (7)
Strategic thinking	29% (17)	34% (20)	24% (14)	10% (6)
Systems thinking	34% (20)	42% (25)	14% (3)	7% (4)

Perceived Relevance of Sustainability Education

Table 4 shows teachers' perceptions about how relevant sustainability education is in their current school setting.

Table 4
Perceived Relevance of Sustainability Education

Question	M	SD
Teachers can play an important role in solving sustainability challenges.	2.98	.82
It is important to include sustainability education in my classroom practice.	2.98	.84
It is important to teach sustainability education to students from an early age.	3.14	.82
Sustainability education is a fad that will pass in time (reversed).	3.34	.69
It is important to include sustainability education in pre-service teacher education programs.	2.80	.92
The inclusion of sustainability education in my teacher education program increased my ability to teach students about sustainability.	2.78	.93

Note: n = 59, Scale: 1 = strongly disagree, 2 = disagree, 3 = agree, 4= strongly agree

Teachers felt strongly that sustainability education is not a fad that would pass in time, and that sustainability education was important to address, beginning at an early age. Seventy-four percent of teachers agreed or strongly agreed that sustainability was an important part of a pre-service teacher program. A few teachers wrote about the perceived relevance. One said, "I do believe sustainability is an important topic that is often put on the back burner and ignored." A different teacher highlighted the relevance of the course, saying it was "very helpful in teaching us how to get our students to think outside of themselves and how our actions affect others." Another teacher had a different opinion, stating: "The sustainability class was a waste of time. My school doesn't even recycle."

Supports and Barriers to Sustainability Education

Teachers found a variety of resources helpful in their efforts to teach about sustainability topics and themes. Table 5 summarizes the number of teachers who reported different supports such as related school-wide initiatives, curricular resources, colleagues with similar interests, instructional materials for students, and supportive administrators.

Table 5
Supports for Teaching about Sustainability

Support	%	n
Related school-wide initiatives (e.g. schoolyard garden, recycling)	49	29
Curricular resources	31	18
Colleagues with related interests	29	17
Instructional materials for students, such as trade books	29	17
Supportive administration	25	15
Community resources and supports (e.g. local agencies, guest speakers)	9	15
Families and parents with related interests	9	15
Professional development opportunities	8	14
No supports	25	15

Barriers reported most often by teachers were lack of time in teaching schedule, lack of alignment with the curriculum at a current grade level, a school-wide focus on other areas, and lack of planning time. One teacher reported "With such a scripted curriculum, I have felt very limited about being able to teach anything outside of the script." Similarly, another teacher said "I love the subject, but am not encouraged by my school to teach it".

Seven teachers reported additional barriers. These and other barriers, reported in Table 6, may be useful to include in future research, and include: being a reading specialist and not having any leveled sustainability books for kids to read; focus on math and not being allowed to deviate from curriculum; students who are low level learners and do not understand; self-contained classroom of students with autism working on functional skills; students' inability to understand (sustainability concepts), and no recycling at the school. One teacher said, "I would love to teach sustainability, but I do not have resources that would be successful in a self-contained autism classroom." Similarly, another special education resource teacher said, "I try to incorporate as many outside concepts with their IEP goals but it can be difficult because sustainability topics can be higher level thinking."

Table 6

Barriers that Limit Teacher Capacity for Teaching about Sustainability

Perceived barrier	%	n
Lack of time in my teaching schedule	74.6	44
Lack of alignment with the curriculum in my current grade level	57.6	34
School-wide focus in other areas	47.5	28
Lack of planning time	39	23
Lack of support from administration	16.9	10
Lack of support from colleagues	15.3	9
Lack of personal interest in sustainability	6.8	4
Lack of public interest in sustainability	6.8	4
Lack of support from parents	5.1	3
Discomfort teaching about controversial issues	5.1	3
No barriers	5.1	3

Discussion

The Bonn Declaration called for teacher education programs around the world to integrate sustainability education into their curriculum (UNESCO, 2009). However, education for and about sustainability is still not a typical practice in most teacher education programs or schools in the United States (McKeown et al., 2013). We extend prior work by reporting how teachers are integrating sustainability concepts and ways of thinking into their classrooms in the years following participation in a required course.

Most alumni in our study believed in the importance of teaching about sustainability and were finding ways to include sustainability topics and ways of thinking into their curriculum. We were particularly encouraged that many educators were introducing or using the ways of thinking to help develop students' critical thinking skills that will be needed to solve complex problems. Our instructional team has begun work on embedding ways of thinking more explicitly throughout the semester, so that students are even more motivated and prepared to incorporate them more frequently into their own teaching across subjects. However, novice teachers face many challenges in their classrooms as they begin their careers. A college course on sustainability science is an entry point for teachers, but it is clear that it is not sufficient in developing teacher leaders who can teach complex critical thinking skills addressing interdisciplinary problems and lead sustainability initiatives.

Teachers expressed a range of views about the relevance of sustainability education. The relevance scores reported here were lower than scores reported for pre-service teachers by Tomas and others (2015). This is likely due to two factors: a different context (e.g., more momentum for sustainability education in Australian schools and universities than in American schools), and the difference between beliefs of pre-service and in-service teachers.

Some reported barriers may be unique to implementation in our context, and others were similar to those reported in Australian primary schools (Evans et al., 2012). Time was a key element mentioned by teachers in both contexts. For teachers in our study, a school-wide focus on other areas were mentioned by 48% of teachers. In Arizona (like many states), standardized tests focus primarily on mathematics and English/language

arts, so teachers must prioritize these areas over social studies and science, which are infrequently tested. However, topics such as water and food systems are very relevant to students and can be engaging ways to learn mathematics and language arts when integrated well. The teachers in our study are similar to those described by Smith and Stevenson (2017), where constraints of recent accountability reforms in Australia limited educators' capacity to choose topics of interest to teachers and students.

Implications for Educators

These results are a first step toward understanding the connection between teacher preparation in sustainability education and implementation in K-12 schools. While they are unique to a teacher education program in Arizona, some of the lessons learned may be applicable to other settings.

Pedagogical Practices: Digital Storytelling and Literacy

Pedagogical practices for teaching about sustainability most commonly reported were the use of videos (M = 19 teachers per topic) and read-aloud books (M=16 teachers per topic). Use of videos as the most prevalent mode of teaching was not surprising given that the pre-service teachers completed a hybrid course and reported learning about sustainability topics through videos as an effective strategy (Shelton, Archambault, & Hale, 2017; Shelton, Hale, & Archambault, 2016). We have found that digital stories offer several pedagogical advantages for sustainability education. First, through using relatable videos with international footage, complex sustainability topics can be portrayed in a more accessible way to a novice audience than through technical articles or textbooks. Digital stories can promote learning and retention by conveying information through integrating visuals, graphics, narrative, moving images, and sound in a cohesive whole (Burmark, 2004; Hibbing & Rakin-Erikson, 2003). Also, they may provide students with experiences that go beyond what is possible in real-life (Mar & Oatley, 2008). For example, students could learn about a village in Kenya and how lack of access to clean drinking water negatively impacts Kenyans. Consequently, the content emotionally connects with students which helps to increase topic interest and engagement (LaMarre & Landreville, 2009). Another study found that media strongly influenced undergraduate students' environmental attitudes, concerns and behaviors, and suggested that media literacy is a critical component of sustainability education initiatives (Keinonen et al., 2016).

Video use among our teachers has many implications. First, the quality of videos that are geared toward younger audiences should be considered and enhanced through future funding efforts. Also, teachers should be taught about how to recognize accurate and age-appropriate content as well as how to design activities and questions that get students to reflect on and integrate information from the videos. They may also wish to learn to create similar digital content that is geared toward their own students or even have their students engage in producing their own digital stories (Shelton et al., 2017).

Similarly, current books on sustainability topics for different reading levels are an important tool in education for sustainability. One easy way to support teachers in their efforts to teach about sustainability is to share lists of well-written texts at different levels and focus on pedagogy for integrating sustainability concepts and themes into literacy lessons (Bradbery, 2013).

Implications for Administrators

Consistent with prior work, some teachers in our study noted the importance of supportive administrators (Evans et al., 2012; Kadji-Beltran et al., 2013; Smith & Stevenson, 2017). Preparing school leaders about how and why they should lead and support education for sustainability is also important (Kensler & Uline, 2017). Courses for administrators should include, and even focus on, ways that a principal can lead and support teachers' sustainability education efforts. Also, professional development initiatives related to sustainability should include administrators. Some teachers mentioned the importance of related school-wide initiatives and colleagues with similar interests. Administrators can be instrumental in helping teachers find colleagues to collaborate on projects such as schoolyard gardens, recycling programs, or energy conservation projects.

Implications for Teacher Educators

Early career teachers face many challenges as they strive to integrate best practices, build relationships, and understand the context of their school. Similar to other domains of teacher education, sustainability education is a continuum of practices that begins when college students start work in the field and continues throughout a teacher's career. Many teacher preparation programs in the United States offer course work in environmental education that include some principles related to sustainability, but most of these courses are electives (Heimlich et al., 2004; McKeown-Ice, 2000). More required courses are needed to ensure that all pre-service teachers have background knowledge in this important, interdisciplinary field. The Sustainable Development goals are an important international effort that should be referenced explicitly in the curriculum across subjects, to bring awareness to pressing global issues. As our findings suggest, modeling of environmentally responsible behaviors should be emphasized, since this may be a high-leverage practice that is easier for teachers to implement in their future classrooms.

Several educators mentioned the challenges of teaching about sustainability to students with disabilities. Students with all levels of functional and cognitive skills can engage in learning about how to make the world a more sustainable place, but may need scaffolding to do so. Many special educators requested level texts and differentiated materials for students for lower level readers. Teacher education programs can share examples of sustainability initiatives that were designed for or inclusive of children with disabilities. For example, the experiential aspect of garden-based learning supports all students in learning about life cycles and food production (Rye et al., 2012). Similarly, recycling programs are concrete, direct ways for students with cognitive disabilities to participate in and learn about sustainability initiatives (Clark, 2013).

Building capacities of educators and trainers is one of the priority areas for UNESCO's global action program on education for sustainable development (UNESCO, 2014). As the field expands, we must consider how to support teachers throughout their careers. Models of professional learning in other disciplines, such as lesson study or instructional coaching, can be applied to improving lessons across all disciplines that are focused on sustainability. Ultimately, what is clear from the current study is that a required course focused on sustainability education can have lasting impact on what teachers ultimately

do in their future classrooms. Such courses should be an essential component to preparing globally-minded, sustainability-literate teachers who are charged with educating the next generation to address some of the most significant problems the world has ever faced.

Acknowledgements

References

Abramovich, A., & Loria, Y. (2015). The long-term impact of an education for sustainability course on Israeli science and technology teachers' pro-environment awareness, commitment and behaviour. *Australian Journal of Environmental Education*, *31*(2), 264–279.

Agne, R. M. (2006). Sustainability in Vermont's K-12 standards-based curriculum framework. *International Journal of Environmental, Cultural, Economic,* & *Social Sustainability*, *1*(1), 3–9.

Andersson, K. (2017). Starting the pluralistic tradition of teaching? Effects of education for sustainable development (ESD) on pre-service teachers' views on teaching about sustainable development. *Environmental Education Research*, *23*(3), 436–449.

Atmaca, Ē. (2017). Effects of contextual factors on ESD in teacher education. *Discourse and Communication for Sustainable Education*, *8*(2), 77–93.

Bertschy, F., Künzli, C., & Lehmann, M. (2013). Teachers' competencies for the implementation of educational offers in the field of education for sustainable development. *Sustainability*, *5*(12), 5067–5080.

Blair, E., & Blair, J. (2015). *Applied survey sampling*. Los Angeles, CA: Sage.

Bradbery, D. (2013). Bridges to global citizenship: Ecologically sustainable futures utilising children's literature in teacher education. *Australian Journal of Environmental Education*, *29*(02), 221–237.

Buchanan, L. B., & Crawford, E. O. (2015). Teaching for sustainability in a social studies methods course: Opportunities and challenges. *Social Studies Research and Practice, 10*(2), 135–158.

Burmark, L. (2004). Visual presentations that prompt, flash & transform: Here are some great ways to have more visually interesting class sessions. *Media and Methods*, *40*, 4–5.

Church, W., & Skelton, L. (2010). Sustainability education in K-12 classrooms. *Journal of Sustainability Education*, *1*(0). Retrieved from http://journalofsustainability education.org/ojs/jse/article/viewFile/21/pdf_9

Clark, K. E. (2013). Ecological intelligence and sustainability education in special education. *Multicultural Education, 21*(1), 38.

Common Core State Standards Initiative. (2010). *Common core state standards.* Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

DeHaan, G. (2006). The BLK '21' programme in Germany: a 'Gestaltungskompetenz'–based model for education for sustainable development. *Environmental Education Research, 12*(1), 19–32.

Dillman, D. A. (2011). *Mail and Internet surveys: The tailored design method – 2007 Update with new Internet, visual, and mixed-mode guide*. US: John Wiley & Sons.

Evans, N., Whitehouse, H., & Gooch, M. (2012). Barriers, successes and enabling practices of education for sustainability in far North Queensland schools: A case study. *The Journal of Environmental Education*, *43*(2), 121–138.

Ferreira, J. L., Ryan, L., Davis, J. M., Cavanagh, M., & Thomas, J. (2009) *Mainstreaming sustainability into pre-service teacher education in Australia.* North Ryde, Australia: Australian Research Institute for Education for Sustainability.

Heimlich, J. E., Braus, J., Olivolo, B., McKeown-Ice, R., & Barringer-Smith, L. (2004). Environmental education and preservice teacher preparation: A national study. *The Journal of Environmental Education*, *35*(2), 17–60.

Hibbing, A. N., & Rakin-Erikson, J. L. (2003). A picture is worth a thousand words: using visual images to improve comprehension in middle school struggling readers. *The Reading Teacher*, *56*(8), 758–770.

Higgs, A. L., & McMillan, V. M. (2006). Teaching through modeling: Four schools' experiences in sustainability education. *The Journal of Environmental Education*, *38*(1), 39–53.

Kadji-Beltran, C., Zachariou, A., & Stevenson, R. B. (2013). Leading sustainable schools: Exploring the role of primary school principals. *Environmental Education Research*, *19*(3), 303–323.

Keinonen, T., Palmberg, I., Kukkonen, J., Yli-Panula, E., Persson, C., & Vilkonis, R. (2016). Higher education students' perceptions of environmental issues and media coverage. *Discourse and Communication for Sustainable Education*, *7*(1), 5–22.

Kennelly, J., Taylor, N., & Maxwell, T. W. (2008). Addressing the challenge of preparing Australian pre-service primary teachers in environmental education: An evaluation of a dedicated unit. *Journal of Education for Sustainable Development*, *2*(2), 141–156.

Kensler, L. A. W., & Uline, Cynthia L. (2017). *Leadership for green schools: Sustainability for our communities, and our planet*. Routledge: New York.

LaMarre, H. L., & Landreville, K. D. (2009). When is fiction as good as fact? Comparing the influence of documentary and historical reenactment films on engagement, affect, issue interest, and learning. *Mass Communication and Society*, *12*, 537–555.

Mahoney, J. (2000). Path dependence in historical sociology. *Theory and Society, 29*(4), 507–548.

Mar, R. A., & Oatley, K. (2008). The function of fiction is the abstraction and simulation of social experience. *Perspectives on Psychological Science, 3*(3), 173–192. doi: 10.1111/j.1745-6924.2008.00073.x.

Maryland Department of Education. (2011). *Maryland Environmental Literacy Standards*. Retrieved from http://marylandpublicschools.org/programs/Documents/Environmental/MDEnvironmentalLitStandards.pdf

McKeown, R. (2002). *Education for sustainable development toolkit*. Knoxville, TN: Energy, Environment and Resources Center, University of Tennessee.

McKeown-Ice, R. (2000). Environmental education in the United States: A survey of preservice teacher education programs. *The Journal of Environmental Education*, *32*(1), 4–11.

McKeown, R., & Nolet, V. (2013). Education for sustainable development in Canada and the United States. In R. McKeown & V. Nolet (Eds.), Schooling for sustainable development in Canada and the United States (pp. 3–21). Dordrecht, The Netherlands: Springer.

McKeown, R., & USTESD Network. (2013). *Reorienting teacher education to address sustainability: The U.S. context*. White Paper Series, No. 1. Indianapolis, IN: United States Teacher Education for Sustainable Development Network.

National Center for Education Statistics. (2011). Teacher questionnaire: Schools and staffing survey. Retrieved from: https://nces.ed.gov/surveys/sass/pdf/1112/SASS4A.pdf

National Council for the Social Studies. (2013). *College, career, and civic life (C3) framework for social studies state standards*. Silver Spring, MD: NCSS.

NGSS Lead States (2013). *Next generation science standards: for states, by states*. Washington, DC: The National Academies Press.

Nolet, V. (2009). Preparing sustainability-literate teachers. *Teachers College Record*, *111*(2), 409–442.

Nolet, V. (2015). *Educating for sustainability: Principles and practices for teachers*. UK: Routledge.

OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education*. Paris, France: OECD Publishing. http://dx.doi.org/10.1787/9789264266490-en

Orr, D. W. (2004). *Earth in mind: On education, environment, and the human prospect*. Washington: Island Press.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge, MA: Cambridge University Press.

Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage Publications, Inc.

Professional Educators Standards Board. (2011). *Standard 5- knowledge and skills*. Retrieved July 5, 2017 from http://program.pesb.wa.gov/standards/standard-5/teacher

Regan, K., & Berkeley, S. (2011). Effective reading and writing instruction: A focus on modeling. *Intervention in School and Clinic, 47*(5), 276–282. doi: 10.1177/1053451211430117

Rittel, H.W.J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(2), 155–169. doi: 10.1007/BF01405730

Rye, J. A., Selmer, S. J., Pennington, S., Vanhorn, L., Fox, S., & Kane, S. (2012). Elementary school garden programs enhance science education for all learners. *Teaching Exceptional Children*, *44*(6), 58–65.

Santone, S., Saunders, S., & Seguin, C. (2014). Essential elements of sustainability in teacher education. *Journal of Sustainability Education, 6*. Retrieved from

http://www.jsedimensions.org/wordpress/wp-content/uploads/2014/05/Santone-Et-Al-JSE-May-2014-PDF-Ready.pdf

Shelton, C., Archambault, L., & Hale, A. (2017). Bringing digital storytelling to the elementary classroom: Video production for pre-service teachers. *Journal of Digital Learning in Teacher Education, 33*(2), 58–68.

Shelton, C., Warren, A., & Archambault, L. (2016). Exploring the use of interactive digital storytelling video: promoting student engagement in a university hybrid course. *TechTrends.* Advanced online publication. *TechTrends*, *60*(5), 465–474.

Smith, G. A., & B. Stevenson, R. (2017). Sustaining education for sustainability in turbulent times. *The Journal of Environmental Education*, *48*(2), 79–95.

Spiropoulou, D., Antonakaki, T., Kontaxaki, S., & Bouras, S. (2007). Primary teachers' literacy and attitudes on education for sustainable development. *Journal of Science Education and Technology*, *16*(5), 443–450.

Stibbe, A., & Luna, H. (2009). Introduction. In A. Stibbe & H. Luna (Eds.), *The handbook of sustainability literacy: Skills for a changing world* (pp. 9–16). Cornwall, UK: Greek Books Ltd.

Tilbury, D. (2011). *Education for sustainable development: An expert review of processes and learning.* Paris, France: UNESCO.

Tomas, L., Girgenti, S., & Jackson, C. (2015). Pre-service teachers' attitudes toward education for sustainability and its relevance to their learning: implications for pedagogical practice. *Environmental Education Research*, 1–24.

UNESCO. (2005). *United Nations decade of education for sustainable development 2005–2014.* International Implementation Scheme. Retrieved from http://unesdoc.unesco.org/images/0014/001486/148654e.pdf

UNESCO. (2009). *Bonn declaration.* Bonn, Germany: UNESCO World Conference on Education for Sustainable Development.

UNESCO. (2014). *UNESCO global action programme on education for sustainable development, goals and objectives*. Retrieved from http://en.unesco.org/gap/goals-and-objectives

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. *New York: United Nations, Department of Economic and Social Affairs*.

U.S. Partnership for Education for Sustainable Development. (2009). National education for sustainability K-12 student learning standards. Version 3. Downloaded from https://s3.amazonaws.com/usp_site_uploads/resources/123/USP_EFS_standards_V3_10_09.pdf

Vincent, S., Bunn, S., & Stevens, S. (2012). *Interdisciplinary environmental and sustainability education: Results from the 2012 census of U.S. four year colleges and universities*. Washington DC: National Council for Science and the Environment.

Warren, A., Archambault, L., & Foley, R. W. (2014). Sustainability education framework for teachers: Developing sustainability literacy through futures, values, systems, and strategic thinking. *Journal of Sustainability Education, 6.*

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science*, *6*(2), 203–218.

World Commission on Environment and Development (WCED). (1987). *Our common future*. Oxford, England: Oxford University Press.

Yavetz, B., Goldman, D., & Peer, S. (2009). Environmental literacy of pre-service teachers in Israel: A comparison between students at the onset and end of their studies. *Environmental Education Research*, *15*(4), 393–415.

Correspondence concerning this paper should be addressed to Dr. Eileen G. Merritt, Assistant Professor, Sustainability Science Education, Mary Lou Fulton Teachers College, Arizona State University. Email: eileen.merritt@asu.edu