Service-Learning: A Vehicle for Inquiry Teaching and Learning

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Abstract

A service learning model was used in a science methods course for elementary teachers as the context for integrating key pedagogical strategies necessary to attain current national and state standards. This innovation provided a real-world problem-solving experience and introduced learners to service-learning through personally relevant environmental issues. Designed as an inquiry, this experiential course, engaged learners in "doing science" and constructing knowledge of science, technology, and societal interaction content on a need to know basis. The intervention taught future teachers to engage their communities in addressing local issues. It also mitigated preservice teachers' science anxiety and enabled preservice teachers to understand and appreciate current national and state standards. Included are the methods course structure, the model used for service-learning, an extensive scenario illustrating classroom interactive inquiry strategies, and excerpts from students' journals revealing attitudinal changes during the course.

This is an innovation in action report derived from an evaluation focusing on how prospective teachers learned to enact service-learning in their future classrooms. A partner created a format for a service-learning project requiring learners research local environmental issues that was implemented in a science methods course for preservice elementary teachers. The instructor integrated key pedagogical strategies within this context to illustrate open-ended extended inquiry fundamental to authentic learning.

Literature Review

Engaged Scholarship and Service-Learning

In 1990, Ernest Boyer, president of the Carnegie Academy for the Advancement of Teaching and Learning, began publishing his perceptions of the need to broaden the definition of scholarship in higher education (the academy). He introduced the concept of engaged scholarship and Barker (2004) described it this way:

> The scholarship of engagement, … consists of (1) research, teaching, integration, and application scholarship that (2) incorporate reciprocal practices of civic engagement into the production of knowledge. It tends to be used inclusively to describe a host of practices cutting across disciplinary boundaries and teaching, research, and outreach functions in which scholars communicate to and work both for and with communities. … The

> scholarship of engagement suggests a set of practices that cuts across all aspects of the traditional functions of higher education (p. 124).

Service-learning is a dominant form of engaged scholarship in K-16. There are many descriptions and definitions of service-learning in the literature. All have in common the idea that service-learning is a teaching strategy that addresses core curriculum objectives while meeting real community needs (Alliance for Service-learning and Educational Reform, 1995). Further, The National Youth Leadership Council (2008) published standards for high quality service-learning. Among their key standards are the focus on youth voice (student-centered learning), meaningful service, extended duration and intensity, and progress monitoring.

Universities now recognize the benefits of service learning as a response to cries for increased educational accountability to show the community in which they reside they are place based institutions cognizant of their role in and responsibility toward their immediate communities. Some universities are striving for AAU standing. This designation requires engaged scholarship as a criterium for membership.

In addition, it is recognized that "service learning considers the needs of adult learners and uses the appropriate method and resources to facilitate meaningful learning and discovery" (Kleinhesselink, et al. 2015 pg. 2) through the following practices:

- Reforming the role of the teacher or instructor as a facilitator of knowledge rather than a controller of knowledge.
- Ensuring that learning by doing is at the center of discovery.
- Engaging the learner in ongoing critical reflection on what is being experienced for effective learning.
- Ensuring that learners help to direct and shape the learning experiences.
- Ensuring that new knowledge, concepts, and skills are linked in meaningful ways to the learner's personal experiences. (Kleinhesselink, et al. 2015, p.2)

These engaged scholarship practices are also inherent in the current reform movement in science education, which engenders a paradigm shift. The shift is from a didactic, mechanistic, reductionist approach to learning and teaching to a holistic, constructivist, inquiry and practice- based approach, referred to as the STS, STEM, or STEAM movement. Thus, service learning provides a vehicle for the desired state of science teaching through a holistic approach that includes inquiry.

Inquiry in Science Education

The holistic paradigm's roots are in the science, technology and society (STS) reform movement that began as grass roots initiatives for school science change in varied parts of the country simultaneously during 1979 and the1980s and continue to influence current science education reform initiatives (Spector, et. al., 2003). STS defined as "The teaching and learning of science and technology in the context of human experience" (NSTA, 2008-2009) fits perfectly with service learning and its objectives. Attachment A contrasts aspects of traditional science education in the didactic paradigm with science education in the holistic paradigm.

Inquiry has been and still is central to science education reform. The National Research Council's 2000 publication, Inquiry and the National Science Education Standards: A Guide for Teaching and Learning, identified five essential features of inquiry:
"1. Learners engage in scientifically oriented questions. 2. Learners give priority to evidence in responding to questions. 3. Learners formulate explanations from evidence. 4. Learners connect explanations to scientific knowledge. 5. Learners communicate and justify explanations" (p. 29).

> These essential features cannot be brought about simply by students reading textbooks or watching or listening, respectively, to teachers' demonstrations and lectures. … Science is a way of thinking, a culturally derived method for systematically and efficiently exercising genetically based curiosity of human beings (Spector & Strong, 2001). Science in schools is, however, rarely based on students' curiosities and interests, even though they are central to the actual practice of scientists (Spector & Yager, 2010 p. 279).

The innovation described herein engaged students in inquiry based on preservice teachers' curiosities and interests. It required preservice teachers to change from a didactic paradigm to the holistic paradigm.

> Change … involves threats to an individual's sense of competence (as new techniques are unfamiliar and untested); sense of control (as the outcomes and reactions of the students are uncertain); sense of confidence (as there is no base of previous experience on which to rely; and sense of comfort (as the emotions associated with these prior concepts are unsettling) (Osborne, 2011 p. 23).

In spite of these perils of change, once preservice teachers of science in elementary school experience features of STS for science learning in a methods course, there is potential to mitigate the science anxiety derived from their past learning experiences. The holistic paradigm empowers learners as citizens to realize they have the power to make changes in society and the responsibility to do so.

Science Anxiety

A perennial problem in methods courses for teachers in elementary schools is the science anxiety common to these students (Blosser,1984; Epstein & Miller, 2011; Finson, 2001; Gunning & Mensah, 2011; Koch,1993; Mallow,1986; Orlich,1980; Westerbeck, 2006; Yeotis,1998) and these students' perceptions that science is inaccessible and unattainable. They usually perceive science as a collection of rote facts to be memorized that they do not understand and that have no relevance to what matters to them. This is related to them having been taught science "starting with basic science concepts and process skills used by science professionals with the promise they will be useful to the learners in the future" (Spector & Yager, p. 305), never having been taught science, or having been taught science as a "reading about" subject. A variety of approaches have been tested over the years to alter these perceptions. However, with changes in society and new pressures on universities, the need to invent new approaches continues.

The Innovation

For this innovation, we used the definition and process for service-learning developed by a national service-learning organization titled, Earth Force. This is a 501(C) (3) organization begun in 1994 and is based in Denver, Colorado. Its mission is teaching educators across the U.S. to engage "young people as active citizens who improve the environment and their communities now and in the future." (Earth Force, 2018). Their vision statement is, "We envision a nation where young people from all walks of life are actively making positive change to the environment at their schools, in their neighborhoods, and in partnership with their communities" (Earth Force, 2010) (see Appendix B for a snapshot of Earth Force).

This organization developed a six-step process labeled, A Community Action and Problem Solving (CAPS) service-learning process (refer to earthforcresources.org for details). Although the steps have distinguishable characteristics, they are overlapping and iterative. The process is student-centered. Youth voice is emphasized throughout. The "launch" starts the process, followed by the six steps labeled this way: Step 1-Checking it out-community environmental inventory; Step 2-Choosing one-issue selection; Step 3-Discovery-policy and community practice research; Step 4-Deciding what to do-goal and strategy selection; Step 5-Getting it done-planning and taking civic action; Step 6-Wrapping up-reflecting, going public and planning for the future. A teacher's approach to these steps determines where this experience lies on a continuum from a teacher-centered experience to a student-centered experience. Student-centered implementation of these steps in our methods course illustrated the features of inquiry described by the NRC in 2000.

Since we believe experiential learning is essential for students to construct meaning, our preservice students were guided through the CAPS process. They went from developing interest in the launch to planning systematic reflection and assessment strategies. Learners also designed how they would integrate service-learning in their future classes while being accountable to national or state standards. This was followed by small group projects that were designed and developed, but not implemented, because of time limitations. Instead, the groups posted their detailed plans on the class website and did creative presentations to their classmates illustrating their projects. The class audience asked questions to ensure each person in the audience had enough information to develop confidence to enact the plan presented. Class members also evaluated each other's presentations using the Earth Force evaluation rubric (see earthforceresources.org).

Students thus designed action plans, including details of how they would construct an Earth Force project from beginning to end, as a culminating activity for the methods course. Students left the course with six fully detailed plans for environmental service-learning, one from each working group. These plans serve as a frame of reference that encourages them to think creatively as they facilitate their own students through the CAPS process.

The Science Methods Course

*The audience***.** The class consisted of twenty-six students, twenty-five females and one male. Their ages ranged from nineteen to twenty-six, with the majority around 20. The propensities of students in this class were typical of those found in other sections of this course in the past. They were accustomed to being explicitly told what they had to know by the textbook and the instructor, memorizing it, and dutifully regurgitating it on a test. They were not accustomed to having to generate questions, explore ideas, or engage in reflection and metacognition. They anticipated class time would be spent doing typical individual cook-book laboratory activities with known outcomes, such as magic powders, oobleck, making volcanoes, etc. Their expectations did not include connecting science to the real world or experiencing a learning opportunity in the formal setting of a college class that required them to gather data from an experience, analyze it, and construct their own meaning (do inquiry).

*Course description***.** The course was described in the syllabus as an inquiry into the question, “What is science teaching in the elementary school consistent with national and state standards?” Students were expected to gather data to construct answers to that focus question from three complimentary strands of activities running simultaneously throughout the first nine weeks of the course: The strands were (a) the textbook (at home), (b) assessment and evaluation experiences (in class), and (c) the Earth Force CAPS Process (in class). Students were assigned to complete the hands-on activities in the textbook, write about those at-home experiences, and integrate them with in-class experiences in weekly journals. Our intent was to facilitate students’ experience with the CAPS service-learning process during class meetings, and students would analyze the CAPS experience using the instructional strategies described in their assigned readings in the textbook as their frame for analysis. The class met fifteen times, once per week for three hours. Field experiences were a separate part of the elementary teacher education program.

*Earth Force process implementation***.**
The service-learning portion of the class was taught by an Earth Force staff member who was completing a Ph.D. in science education. This portion of the class used 24 out of the 45 contact hours during which he deliberately modeled inquiry strategies. This modeling provided opportunities for learners to experience student-centered open-ended inquiry while using the CAPS format. This portion of the class began during the second class session. The first session consisted of housekeeping, such as reviewing the course syllabus, textbook, grading and grading procedures through traditional means, followed by an introduction to the paradigm shift using a video.

During the second session students engaged in teambuilding activities followed by an introduction to service-learning through a video illustrating middle school students completing a project using the six steps of the Earth Force process (CAPS). The written description of CAPS on the course website was assigned for reading as an advanced organizer, even though our expectations based on past courses were that students would not read it carefully, or not at all.

The CAPS launch session began in the week three class meeting, with the instructor using various questioning strategies to elicit learners' prior knowledge about the concepts of community, environment, issue, service-learning, and youth-voice. The instructor used a Socratic style to engage students. He tended to answer a question with a question as a way to guide students. He usually began with a broad question followed by focused questions. The discussion pattern he would use throughout the project became evident: ask a broad question, listen to responses and thinking illustrated, ask for evidence or explanations, and ask for alternative opinions or ideas.

Student generated definitions for community reflected a variety of parameters apparent in the social sciences: Community may be delineated by a geographic area, similar attitudes or interests of participants, religious identification, a place, an institution, or other shared characteristics.

Students worked together as a large group in order to learn to do the CAPS process. For convenience, the class agreed to use the geographic delineator of the University campus and its immediate surrounding as its sample community to illustrate the CAPS process. Four major roads border the campus. If an area to be explored did not touch at least one of the four identified roads creating the campus perimeter, that area was out of bounds.

Additionally, students generated these definitions: Environment included features of the natural or built surroundings as well as the humans affecting each other and the setting. An issue encompassed a situation requiring resolution of conflicting multiple perspectives with potential to effect humans. It could include mitigating a weakness or enhancing a strength. The instructor noted a few issues typically identified by youngsters in local schools: removal of strewn trash, recycling, global warming, availability of water resources, and protection of wildlife. Service-learning was defined as the CAPS six-step process. Youth voice was defined as student-centered or directed learning in contrast to teacher-centered or directed learning.

Step 1. Community environmental inventory. A question was raised about limitations on the nature of issues students should include in their community inventory. The professor shared the following observations about issues relative to teaching science:

> An inventory of environmental issues in any community is going to require understanding science concepts and technological principles engendered in the issues, because we live in a science and technology driven society. This knowledge is required to understand multiple dimensions of a problem and to design a solution to mitigate the problem. As learners engage in CAPS, they will identify science and technology needed to understand the problem, how it came to be, and how one might resolve it. They will learn science and technology content on a need to know basis in a context of real-world events and issues.

At this point in the CAPS process, an outside expert, such as a scientist or engineer, would be invited to class to lead the inventory process. Logistics and time constraints made bringing in outside experts not a viable option. Instead, the Earth

Force instructor, a marine and environmental scientist by training, put on the hat from his former job as a researcher and fulfilled the role of the outside expert. He served as a catalyst for learner identification of issues. He asked students, “What do you see?” and pointed to things they might have missed. For example, what is the problem with that big tree growing up through the storm drain? What was the drain originally designed to do? Is it being used properly or not? Does it distribute water to other points?

The community inventory process began with a brainstorming session ascertaining students’ prior knowledge of issues around the campus. Use of a map as a tool for a community inventory was introduced by viewing the campus projected via Google Earth. Students explored the campus structures and natural areas nearby to identify strengths and weaknesses visible on the screen. The view encompassed about a ten-mile radius from the classroom building. The place where a cougar was killed by a car was identified. This led to a discussion of endangered species and their use of green corridors as travel pathways near campus, as well as the ecological roles of other visible green spaces. Learners discussed additional animals using the green corridors and the biodiversity, or lack thereof, because of human encroachment with a large planned residential community beginning less than a mile from campus.

The significance of the wetland community in this green space encompassed discussion of flooding issues in this hydrologic area and the need to preserve several Native American burial mounds on the site. Another green space discussed was the University’s golf course, a monoculture of grass which serves as a wildlife preserve but could negatively impact the pristine wetlands to the east of it, because of the considerable chemicals and fertilizer required to maintain the golf course. The sports fields visible on Google Earth revealed the lack of biological diversity around them and the absence of plants or trees for shelter, shade, or habitat for animals. Further, there was discussion about the disparity between the women’s and men’s sports fields.

The concept of green engineering emerged while counting the number of buildings with flat, black roofs showing mold growth. Discussions ensued about energy, permeability of surfaces, and surfaces that hold heat and or water, and serve as a substrate for molds. The black roofs were compared to the sports arena, with its white, reflective, rounded roof, no mold, and tendency to be cooler than the others. A spontaneous solution to the flat roofs surfaced with the potential to create a roof top garden using native plants. The problems caused by the exotic plants on campus and in the residential community stimulated a spirited discussion. Waste water and storm water became topics of interest as students learned the history of a lake near the chemistry department. The drains from this old building used to dump toxic waste into the lake. Storm water run-off from the multitude of parking areas with black-top surfaces was noted and led to discussion of roadway traffic patterns used by people to get on and off campus. The subsequent congestion added another dimension to the energy discussion. The extensiveness of the medical research complex on campus was vivid on the map and prompted conversations about potential projects on cancer.

For the next part of the community inventory, the class took a mini-field trip walking around campus together for an hour to ground truth ideas noted through Google

Earth. Everyone looked for evidence of environmental problems and gathered related information. As the issues were identified, related science and technology were noted.

Energy issues loomed up quickly as learners examined the large expanse of glass enclosing a stairwell on the outside of the building. It was not sealed properly, and cold air was escaping from the building. The glass served as a heat sink, raising temperature in the stairwell. An air conditioner was prominent on the upper floor of the stairwell. This was essential for safety to ensure no one passed out from the heat during the warmer months. A cost-benefit analysis ensued balancing the benefit of having natural lighting in the large stairwell, which reduced energy costs, with the need for the air conditioner to moderate the temperature. The building's large open space design and high ceiling prompted another cost-benefit discussion about the amount of energy consumed to cool or heat the space compared to a more classic room design. Further, the concept of noise pollution was introduced, because the sound traveled easily from one floor to another.

Students noticed the drink machines dispensed only plastic containers while the only recycling bins available were for aluminum cans. They also noted the concrete walkway was eroding from water draining out of the gutter coming off the building. It could have been draining onto the grass along the side of the walkway to be absorbed by the soil. Metal lamps with sections for cigarette disposal lined the walks around the building, including the front door. A smoldering cigarette in one lamp was blowing smoke into the building when the automatic doors opened. The branches at the crown of the laurel oak trees along the side of the building were at the height of windows in the classrooms. Students raised questions about the potential for these trees to break the windows during one of the many normal Florida storms. They learned this tree species has a short life span, about 40 years. In a decade or so these trees will die and represent a significant hazard to those classrooms.

Back in the classroom for debriefing, the science and technology present in each area of concern listed were further explored. We started with discussion of students' prior knowledge. The "visiting expert" was asked to expand on specific topics about which students expressed a need to know in order to generate potential solutions.

The professor explained: In a class with more time allocated to service-learning initiatives, students would invite several experts to come to speak to them about more science concepts inherent in various issues identified, thus elaborating on many of the problems students identified as potentials for their service-learning projects.

Step 2. Issue selection. Class week four began with students reflecting on the list of issues generated in the previous session. The obvious question surfaced, "How should we reduce the large number of issues to one for the class to further address in the service-learning process?"

The instructor used this opportunity to introduce criteria-based decision-making. Students asked, "What should we use for criteria?" Rather than providing students with a list of criteria, the instructor, still wearing his scientist expert hat, engaged students in an activity to help them experience generating meaningful criteria to make an informed decision.

For this activity, he introduced the concepts of climate change and global warming. These issues had not surfaced in class but were part of pop culture from public media discussions. They provided a context to approach these students' prior knowledge for this experience in criteria-based decision-making.

The students were asked if they were familiar with the concept of global climate change. Very few responded affirmatively. They were then asked if they were familiar with global warming. All hands went up. Students were asked if they knew about or had seen the movie, An Inconvenient Truth. Most had. From this platform, a discussion was launched on what the students perceived global warming to be and the negatives that would occur from it. As anticipated, the students described their expectations of the world with global warming through the narrow doomsday lens of the movie. They described the extinction of "cute and cuddly" polar bears left floating on ever-shrinking ice floes with no food or place to go, and images of ocean (sea level) rise depicting destruction of Florida and most of the Eastern Seaboard.

Students were then asked how they formed their opinions about global warming and what evidence they used. The response for many was the information gleaned from An Inconvenient Truth and Al Gore. The class viewed him as an expert on global warming. One student pointed out, "You can't help but watch the news and hear how humanity had created global warming, and we are now doomed to fix it or perish". The discussion continued, and the students were charged up about the need to do something.

At this point, the "expert" began playing devil's advocate. He asked questions to disequilibrate the students and their understanding of what global warming was and who genuinely were the experts. A collection of information was presented to make students question the validity of their preconceptions. This included popular myths about Al Gore, misspoken statements credited to him, and other information garnered from the internet: It was pointed out that Al Gore himself had significant investments in the oil industry and had made a large amount of money producing the product he was stating was the root of the global warming crisis. A news article was referenced from the Tennessee Policy Research Center (2007) that was run in print by the Associated Press stating the Gore household in Tennessee consumed twenty times the amount of energy as that of the average American home. The students were then asked if they knew that Al Gore was the "Father of the Internet?" With these "news" sources as new evidence competing for the students' mental frameworks, they became confused and irritated. They believed they had been giving priority to evidence in responding to the questions about global warming and thought they had been formulating reasoned explanations from the evidence. The contradictory evidence was difficult for them to process.

The "expert" then talked about the controversy of global climate change in the scientific community and its ongoing debate. He pointed to a "leak" of emails painting a lot of the proponents of climate change as having doubts to the validity of their own data. They themselves weren't sure about the thing they were promoting. Again, the students did not know what to believe.

This cognitive dissonance provided opportunity to focus learners' attention on criteria-based decision-making. What criteria were students going to use to make decisions to accept or reject global warming and, or global climate change? They established a need to determine whether there was adequate evidence, was it valid, and did the "news" network give it a particular slant. Most importantly, they discussed what they could do to vet the available evidence and obtain more scientific knowledge to fill in visible gaps. Criteria used as a base for decision-making to determine whether they believed in global warming and, or, global climate change were thus identified as (a) availability of data to use as evidence, (b) whether available data had a particular political slant, (c) accuracy of data, and (d) credibility of data sources.

Returning to the list of issues on the board the class had generated, the instructor asked what criteria learners wanted to use to select a single issue for investigation. Students suggested the following: Time needed, monetary cost involved, personnel availability, ease of acquiring data, resources available, whether it would really make a difference to the community, and whether it would be fun to do. Based on these criteria, each student made a private decision about the placement of issues on the whiteboard in his/her prioritized list.

A variety of strategies were used to assist the preservice teachers in building consensus within the class for the final issue to address. Many of the strategies were designed to enable individuals to express their opinions without feeling intimidated by opinions of other class participants. For example, the "Heads down, thumbs up" strategy had all students close their eyes and put their heads down on the tables while the instructor stated each option. Students were asked to raise their thumbs up for options they wanted. The instructor tallied the votes. Other strategies involving physical movement and changes in group composition and size were also used: dot voting method, ballot voting, and the human line continuum. Eventually, a group list of prioritized issues emerged based on the numbers generated by these processes.

A process to ensure each student would buy into the final group topic and provide opportunity to address state or national standards involved students identifying relationships they saw among the topics on the class prioritized list. In some cases, broad topics could be used as umbrellas for several specific topics, such as consolidating invasive species, monocultures, green corridors, and habitats for species under biodiversity. Other relationships involved one task supporting another. For example, money obtained from collecting recycling could be used to support planting roof top gardens and increasing biodiversity on campus.

Step 3. Policy and community practice research. Class week 5 required students to bring their laptop computers. This session built on Earth Force handout titled, "What do we want to know?" This called students' attention to who, what, when, where, why, and how of the issue. A discussion ensued in which the instructor and students elaborated on these questions. Working in groups of four or five, students responded to the emergent guiding questions. Sample questions follow: "What do you want to know about the issue?" "What stakeholders are involved in the issue?" A stakeholder Earth Force handout was used to diagram groups of people involved. "What is currently being done to address the issue and by whom?" "What factors relate to the issue?" "What science and technology ideas need to be known to understand the complexity of the issue? "Who is affected by the issue? "How has it impacted the community to date?" "How did the issue begin and when? "Why hasn't it been fixed already?" "Do stakeholders agree about the policies and practices and why?" Essentially, in this session students began to investigate procedures and policies setting the parameters in which the issue existed, and the impact occurred.

Students explored the Internet to answer the questions and followed up with telephone calls to individuals and agencies. They identified organizations in the community outside the school with potential to assist. This key question was raised: How do we get community resources into the classroom? It became obvious phone calls were needed in addition to the web exploration and speakers needed to be engaged. They learned resources could be obtained from organizations. For example, the water management district provides literature describing the correct way to create a garden and can also provide funding for materials. A company specializing in retrofitting buildings could provide materials and expertise.

Toward the end of session 5, students organized themselves in new groups of four or five to begin working on the syllabus task to “practice planning a service-learning project for their future students” by building on their experiences as a full group with the Earth Force process. Students in each group would determine what issue to address and how to acquire necessary resources. They needed to actively seek information to apply to solving their real-world problem. This would take them beyond the time and resources available in a school as they looked for professionals in careers related to the science and technology of the problem with whom to engage in person or electronically.

Step 4. Strategy building. To answer the question, “What are we going to do?” students had to ascertain whether to plan to impact policy and law related to the issue or impact changes in individual behavior related to the issue. Then specific activities in which to engage were identified and organized into a plan of action for the group.

The sixth week of class was devoted to students working in small groups to complete the group’s identified project. At various points, groups volunteered progress reports to the class. This provided input from others beyond their work group. The instructor and professor consulted with groups on an as needed basis by invitation.

Step 5. Implementation. As noted earlier, course time restrictions did not allow for implementation of the plan.

Step 6. Reflection. The instructor-initiated reflection each week through a review of the previous session. He asked students what was done and why it is was done. Often lists were generated on the board to review activities. This led a few students to exasperation, because they perceived everyone should have already known what was done and why. Journals required individual students to reflect each week. Multiple literacies were explicitly encouraged for journal entries and responses. Debriefings of pop quizzes and a midterm exam also required reflection. At the close of each class, the ticket out of the room was an exit memo describing an open-ended short reflection on the class session. In one exit memo, students were asked to list two things they liked about the course and one thing they wanted to change. In these ways, reflection was not treated as only the last step in the Earth Force process.

The need to explicitly teach some students to be reflective became painfully visible during one of the consensus building activities: The instructor asked a student, “What are you thinking?” The response was, “What do you mean what am I thinking?”

The instructor said, “How are you making sense of what we are doing? The student was at a loss. Rather than embarrass her, the instructor moved on. After class the student made it clear she was trying to find the answer to the metacognitive question by searching for something to repeat back that she had been told. Regurgitating information was all she seemed to know to do when asked a question.

During the seventh week of class, each group of students presented the service-learning project their small group had selected to develop. (These were not part of the same topic explored by the full class.) A variety of novel formats were used to focus each group’s description of its project. Included were role play, puppet show, diorama, video, and PowerPoint slide show. After each presentation, the audience asked questions and filled out the Earth Force evaluation sheet to share with the presenters.

The eighth week of class was used for a midterm exam composed of questions selected by the professor from a collection of student generated questions related primarily to the textbook information. It was graded in class by students and debriefed.

The ninth week of class began with a reflection activity, part of step six in CAPS. Students conducted two consecutive brainstorming sessions to reflect on the work they had completed. First, they listed things they had done and learned about service-learning. Second, they listed key ideas from their textbook reading. As the second list was being generated, side comments could be heard such as “ooh - look at that”, referring to the first list and recognizing the similarity of what they were generating. They began to use the first list as prompts for reminders of what they had learned in the textbook. Next, they were asked to discuss any relationships they saw between the two lists. They became excited as they identified where in the CAPS process they had actually been doing, experiencing, each of the items in their textbook list. There were “Ah Ha!” moments when they realized they had been engaging in sustained inquiry through the CAPS process. With body language, side comments in class, and in journals, students reported this experience of sustained inquiry was comfortable and logical, thus contributing to mitigating science anxiety.

Students’ Responses

A progression of attitudinal changes is visible in excerpts from students’ journals. The names are fictitious. It was not a surprise to find many students responding negatively to the changing paradigm during the early class sessions, because when people’s expectations for a situation are not met, they become disequilibrated and uncomfortable. For example, “This is fun, but when are we going to learn to teach science?” (Belinda). Many did not recognize science and technology content when it was presented in the context of real-world events. For example, “When I look back upon my science education, I find that I never seemed to put science and life together, which could be why I struggled with science for so long. I didn’t understand how science affected my life.” (Betty)

Some students indicated they were relating the textbook to class experiences by week five and recognized they were using themselves as a learning laboratory (Burkett, Leard & Spector, 2003). Most did not.

> My favorite part in the textbook is titled, “Extending Curriculum: Taking Advantage of Emerging Relevance.” I really enjoyed this section because

> it relates back to what we have learned in previous weeks about service-learning projects and letting the students have a voice. Emerging Relevance is the perception by students that questions or ideas arising from investigation have personal significance to them. The key part of this concept is certain matters become relevant to students as they engage in learning activities. By helping them to explore these emerging questions and ideas, teachers can help students construct their own meaning. Because the idea is significant to them, the students are excited about the curriculum and eager to expand upon what they are learning. This week's reading was very helpful for me … because it helped me to relate the ideas that we have been learning in class with the required reading." (Paul).

Some students had no appreciation for process in science and in teaching and learning. They assumed the extensive discussions of science and technology inherent in an issue and the lengthy decision-making steps experienced during class were solely to determine the environmental issue on which the class would work.

> Yet again in class today, we talked more about the service-learning project. I wish at some point if we were going to start this project, that we just start it already. It is really frustrating that we are just wasting time talking about the same things over and over again. We already know what our topic is, Recycling and Biodiversity, so why can't we just start the project already. This whole thing seems like a waste of time. … This is in no way teaching me the concepts of how to teach children science. (Athena)

> We spent a significant amount of time in class talking about global warming and brainstorming its effects and making an argument for both sides. I'm not sure why, it falls under the environmental science umbrella, but other than that I don't understand how the global warming exercise connects. We spent a lot of time on it, only to do nothing with it, was there a purpose? Was something being modeled?" (Kelly)

Some students' journal entries revealed a contrasting perspective. There was recognition of in-class experiences as multifaceted integration of many concepts about which they were reading in the textbook:

> I have realized that the activities we learn in class are to not only teach us but teach us different scenarios of what could happen in our classroom when we are teaching. I kind of feel like we get tricked because we think we are doing an activity, but it is really many activities in one and we have to think about the problem in a few different aspects. We have to answer the question to our classmate's problems they gave us from the readings as students. We also have to think about the teachers view. Did our classmates read the chapter?" (Regina)

This student pointed to the learning resulting from instructors' modeling:

> So, in this class we are not only learning science activities and things about science for elementary students, but I think we are secretly given ideas of how to handle situations. Also, I feel we are put into scenarios ourselves in our classroom that we will one day have to face as teachers. (Abbey)

A shy student, reluctant to speak during class meetings, demonstrated the way she was using inductive reasoning to synthesize varied sources of data to show relationships among scaffolded course experiences after a consensus building session.

> Today we did kind of a free flow of thoughts and opinions with the whole class. But what I loved about this is that it was anonymous. I felt that this really would provide the students with an opportunity to show that they do have a chance to get their true feelings out and say or ask what they would otherwise be nervous to. I also felt that for a teacher this could be very beneficial. It allows the teacher to gage where the students are at on more than one level. Like I mentioned before I was one of those shy students and I wish that every now and then my teachers would have done something like this. It's amazing to see what students are thinking. It really provides a chance for them to become actively involved with their learning when they are otherwise not.
>
> When I mentioned in one of my other journals about how I didn't understand why the choosing process could take such a long time for a service-learning project, well after this class I started to understand the importance to it. What I took from (the instructor's) lesson today was that you want the WHOLE ENTIRE class to agree upon a subject. And getting the students to ALL agree on one subject can turn out to be extremely time consuming. I also liked that I was allowed the opportunity to learn that majority voting is not always the best answer. In this case for the service-learning project we want every person in our classroom community to agree on our decision, because if not they could possible cause the rest of the group a living hell, because they feel they weren't given a fair chance and they didn't choose this topic, so they don't care about it. Typically for time saving purposes we go for the majority vote, but what I am making note … that this is not always the best route to take when wanting to come to a whole class decision. We want every student to feel important and involved in this so the best possible solution or product can come out of our service-learning project. Today also showed me many ways we can kind of lead the whole class to one decision. We can always add pieces into what the majority vote was to connect the few other students to the project. I really appreciate this class when it comes to teaching ways and

> strategies that we really will be able to use in the future. And these journals are providing me a way to save all of my ideas! (Teresa)

The next student echoed an awareness of the discussion and questioning strategies used to merge the different issues students wanted to investigate mentioned above. She also attributed value to networking as a vehicle to obtain human and material resources for teaching and learning.

> This week we worked more on the service-learning project. First, we reiterated the problems that we agreed on. The service-learning project is going to be on recycling, and the money that we earn will go towards creating biodiversity on the campus. Second, we started to think of questions that needed to be answered about the problems. These were when, where, why, how, and why questions. By answering these questions, we were able to think of things that needed to be looked into. We also thought of the resources that we will need, and who we need to contact. This was a very important step because we were able to understand a little bit more about what goes into a service-learning project. One of the big questions that were asked in class was: how do you get community resources in the classroom? This was a great question because I have never really thought about it. I would love to have speakers come into my classroom, to speak to my future students. The entire class thought of great answers, and we as future teachers need to make these connections now because we will need them in the future. I need to start creating a list of the connections that I have made. I also thought it was great that (…the instructor) is a resource for teachers. I really enjoyed class today. (Elsa)

Another student recognized the importance of the way the textbook presented multiple perspectives.

Critical Incident

The brainstorming episode during week nine was a critical incident for most students. Prior to that many students were still discomforted, because the structure of the course did not meet their expectations and they continued to be worried they had not learned how to teach science. Paradoxically, even though the students had anxiety about science teaching and learning in a traditional didactic reductionist way, they exhibited significant resistance to the different paradigm enacted, because their expectations for the traditional approach were not met.

It took many of them until the ninth week (after mid-semester) with the brainstorm activity for them to understand they were actually learning how to teach science by doing it within the service-learning context. The quotes below are each from a different student's journal after the week nine session:

“The biggest meaning I’ve gotten from this class is that science is a process, a set of ideas, and a set of attitudes. By doing the service-learning project, we were learning all of this.” (Greer)

> As we progressed through our education on service-learning projects, it is interesting to notice how many connections exist between these projects and the ideas presented in our text that are beneficial to a science classroom. As I list these connections it seems that just about any concept taught in the text can somehow be related to a service-learning project. (Rene)

“…nice thing about the Earth Force guidelines is that it covers the learning cycle that we learned in class.” (Danyell)

Many students had not understood the instructors were modeling ways to answer the course’s overarching question, “What is science teaching in the elementary school consistent with national and state standards?” until week nine.

> I didn’t realize that the entire class was based on the national standards. Going through the standards, I realized that the class was teaching and modeling ways to follow the standards successfully I, as the teacher, can incorporate all of the subjects that I have to teach into my service-learning project. (Anita)

After the week nine session, students expressed their intent to implement service-learning when they have their own classes to teach:

“I will definitely use a service-learning project in the future and I am more cognizant of the standards and how to incorporate them into a lesson plan”. (Teresa)

“Now I feel more comfortable doing a service-learning project, however not my first year of teaching.” (Xena)

‘I will use (service-learning) in a classroom someday”. (Margaret)

In the end this service-learning project has taught me so much about creating a community, collaboration, and other methods presented in the book. (Athena)

> At the beginning of the semester I thought spending so much time on service-learning was a waste of time. But now I see how important it is… Teaching science and service-learning go hand in hand. I can have a service-learning project in my classroom and the students will be learning and doing science too. I thought the service-learning project would take too much time out of the school day, but it actually does not. I am teaching

> my core subjects while I am teaching the project. I, as the teacher, can incorporate all of the subjects that I have (Angie).
>
> From the beginning of class service-learning projects were sort of unclear to me as to how they pertained to teaching science in the classroom setting. After creating our group project and watching the others present, I really can see how much they can benefit students learning and promote sustained inquiry. I believe it is a great method for any teacher, but I still worry how practical it would be or even if it would be allowed in the classroom at a public school, especially in Florida. I wish it were as feasible as our projects make it look, because it really is a great method for incorporating other subjects and having children learn for themselves rather than having us as their teachers or a book spit out facts at them. (Frieda)
>
> It is important as the teacher to act as the facilitator. I would support students as they faced difficulties in the project and ask them questions in order to promote problem-solving in themselves rather than just solve it for them. Service-learning is very student-centered. The teachers simply guide the students as they make the important decisions and take the steps to move them forward toward a common classroom goal. Service-learning promotes teamwork within a class, forming a special cohesiveness among students. Students learn to take initiative in solving problems and learn that children do have the power to make a difference in society. If students learn this at an early age, they will possess the confidence and problem-solving skills as adults to tackle even bigger issues in society that need the attention of an educated and courageous individual. Service-learning projects create these types of individuals in today's youth, who are tomorrow's leaders. My hope is to create role models of good citizens in my classroom. I want my students to find passion in something and make a difference in the world around them. I want them to be empowered by learning and doing, and I want to assist them in becoming well rounded, scientific thinkers. This class has obviously changed my view on service-learning in only a few short weeks, now imagine what I could do in a year with a classroom full of elementary students. (Belinda)

By the end of the fifteen-week semester, most students indicated their thoughts of teaching science had changed from science being boring or formidable to being comfortable with the idea of teaching science. The quotes below typify those from the last journal of the semester.

"I can say that I am way more comfortable teaching science now." (Angie)

> My concepts of Science are genuinely shifting. I'm beginning to see that Science is all around me; it's thinking, analyzing, questioning, exploring,

> making observations, collecting data, and so much more! Science isn't boring to me anymore, it's actually fascinating to think of how the things of this world work from the clouds to the soil on the ground it's all so incredibly detailed. (Sybil)

"Some of my students may dread science, like I did as a child, but I now have more tools to help them discover, investigate, and overall learn." (Kelly)

"My perspective on Science has definitely changed and my goal is to give my students a positive foundation to their science education." (Frieda)

> I have realized that the ideas and concepts modeled in this class can be applied not only to my life as a student and professional, but to the lives I influence as a teacher. I hope to implement these important ideas in my classroom and pass along the skills and confidence my students will need to be successful students and successful adults in the future." (Paul)

Some changes could be made in the implementation of the service-learning process in the future to accelerate the time students come to recognize the relationships among the course's various data sources and synthesize these into their own construction of teaching and learning.

Future of This Innovative Intervention

Changes being considered are the following: Explicitly discuss during the first class session (a) experiential learning and its benefits, (b) what it means for instructors to model inquiry, (c) the way modeling illustrates the integration of teaching and learning concepts, and (d) using yourself as a learning laboratory for reflection. In addition, we could explicitly point out the features the students are studying in the textbook as they are being modeled throughout each class meeting. As the Earth Force person models a particular characteristic of appropriate science teaching, the professor could overtly state, "He is now modeling cooperative learning" or "You have just experienced what your textbook in chapter x, labels, cooperative learning. An unresolved concern is the degree to which such changes might interfere with students moving toward autonomous learning, one of our goals for open-ended inquiry.

Summary

Using the environmental service-learning process from Earth Force as a vehicle for inquiry within a preservice elementary science methods course was effective in shifting students' paradigms. They recognized the complexities of teaching and learning science and increased their skill level and confidence in being able to teach science. The intervention succeeded in mitigating anxiety. Learners reported more positive feelings about teaching science. They said they look forward to partnering with their communities to address real-world issues that give their young students meaningful opportunities to have their voices heard and contribute to their communities' well-being in the future. In addition, these preservice teachers expressed desire to incorporate resources from the community in their teaching using additional strategies they developed during this methods course. Learners also indicated they felt comfortable and confident modeling the inquiry strategies they had experienced and would incorporate service-learning as a teaching/learning strategy in their future classes. They further noted this service-learning instructional strategy simultaneously contributes to helping them attain standards in other disciplines they will be required to teach in an elementary classroom.

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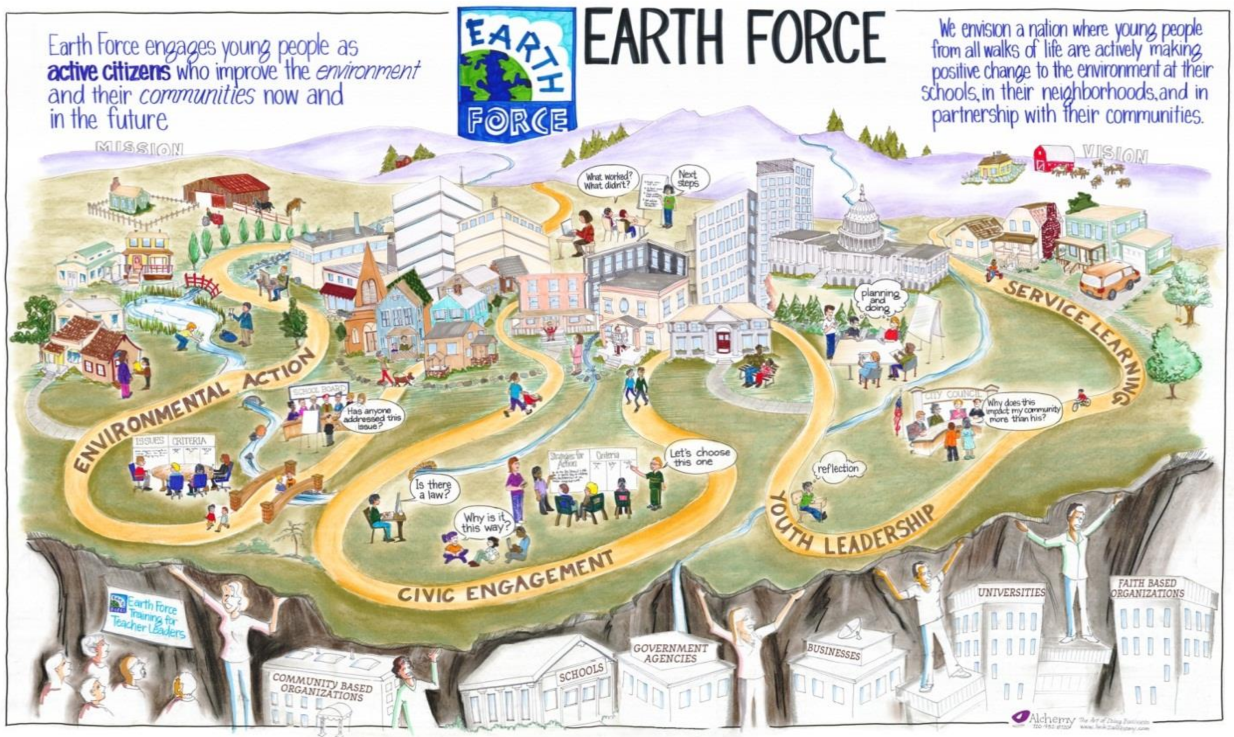
Attachment A

Question	***Mechanistic (didactic)***	***Holistic (inquiry) paradigm (NGSS)***
What does I teach mean?	An Spector,ity (instructor or textbook) transmits-(tells- learners) ideas-(thoughts)-they must be able to reproduce	An Spector,ity facilitates learners to ask questions systematically, to seek input, gather and organize data, analyze and synthesize data (process data) to construct answers to their questions
What does I learn mean?	Guess what is in the teacher's head and give the teacher what he/she wants to hear: and, or, I give back precisely what the Spector,ity told me	Learner makes sense of input (data) from his/her experiences by constructing meaning and is able and empowered to act based on that meaning
What is the job of a student?	Commit to memory what was transmitted	Process input: Select and process data to construct answers to their questions Integrate thinking, feeling, and acting (thus empowering meaning making). Engage in reflection (about input processed) and metacognition (thinking about thinking processes)
What is the job of the teacher?	Transmit information	Facilitate students' construction of meaning
What is the function of assignments?	Assignments are tests of students' ability to replicate information from an Spector,ity into a product	Assignments are experiences that provide sources of input for data and opportunities to process data to construct meaning and test meaning made with peers
How is instruction organized?	Around basics first	Around sensitive and intellectually complex phenomena
Who evaluates what?	Spector,ity evaluates students' performance with grade indicating the extent to which the learner's assignment product matches a list – rubric- developed by the teacher	Learner evaluates sense being made, identifies where there are gaps in the sense being made, asks questions about the gaps, and seeks more data until gaps are filled
Who primarily directs the learning process?	Teacher	Student
What kind of learning occurs?	Passive	Active
What kind of learner emerges?	Dependent	Autonomous

(adapted from Spector,, 2016 Pg.22-23)

Attachment B



The Earth Force "Map"

This drawing is a visual representation of the vision and mission of Earth Force. The middle of the drawing represents the active engagement we envision of young people. The "path" depicts the cornerstones of our work: service-learning, youth leadership, civic engagement and environmental action. Along that path, we have young people doing Earth Force in their community; each call out bubble along the way represents a step in the Earth Force process. What supports the work of these young people? The bottom of the map depicts the critical role of adults and partners in achieving this vision. In order for young people to have success engaging as civic actors in their communities, we want to enlist the collective involvement of community- based organizations, schools - teachers, administrators, and parents, businesses, universities, government agencies, and faith-based organizations.

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