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Practice or Theory: Situating Science Teacher Preparation Within a Context of Ecojustice Philosophy

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Abstract Theory is taught to preservice teachers from the moment they enter the education program until they graduate. While theory serves as the foundation in many teacher preparation courses, these future teachers must also understand the relationship it has to practice. The focus of this article is on the journey of one group of preservice secondary science teachers toward becoming practitioners with a theoretical understanding of what and how they would teach science. Ecojustice philosophy, being implemented through citizen science pedagogy, served as the framework for this method course and proved challenging for both the professor and the preservice teacher. Hermeneutic ethnography served as the guiding methodological/theoretical framework for this research and provided an opportunity for extensive data collection in an attempt to better understand how participants made sense of learning to teach within a method course focused around ecojustice philosophy. By using hermeneutic ethnography, we are encouraged to make sense of what we are seeing, while considering our own cultural experiences and abilities to interact with others taking part in these events. This research highlights the need for dialogue within science teacher preparation classrooms, addresses the challenges in teaching for practice-theory, and suggests possibilities for future considerations within science teacher preparation.

Keywords Practice theory · Citizen science · Teacher preparation · Hermeneutic ethnography · Science methods

Introduction

In an effort to establish the slate for anticipated learning goals and expectations for the first senior block of courses, groups of three to four secondary science preservice teachers,

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professors, researchers, and teaching assistants met informally to get to know one another. This meeting marked the beginning of the final semester before student teaching, a coming together of key partners to ask: "What do you want to learn? What goals do you have and how can we as instructors help facilitate learning and achievement of these goals?"

> Emma, a preservice teacher in the first group, shared her strengths in chemistry… that she really knew how to run a laboratory but was worried about her ability to manage students. High on her list of concerns, and common to the majority of preservice teachers throughout the morning, were questions like "how do I make sure the students really learn science and still have an active classroom? How do I keep the kids interested? What about learning how to actually 'teach'? How do I challenge my students? How can I keep from being outsmarted? I don't want to be walked on, so I need help with classroom management. How do I establish and maintain authority?" Paul, the sole physics preservice teacher in the course, wanted to be a motivating teacher; with no actual teaching experience, he admitted that the only things he knew were what he had experienced as a student. He expressed a lack of confidence. Still, others had concerns with their ability to create an interesting curriculum that would be well-timed and not overlook the needs of students with different needs. "Mostly, we all just want to make sure we can be taken seriously as teachers. Things like planning for different types of learners and not just relying on notes as a way of teaching." (researcher field notes 8/19)

What are these preservice teachers asking for? Is it management? Help with selecting and implementing science curriculum? Or is it a theoretical understanding of what it means to teach science? Ideally, a course focused on understanding theories of teaching would enable future educators to face a classroom and be successful in any situation they encounter. Do future educators value theory application, or are they really more concerned with explicit directions on "how and what" to teach? Some science educators would argue that preservice teachers purvey pedagogical expectations that are often challenging, without direct understanding of how to apply theory (Kang 2008; Stetsenko 2008). An ideal situation might provide preparation in both theory and practice by allowing opportunity for students to merge their theoretical understandings with knowledge of how they will teach effectively. This article discusses the practice theory relationship within the context of a study conducted in a secondary science teacher preparation course organized around the tenets of citizen science. The study reflects the emerging tension between theory and practice as seen by the researcher through analysis of data; a disconnect was expressed by the preservice teachers, professor, and additional course instructors in understanding the relationship between practice and theory as it relates to the teaching of science.

The original intent of the research was to understand how participants made sense of learning to teach while engaged in a secondary science teacher preparation course designed within the framework of ecojustice philosophy. After data analysis, it because evident that there were underlying issues of knowledge acquisition in terms of both practice and theory. The initial research question, related to the type of instruction the preservice teachers would receive, became a subcategory to the emergent challenge of understanding how ecojustice philosophy was being used to guide teacher preparation. These developing tensions led to the following question: How does the practice theory relationship challenge participants in a preservice secondary science teacher methods course designed around the constructs of ecojustice philosophy?

Defining the Practice Theory Relationship

The practice theory relationship considers approaches to teaching (and learning) that involve processes of understanding both theory and pedagogical application. Traditional notions of "theory to practice", as described by Martin (2009), represent an approach to science teaching and learning that is very de-contextualized with the focus more on strategies for instruction that may not be transferable to another location or another aspect of society. One concern with the use of a de-contextualized approach is that learning environments may differ vastly and, without training and dialogue, preservice teachers are ill-equipped to negotiate teaching and learning in different settings. Her work indicates that more developed knowledge of teaching practice and theory could promote a major "epistemological shift in understanding how teaching and learning occurs" (Martin 2009, p. 574). Martin (2009) argues for a more contextualized "practice to theory" approach, where learning and teaching occur within parameters that prove more relevant to the preservice teachers. The practice to theory approach situates learning and teaching within a sociocultural setting, one in which experience is embedded within a familiar set of circumstances. Practice to theory tends to represent a more applied approach that enables preservice teachers to learn teaching practices which are then transferable and more inclusive of multiple perspectives. In understanding practice to theory, it is important to recognize that theory is still a major part of the practice; however, logic encourages that one action will not work in all situations.

Within the realm of science education, learners are encouraged to discuss and consider the potential factors which could promote or hinder a certain "practice" while remaining cognizant of specific teaching theories (Braund 2010; Martin 2009). These opportunities for dialogue may likely encourage greater reception of theory as it relates to eventual practice as a classroom teacher. Braund (2010) argues for an explicitly discussed connection between what we learn about how to teach and how teaching actually occurs in the classroom. He notes that precareer teachers are often conflicted regarding how to interpret theory within a given situation, preventing their ability to relate theoretical classroom actions with what they would do in a similar situation. By contrast, Korthagen et al. (2006) argue for situating teachers within experiences that allow them to define what needs to be learned and, in turn, become teachers who are enacting their own understanding of theory. Korthagen (2001) provides an extensive review of theory-practice literature as it relates to science education. One of the key points he mentions in his review is the challenge preservice teachers face about teaching that occurs when they shift from formal course work into the field. He describes how new teachers (even student teachers) become overwhelmed with the contextual concerns they face on a daily basis, often dismissing what they have learned in favor of survival. In the review Korthagen (2001), suggests that preservice teachers should respond to the whole of their prior experiences, creating a portrait of what they think teaching should include. Essentially, he argues that many preservice science teachers expect a recipe for how they should teach their future students—a recipe that they can fall back on for their instruction, even as they emphasize the lack of value it had for them as students. Table 1 provides an overview of relevant literature (Braund 2010; Fenstermacher 1994; Korthagen et al. 2006; Martin 2009; Stetsenko 2008) and how the relationship between theory and practice was understood.

Three of the preservice teachers taking part in this study, Rose, Bernie, and Sarah, repeatedly expressed concern over what they perceived as a lack of "methods" in the course. Conversation with this group of preservice teachers indicated a yearning for learning methods, since that is what they understood and had previously experienced as "learners". In their view of what teaching should be, methods were something they anticipated; accordingly, they expressed discomfort in not having more exposure to specific teaching strategies. In essence,

Table 1 Contrasting and comparing "theory"-based instruction with "practice"-based instruction

Theory focused	Practice focused
De-contextualized	Situated/embedded
Includes "strategies" that may not be 'transferable'	Encourages making sense of theory by taking part in an experience within a sociocultural context
New teachers struggle in knowing when to apply certain ideas	Involves learning process rather than recipe
Instruction is geared more toward examples rather on application	Includes aspects of reflection and dialogue
Practice to theory (identifying which theory the practice most closely aligns)	Theory to practice (identifying practices that represent a specific theory)
Teacher Knowledge as Formal (TK/F)	Teacher Knowledge as Practical (TK/P)

the preservice teacher participants anticipated a constant barrage of translating theory into practice for their teaching preparation and were somewhat unsettled when this was not what occurred. As evidenced in the introduction, preservice teachers sought ways to manage a classroom and enact certain theoretical understandings; in other words, they wanted to know how to practice. However, this anticipated learning goal contradicted the often unspoken focus of the course instructor to delve further into theoretical aspects of teaching, rather than practice. What connection to their prior learning promoted a belief in a situated, highly relevant, and student-centered science and influenced them to seek out "strategies" for keeping track of behavior and teaching content knowledge? The question of how to manage the class or what to do in specific situations was revealed to be of greater concern than application of teaching theory, seeming to imply that the preservice teachers in this study wanted a prescriptive approach to secondary teaching—rather than the theoretical approach being shared by Morgan (course professor).

Inherent in the design of teacher preparation programs is the challenge for science teacher educators to help preservice teachers discover the connections between theory and practice, by providing opportunities for them to participate in projects that align theoretical knowledge with practical experience. The question in science teacher education becomes one of teaching and learning and whether the focus should be on an approach that moves from "theory to practice", "practice to theory", or a combination of both; alternatively, it may be that the two approaches to teaching and learning science are incommensurable. Consider the following statement by Stetsenko (2008) describing the "practice/theory" debate:

> …knowledge embodies past practices, at a given point in history and in a given sociocultural context, to only momentarily reflect these past practices through the lenses of future goals in what essentially are continuously expanding and unbroken cycles of 'practice-theory-practice'. (Stetsenko 2008, p. 531)

Stetsenko further elaborates on the practice to theory/theory to practice perspectives by indicating that knowledge is gained through contextualized action with theoretical understanding becoming intertwined within the process of practice. This argument suggests the need for preservice teachers to gain exposure to multiple realities and "learning contexts" in an effort to encourage thinking and action in their future teaching.

Fenstermacher (1994) discusses types of knowledge, indicating that on some level, these "types" are malleable with definitions dependent upon circumstances; within this same body of work, he identifies Teacher Knowledge as Practical (TK/P) and Teacher Knowledge as Formal (TK/F). In his extensive review, TK/P is described as that which is necessary to function in the

classroom or the knowledge gained for engaging as a teacher. Practical knowledge can be attained in a variety of ways, including "knowledge of self, milieu, subject matter, curriculum development, and instruction"; in other words, practical knowledge can be learned by the actual practice of teaching. On the other hand, formal knowledge is gained through extensive immersion within research *about* teaching and classroom engagement. Essentially, formal knowledge is "gained from studies of teaching" (Fenstermacher 1994, p. 7). For the purposes of this research, theory is discussed in association with ecojustice philosophy and more closely resembles the type of knowledge described as TK/F. Practice, on the other hand, is considered as the type of knowledge described by Fenstermacher (1994) as TK/P and involves the actions of teaching, as portrayed within the class narratives.

Context of The Research

Experiences for this article are drawn from a study conducted in a method course, framed around the tenets of citizen science, as part of the secondary science teacher preparation program at a major university in the southern USA. Citizen science is an emerging trend in science education that involves the student and the community participating together in science that is relevant to the "local" through location, time, and population. The most concise definition of citizen science comes from the Cornell Lab of Ornithology and describes projects originating with local concerns and issues and currently being investigated by scientists with the aid of citizen researchers. Citizen science opportunities exist within life science, physical science, and earth space science (Bonney and LaBranche 2004; Raddick et al. 2009). The principles of citizen science reflect learning and doing science in the community by discovering concerns that exist, working to solve problems through the inclusion of local resources, and fostering an appreciation and awareness for all types of knowledge (Brossard et al. 2005; Tippins and Mueller 2009; Trumbull et al. 2000). Citizen science promotes daily involvement in the community with decision-making occurring as an ongoing learning enterprise while citizens work with experts in diverse disciplines. Citizen science has the capacity to create opportunities for the community to participate in science activities that benefit the local area in a multitude of ways, such as increasing awareness of the role of scientists, helping people understand the nature of science and problem-solving, and improving the environmental, physical, and emotional health of the community—all while empowering often marginalized populations (Braschler 2009; Cooper et al. 2007; Jenkins and Jenkins 1999). Karrow and Fazio (2010) suggest that citizen science appears to present itself as a viable approach to teaching science in ways that make it more relevant to the actual needs of a society. They propose that citizen science promotes learning science at a community level by encouraging learners to become actively engaged in their world.

Citizen science, in this study, served as the pedagogical approach used to express ecojustice philosophy. Ecojustice can be described as the crossroads for theories related to both social and environmental justice. The very premise of ecojustice requires thinking beyond the scope of self and culture to all things interacting within a space that can be harmful or beneficial to the members of that space (Sachs 1995; Bowers 2001). Thought is given to the smallest organism without a voice, to the encompassing air which surrounds you, to the people who may experience economical gain or hardship, and to those individuals who have often not been considered (Bowers 2002; Tippins et al. 2010). With an emphasis on expanded understanding of how humans and nature are interconnected, ecojustice philosophy serves to engage multiple generations in local as well as global decision-making.

Setting

The setting for this research was a method course which is required of all preservice secondary science teacher candidates and is typically taken during the fall semester of their senior year, prior to a summative student teaching experience. Over the course of 18 weeks, this particular class met at the Piedmont Arboretum (primary location for the data presented in this publication), a local farm cooperative, a traditional university classroom and laboratory, and at the University environmental complex. See Table 2 for meeting information.

The Piedmont Arboretum, the location of five class meetings, has hardwood forests, engineered gardens, and both paved and natural trails which encompass a vast array of habitats. Every class meeting held at the arboretum had some outdoor components; many days the students were outside for the entire class period.

Participants

At the beginning of the semester, there were 12 males and 11 females enrolled in the class. Of these 23 students, 7 were classified as undergraduates, 6 with a concentration in biology (4 males, 2 females), and 1 with a concentration in chemistry (female). Of the remaining 16 graduate students, 12 were in biology (5 males, 7 females), 3 in chemistry (2 males, 1 female), 1 in physics (1 male), and 1 in earth science (1 female). Four preservice teachers, in addition to the course professor, were selected as primary participants. The author served as a primary participant, conducting research in this course as a participant observer; the role as a participant did not include any teaching or oversight of preservice teachers in a supervisory capacity. Graduate assistants and "other" course instructors were considered secondary participants. All participants, primary and secondary, were briefed regarding the study, during one of the first class meetings. Involvement was optional, with no incentive being given for participation. Selection of primary participants was based upon level of agreement (willing to participate fully or observation only), degree level, gender, and concentration area. Based on the literature available, and a need to maintain diversity in research population, students with different science content areas were selected for participation in the study. The researcher felt that scientific discipline may have an affect on how citizen science was understood, in terms of teaching practices and perceived relevance to varied content areas. The research perception was based on the existence of literature relating to citizen science coming primarily, at the time, from the field of biology (Braschler 2009; Cooper et al. 2007). While Raddick et al. (2009) present the value of citizen involvement within an astronomy endeavor, research literature was not as common in fields outside of life science. Additionally, the researcher's background in biology made the connections to life science very obvious, while the physical science links were deemed as more challenging and warranted observance. A guide to the primary participants is included in Table 3.

Table 2 Location of scheduled class meetings

Location	Number of class meetings
Piedmont Arboretum	5
Luna Farms	1
Environmental Complex	1
Ecology laboratory	1
Education classroom (Lafayette Hall)	8

Table 3 Participant profiles

Participant Identity	Profile
Morgan	University Professor—science teacher educator (<5 years); background in life science; white male
Stacey	Participant researcher—held no supervisory role; served only as a participant observer; white female
Bernie	White male graduate student with background in chemistry
Rose	Hispanic female graduate student with background in biology
Sarah	White female undergraduate student with background in chemistry
Paul	Asian male graduate student with background in physics
Patricia	Secondary instructor; facilitator for the School Yard Project; white female

Methodology

The extended time period involved in collecting data, and the attempt to make sense of what was happening, promoted the use of hermeneutic ethnography as a research methodology. At its very essence, hermeneutic ethnography is a theory of understanding, both of others and self, that takes place through interpretation of meanings assigned to objects or encounters (Goodall and H. L 2003; Michrina and Richards 1996; Vanhoozer 2006). Hermeneutic ethnography encourages constant interaction with the participants, self, and one's own attempt at understanding what was meant by the participants in any given situation (Michrina and Richards 1996). Placing oneself within the social group, while still avoiding the imposition of self, is essential to interpretations that reflect the most probable understanding of the participants. According to Goodall and H. L (2003), hermeneutic ethnography involves a personal relationship with all sources of data during the process of research, an acceptance and integration of different ideas, and reflection upon personal beliefs and perspectives that might influence understanding and attempts at making meaning.

The use of hermeneutic ethnography as a guide within this study allowed for a better attempt at understanding what was meant by particular actions or expressions and the possible significance they held for the participants. Hermeneutics provides a framework that supports reflection on how experiences are shaped by the group and how each individual, including the researcher, influences the making of meaning as interpretation of these events is attempted (Bauman 1978). Additionally, ethnography is described as a long-term study of a particular culture in which the researcher becomes a participant in the activities of that culture, with the intent of developing relationships that strengthen the understanding of interactions between group members (Spindler and Spindler 2000; Wolcott 1982, 2002; Geertz 1973).

Hermeneutic ethnography, as both the theoretical and methodological framework, enabled the researcher to accumulate data while a participant observer, attempting to take everything in and make sense of how others were formulating an understanding of citizen science. Questions began to unfold as meaning was ascribed and subsequently dismissed or embedded within the "sense-making" process; this occurred as part of a continuous cycle of attempting to understand that which was beneath the surface. Data is presented from the perspective of an ethnographer, meaning that all participants have a voice that is equal in value, and shares multiple viewpoints as a way to help the reader better understand the tensions uncovered in data analysis.

Data Collection and Analysis

The primary participants were interviewed three times each, observed during scheduled class interactions, and allowed the researcher access to classroom artifacts which were completed during the semester. The primary course professor was interviewed three times, observed during scheduled class interactions, and took part in after class discussions. Interviews with all participants were audio-recorded; some research/instructor contact resulted from electronic correspondence as limited time was often a factor in face to face conversation. Michrina and Richards (1996) ascribe value to the researcher maintaining a reflective journal throughout the entire study. Reflective journaling fosters a deeper level of introspection and can be used to identify possible questions and themes emerging from the data, researcher biases, and other areas of special attention (Ortlipp 2008). Data presented in this manuscript, shown in Table 4, rely primarily on interviews and participant observation field notes.

Table 4 Artifacts used in data analysis

Data source	Total occurrences	Description
Field notes		
	Date	Location
1 First day	8/19	University, classroom
2 Small group introductions	8/21	University, classroom
3 Introducing citizen science	8/28	University, classroom
4 Hike	9/2	Arboretum
5 Magazines, types of intelligence	9/4	University, classroom
6 Challenge comfort—questions teachers face	9/11	University, classroom
7 Fire training	9/16	University Enviro Complex
8 SYP training rain	9/18	Arboretum
9 Probe demonstration	9/25	University, classroom
10 Journaling	9/30	Arboretum
11 Taking pictures	10/2	Arboretum
12 Mars and CSI	10/9	University, classroom
13 Butterflies	10/14	University, classroom, and ecology lab
14 SYP workshop	10/23	Arboretum
15 Garlic	11/2	Full Moon Farm
Interview with professor	Three over the semester	Formal interview protocol utilized
Interview with four preservice teachers	(12) Three per student, over the semester	Formal interview protocol utilized
After class debriefing with professor	Seven face to face, three via email	Informal questions and discussion regarding issues covered/rising in class
Personal research journal		Varied times over the semester—as issues arose and thoughts needed to be hashed out
Peer-debriefing regarding unfolding research	6	Discussion of research journal, issues on bias, questions on making sense of the process

Data analysis consisted of reading, listening, and coding each piece of data. The considerable accumulation of data required the use of software (AtlasTI) for the coding process, which enabled similar ideas to then be grouped and further analyzed for broader connections. Once the initial segments of data were printed and categorized by similarity, those were then grouped into larger themes. These themes provided the necessary descriptions of the course, as per the original intent of the research. Table 5 shares a brief outline of what codes were developed, then grouped into categories, with the resultant themes that emerged.

Additionally, these larger themes exposed several challenges, consistent tensions which appeared throughout the semester and were evident across the data. One resulting challenge involved the students' attempt to make sense of how citizen science could function within their future classroom. After deeper analysis, it became evident that a tension existed, for both the preservice teacher and the course professor, related to the understanding and application of theory as it informs the practice of teaching science. Although not part of the initial research intent, this emergent struggle between practice and theory was identified through analysis of the extensive data collected by the researcher and serves as the focus of this paper.

How Did This Study Illuminate Participants' Understanding of the Practice Theory Relationship?

Citizen science, a pedagogical approach grounded in ecojustice philosophy, fosters interactions between multiple groups while utilizing diverse settings and approaches that do not necessarily follow tradition (Mueller et al. 2012). According to Bowers (2001), one aspect of philosophical understanding expressed in ecojustice is the idea of challenging existing assumptions which are deeply held by individuals, as a way of having them explore alternatives. Ecojustice merges social and environmental justice theory by promoting awareness of the obvious connections between environmental degradation and areas of diversity and poverty (Bowers 2001, 2002; Tippins et al. 2010). The overarching idea of ecojustice allows the natural connection, which exists between social/environmental inequities, to be addressed in a more holistic manner. A primary focus of the course, and emphasized in this manuscript, is the inclusion of nature as a setting for over half of the course meetings. Additionally, the outdoor meetings which were held at the Piedmont Arboretum served as a framework for the preservice teachers to construct lessons which would be used to teach in-service teachers; this in-service teacher training is a primary source for the knowledge gained regarding practice and theory.

In the earliest discussion of the course, Morgan, the course professor, argued for designing the secondary method course as a philosophy class. One way he chose to encourage philosophical interpretations was through his focus on nature as a primary location for the scheduled weekly sessions. In our first course interview, it became evident that Morgan considered 'our minds as being part of the Earth….that cultural assumptions exist, but by allowing your mind to be part of the place in which you live—by experiencing nature—it becomes easier to make connections with other parts of the Earth.[1]' In furthering his intention of incorporating nature as an integral part of the course, he asserted that "they [preservice science teachers] need help to make what they are taking for granted, visible" (Morgan 9/10). The presentation of an alternative course setting raised questions for many of the preservice teachers and forced them to attempt to "make sense" of why the location mattered for Morgan. In one sense, the use of a unique context promoted introspection with the potential to extend the development of a more diverse philosophical understanding of what it meant to teach and learn science. By placing an

[1] Single quotation marks will be used when combining or paraphrasing statements of the participant. When possible, double quotes will be used to represent exact statements.

Table 5 Progression of data analysis

ATLAS.ti Co-occurring Codes

1. Administrative tasks
2. Autonomy and/or responsibility for self
3. Autonomy for educational
4. Awareness for nature
5. Balancing risk and safety
6. Class routines
7. Conflict between nature and culture
8. Connecting formal with informal education
9. Connecting knowledge to personal experiences
10. Create a community of learners, network of resources
11. Ecojustice philosophy
12. Encourage fostering concern for the environment
13. Encouraging student observation and awareness
14. Extending classroom to include outdoors
15. Instructor encourages fostering relationship with peers
16. Instructor philosophy
17. Instructor view of 'role of the teacher'
18. Introducing students to new experiences
19. Learning to teach through stories
20. not romanticizing outdoors
21. Power of narratives for teaching and learning
22. Student as holder of knowledge, expert in interest
23. Student inquiry evidence
24. Student interest in firsthand
25. Student responsibility
26. Teacher as enforcer/observer
27. Using co-educators as instruction
28. Value placed in foster decision
29. Values outdoors as an instructional setting
30. Willingness to overcome convenience for the experience

Initial categories

1. Autonomy/responsibility (which entails student, educational partners, and instructor),
2. Nature as a classroom (within the same heading as challenging traditions),
3. Role of a teacher (in relation to ideas put forth by the instructor and students, as well as some personal thoughts),
4. Experiencing community (involves individual actions and group-generated encounters),
5. Learning through modeling/observing (representational of the instructor or educational partners)

Larger themes used for organizing data

1. Organizing for a citizen science approach
2. Learning by doing
3. Actions speak louder than words
4. Preservice teacher perspectives
5. Considering citizen science as a pedagogical organizer for secondary science

Tensions which emerged from data

1. Practice or theory? Grounding science education in context rather than content
2. Embodied learning
3. Building communities: encouraging intellectual discourse

emphasis on location rather than the comfort level of the student, and extending the boundaries of class to include the natural world, Morgan hoped to encourage a different way of thinking and a more theoretically based approach to instruction.

By far, the biggest challenge for the preservice teachers was in understanding why nature was used as a classroom context, since it did not drive the content nor did it serve as an explicit

topic of conversation. In essence, Morgan's approach to teaching through ecojustice made practice a component of theory; ecojustice emphasizes the interconnectedness with the environment and by being in nature, the students were unknowingly experiencing theory by practice. By expressing a lack of understanding as to why they were outdoors, the preservice teachers were challenged to overcome their assumption that location must be important. It is possible that encouraging an "outside of the box" mentality may help the preservice teachers' transition between theoretical understanding and pedagogical application. The teaching location, rather than serving as a platform for content, challenged their expectations. The use of nature as a classroom traditionally meant, for the participants, that some component of learning would involve the location. While outdoors, they discovered familiar mechanisms of learning without explicit discussion as to why nature was being used *only* as the setting, rather than the focal point of a content-driven learning experience. The practice to theory approach tends to suggest that learning to teach is more effective when candidates are embedded within opportunities to gain varied experience. While different than embodied learning, educational experiences that are situated (or embedded) within a context suggest a degree of internalization that might enable preservice teachers to apply their knowledge in more productive ways (Barab et al. 2007; Barton 2009; Roth and Lee 2004). In a study conducted by DeWitt and Osborne (2007), which focused specifically on the use of informal learning settings such as museums or zoos for teacher preparation, a connection was suggested between context and pedagogy. These researchers argue that changing the setting of instruction requires the teacher to alter his or her pedagogy to accommodate the informal learning environment and the challenges which exist. Through the change in emphasis to location rather than just content, students were required to consider multiple types of knowledge (TK/F) and plan, giving consideration to, which would be most effective in that situation. By placing emphasis on the location, rather than the content being taught (or the practice of teaching), it is not impossible to imagine that Morgan likely intended for the preservice teachers to make a connection to ecojustice philosophy.

The School Yard Project—Citizen Science in Action

After experiencing several outdoor class meetings, which featured Morgan's discussion of both ecojustice and citizen science, preservice teachers had inexplicitly witnessed a connection between theory and practice. One of the key course experiences, the School Yard Project (SYP), emerged as a primary example of potentially connecting theory to practice. This unique project allowed the preservice science teachers to provide instruction to in-service elementary teachers who were taking part in a professional development opportunity at the Piedmont Arboretum. As a requirement for the method course, the preservice teachers were placed in small groups and assigned a particular set of environmental "data collection" protocols to master and share during the professional development workshop. These protocols, a prescribed method of collecting data, included actions related to "biodiversity," "air," "pollination," and other components of an ecosystem. Each group developed activities to highlight their protocol, which included content and local knowledge. They were tasked with using their science knowledge and skill set (as future secondary science content teachers) to make the project protocols accessible to elementary teachers. The connection between citizen science and teaching protocols enabled the preservice teachers to engage in teaching practices that were more aligned with the tenets of ecojustice philosophy. Essentially, the preservice teachers were given an opportunity to practice (through sharing citizen science with in-service elementary teachers) the

"theoretical" tenets they had experienced throughout the semester as ecojustice philosophy.

At the onset of this project, the preservice science teachers were encouraged to develop their teacher persona while attempting to understand and enact the theoretical underpinnings involved with teaching environmental concepts in an outdoor setting. The preservice teachers were then allotted 3 hours to share their expertise with in-service teachers at the Piedmont Arboretum (primary study site). Small groups of preservice teachers facilitated activities for determining water and air quality, conducting biodiversity counts, and other concepts relating to the overall topic of citizen science. The project was positioned at a time and location that could have encouraged translation of theory-practice/practice-theory in ways which could foster a deeper understanding of the theoretical basis for citizen science pedagogy.

The following is the story of how the preservice teachers came to be involved in the SYP, how they attempted to make sense of the expectations and demands placed on them, and what happened over the course of the project. The combined voices of the researcher, the preservice teachers, the course professor, and other participants in the SYP journey describe an experience in demonstrating teaching prowess, while enacting the principles associated with ecojustice philosophy (as previously portrayed by the course professor).

Preparing Preservice Teachers to "Train the Teachers"

On the day of the introductory SYP overview presentation, the preservice teachers met in one of the newly remodeled classrooms at Piedmont Arboretum for introductions to program staff and to learn what their involvement in the project would entail. Patricia, a naturalist at the arboretum, served as the Arboretum liaison and trainer for the SYP protocols. In describing how he organized the groups, Morgan explained, "I grouped the students based on how they have been responding in class; some seem to keep things internal while others express their excitement at this type of learning. I think by mixing the different backgrounds and personalities, they will be able to design something really cool" (Morgan 9/18). The SYP required the preservice teachers to conceptualize environmental activities around a "protocol" and to make sense of how citizen science could best be integrated within their presentations to the elementary teachers. In developing their teaching presentation for SYP, the preservice teachers were encouraged to use good teaching skills and create different methods of incorporating citizen science into their training session. Throughout the remainder of this manuscript, narratives (derived from observational notes and interviews by the researcher) are presented as a snapshot for providing deeper understanding of the learning experience. The first narrative describes the experience of the preservice teachers as they initially learned about the project, and emphasizes key aspects of ecojustice philosophy. Learning about nature during a thunderstorm required them to move past assumptions of comfort to recognize that they were part of a larger system and were inherently connected to the natural world.

> Dancing in the rain (an example of experiencing 'theory')
> It had been raining heavily since Tuesday, downpours on and off every day and night for four days. The occasional flip flop, inevitably being ruined, and hiking boot plodded the path to our outdoor classroom. "Meet at the outdoor gazebo, and bring your test bags." The invasive vine protecting the structure gave little protection from the rain that fell in fat droplets onto our papers, down the back of our necks, and onto the brick pathway. Minutes into the adventure, the skies opened again. Slowly at first, the rain guided our path, dampening already moist clipboards and question sheets. The rain drops continued to multiply in number and diameter as we moved to phase two of 'outdoor learning'.

> Passing asphalt streams and manufactured puddles we entered the quieter cove of woods with trails branching in representation of the surrounding trees. Huddled together under the few present umbrellas, the preservice teachers strained to hear Patricia over the sounds of woods, fallen leaves, and torrential rain. Moving further together and more tightly under the largest umbrellas, few students ventured out to hold the test ropes and perform the actions that could be simulated later in their classes. If responses were made…they were overshadowed by the rain steadily falling on our outdoor classroom. (researcher field notes, 9/18)

For the preservice teachers, the field training for SYP highlighted the potential for integrating citizen science within their current teaching schemata. The preservice teachers raised many questions before going outside—'can you collect this information and send it to experts?' It appeared that some of the preservice teachers could get past the soggy day enough to experience learning. After being outside for almost an hour, student comments changed to "can you actually do this in class?," and "these are methods we used in our science class for collecting data." Morgan was initially concerned that the secondary preservice teachers would think that the SYP was "too low level" since it was geared toward elementary teachers and their students. However, as the planning continued, he privately shared that the SYP helped to "mediate some of the tensions" which had been problematic in earlier course meetings, by allowing the preservice teachers to experience how citizen science could unfold in their classroom. Regardless of grade level, the SYP would provide an opportunity for the preservice teachers to work together and develop a new understanding of how to use nature as a context for science teaching. The next narrative depicts how the preservice teachers were tasked with negotiating what it meant to be a teacher of citizen science. By directing the outdoor learning experiences and guiding in-service teachers through specific scientific protocols, the preservice teachers were engaged in the role of practitioner.

School Yard Project—Unpacking the Experience of Becoming the Teacher

> Chasing butterflies (the practice of enacting citizen science)
> The day of teacher training dawned bright and sunny, preservice teachers nervously awaiting their chance to be the expert and share their knowledge with others. In-service elementary teachers were introduced to the preservice teachers who would provide outdoor training for environmental data protocols found in the workshop handbook. Two groups of in-service teachers were established for easy rotation through each of the five 'protocol' stations. A wooded space with an adjoining open green area served as the site for two of the presentations, with the group first measuring biodiversity and then talking about vegetation and air quality.
> The two groups rotated to the creek area for the remaining presentations where preservice teachers discussed and modeled actions for the subsequent group activities. Introduction to pollinators was conducted by Bernie, a preservice teacher who attempted to capture a butterfly with his fingers. He had learned how to hold butterflies in an earlier meeting of the methods course, and repeated the handling techniques he was shown during a special monarch activity in which the entire class learned about citizen science projects involving Monarchs.
> The preservice teacher portion of the workshop ended with questions directed at how citizen science integration could and should take place in the classroom. The final preservice teacher presenting posed the following question to the larger group of

> participants: 'what is citizen science?' After a few comments from the group, a preservice teacher explained that it was a way to enable students to participate in work that would be meaningful and beneficial to local and scientific communities as a whole. It was reiterated that each group had made reference to a specific citizen science project during their group presentations. Preservice teachers suggested ways in which to involve each of the classrooms represented in real world science, highlighting the value of making learning relevant to the community. (researcher field notes, 10/23)

Reflecting on the Experience

Responses to the SYP varied among preservice teachers in this study, with some expressing value and others adamantly refusing to alter their ideas about what secondary science should embody. While outdoor instruction was an experience with which Rose was familiar, she indicated that the time spent with the in-service teachers, discussing ways to alter current teaching skills that could enhance outdoor learning, was beneficial to her growth as a preservice teacher. Rose described going beyond the scope of the goals of the SYP to utilize the outdoors as a context for science teaching, citing the necessity of the repetition embedded in the activities as a way of extending and elaborating on experiential knowledge. She further emphasized that projects such as SYP allowed the teachers to learn alternative ways of exploring their local area, something which she greatly appreciates. Other preservice teacher candidates shared their feelings about the School Yard Project:

> "[I] valued having an opportunity to talk with in-service teachers about their thoughts on working outdoors with middle school students"… (Paul 11/4)
> "[I was] frustrated with the project, SYP was meaningful but only in that it provided an opportunity to work with and instruct other teachers. The content and activities were geared more towards elementary students and don't apply to the age range with which I will work"… (Sarah 11/4)

These three primary participants ranged from viewing SYP as an approach to altering theories of learning to a simple experience of teaching others about the natural world.

There were preservice teachers in this study who were not confident that the School Yard Project represented anything valuable in relation to teaching at the secondary level. Yet, there was evidence of conceptual understanding regarding how they needed to present their knowledge, alongside a basic awareness of how this particular approach should unfold in terms of teaching. Unfortunately, the majority of the preservice teacher participants did not understand how this experience, and the foundation of ecojustice philosophy, could relate to their future classroom. The very nature of citizen science, as described by literature, represents an active process of making science relevant and authentic to the learner who identifies an issue and gains knowledge by socially constructing meaning with others (Mueller et al. 2012). Morgan explicitly stated his intent for the course to promote philosophical development, and subsequently planned activities which he believed had the potential for integration of new beliefs. However, the intent, which was discussed with the researcher, was never explicitly detailed in any class activity or discussion. The lack of communication left the preservice teachers questioning how these newly proposed beliefs, of citizen science, outdoor learning, and the School Yard Project, would unfold in a secondary classroom. The preservice teachers were not afforded the knowledge shared with the researcher, that ecojustice would serve as a larger theoretical approach to instruction while citizen science was a representative strategy for teaching and learning. The challenge for the preservice teachers became one of attempting to understand the classroom projects and how these activities could translate into the practice they

sought to learn in the course. As indicated in the introductory narrative, the preservice teachers held basic assumptions as to what a method class would entail. They expressed ideas of wanting to learn about management and curriculum, positioning these as what they considered the norm for a course in teacher preparation. However, to better demonstrate ecojustice philosophy, the course professor maintained an agenda that placed emphasis on challenging beliefs about how science teaching and learning should unfold.

Why Should We Challenge Assumptions About Science Teaching?

DeWitt and Osborne (2007) indicated that changing the context in which instruction occurred had an impact on learning; thereby it could be argued that, for Morgan, a different context would require using a different pedagogy. In turn, highlighting citizen science as a pedagogical framework indicated a possible belief that instruction should be contextualized, with direct relevance to the livelihood of the community. The contextualized instruction surrounding SYP may have encouraged the preservice teachers to challenge their currently held idea that the four walls of the classroom are the most appropriate context for science instruction. During her third interview, Rose shared the challenges she observed with teaching science outdoors.

> "They feel like it's too much for them, always outdoors. Or, a lot of them are chemistry and physics majors and [think] this has nothing to do with me, and I say you never know. Think about what you could do, if there is a possibility … I always imagined them [my students] being outdoors and stuff. He's [Morgan] showing me the realities of what things I can and can't do" (Rose 12/10).

By challenging current assumptions about productive teaching, the preservice teachers were encouraged to question the acceptance of traditional practice as being the best "approach." What prompts a science teacher educator to seek change in personal praxis, and how can that translate to the student? Is it possible to challenge current perceptions in a way that helps the preservice teachers connect their knowledge of citizen science to the practice of teaching? These were both questions Morgan attempted to uncover with his emphasis on ecojustice philosophy and teaching by challenging perception.

A key component of transitioning into a "theory-based" or "practice-based" approach is the need for constant dialogue between learners, course instructors, and other educators (Braund 2010; Korthagen et al. 2006). These opportunities for critical moments of discourse and praxis, so important to the "School Yard Project," were few and far between. The disconnect positioned the project as something that "just had to be done," with little influence or relevance on how the preservice teachers viewed their future classrooms. While SYP positioned the preservice teachers as both learners and teachers, this duality led to a personal dilemma, for many, of what they were supposed to gain from the experience.

According to the descriptions of theory to practice and practice to theory described by Martin (2009), the preservice teachers in this study were more closely associating their needs for successful preparation for teaching science within the realm of practice. Conversations with the preservice teachers indicated a quest for instructional "techniques" which they could use for future teaching; this preference for learning teaching strategies suggested a belief in traditional methods of instruction. The dichotomy in Morgan's multiple approaches to instruction and the apparent disconnect between how learning was intended and received by the preservice teachers highlights the difference between a theory-based and practice-based approach to teacher preparation. For the preservice teachers in this study, the constant

transitioning between theory and practice created confusion and extended, in some part, to how they understood and accepted citizen science as a relevant pedagogy. While Morgan encouraged the preservice teachers to take in their surroundings and vocalized his expectation that they learn from nature, he placed equal emphasis on sharing specific strategies for teaching. The lack of direction between these may have supported the expectations, by the student, that strategies were most important.

Morgan's emphasis on nature as a teacher was intended to represent and embrace a "theoretical" model of instruction, while his use of citizen science helped to provide the preservice teachers with a context for developing a teaching persona. Through positioning preservice teachers as both learners and educators, he encouraged a relationship with context which could, in turn, be integrated with their personal educational philosophy. While the preservice teachers may not have recognized the transitioning between theory to practice and practice to theory, they gained exposure to diverse representations of science teaching and were challenged to acknowledge their current suppositions as to what it meant to teach science.

Morgan further described the SYP project as allowing some of the preservice teachers previously held conventions to be mediated, making it easier for them to "apply [citizen science] to their middle and high school classrooms" (Morgan 9/18). The experiences related to the SYP project provided opportunities for the preservice teachers to have some level of control in making decisions on how to collect scientific data. Through balancing the traditional top-down approach to citizen science, which Morgan assumed the preservice teachers were more comfortable and familiar with, the SYP project placed value on how local knowledge was expressed in the community. This project allowed the preservice teachers an opportunity to share their knowledge with multiple generations while focusing on aspects of science that could be taught in their own classroom. The School Yard Project allowed for a key aspect of ecojustice philosophy, the emphasis on local environment, to be highlighted.

There was a realization that the experiences which took place may have been different than other courses but nonetheless were deemed valuable by participants of the study. Almost inadvertently, participants recognized the emphasis on theory as they observed what they believed to be a perceived lack of practical knowledge shared in the class. In discussion of how her views on teaching and learning were specifically influenced, Rose indicated

> "…I don't think it applies to everybody because I do want to do so much hands-on, and do what he does like taking them out to centers and getting their hands in the dirt. But I do feel like there was a lack of instruction to the classroom, how to apply methods in the classroom. I really wish he would have focused a little bit more on that…" (Rose 12/10)

Through conversation and questioning for further elaboration on the value of citizen science being used as the framework for the course, Sarah shared that she found value in her experiences.

> "It taught me that citizen science is completely doable for most ages…citizen science doesn't have to be complicated, the gathering of the information is not complicated, there are ways you have to do it to do it right, but it is a way to introduce kids to a real side of science than just seeing the crazy white-haired guy with glasses and lab coat that we had to draw." (Sarah 12/10)

The dialogue between the researcher and participants indicated that while the preservice teachers often felt a lack of connection between the theories and experiences of the course, many sought to uncover the meaning through their coursework. Not only did they seek to find

meaning, they attempted to make sense of how certain ideals could be situated within their future teaching. While at times not recognizing the intent, the participants recognized aspects of ecojustice philosophy that were retained.

Connecting to the Larger Body of Knowledge…Implications for Science Teacher Preparation

While this study is representative of what happened when citizen science was used by a particular professor, with a specific set of students in a unique setting, the tension between practice-based and theory-based instructions within a method course is relevant to all teacher educators. It is imperative to remember that encouraging preservice teachers to become aware of multiple philosophical (theoretical) approaches to instruction is valuable in challenging their perceptions of a theory-practice relationship. For science teacher education, the dichotomy between theory and practice is especially important as we often attempt to instill a belief in alternative types of instruction which have proven to be effective, either through research or experience. We often assume that our students are aware of the theoretical underpinnings related to what and how we teach; yet, we should challenge our own assumptions. At times, as teacher educators, we must move beyond our comfort zone and attempt to teach in ways that increase our own learning. Transitioning between theory and practice is not reprehensible; however, it is confusing when one approach tends to focus more on abstract philosophical ideas while the other isolates specific techniques. Representation of one perspective, such as a focus on theory, is often undermined in an attempt to make the larger population more willing to accept frameworks which seem vastly different on the surface, though underneath represent a more familiar and relevant approach to learning. In Morgan's case, it was apparent that he felt pressured, by other staff members and students, to conform to what he (and they) deemed as a more traditional theoretical approach to instruction. He fought his personal need to establish a course structure around ecojustice philosophy, when tradition led to different student expectations; the result was a course that represented both theory and practice, without either being emphasized.

Swennen et al. (2008) conducted a study with teacher educators who were challenged with identifying the theory behind specific teaching practices they exhibited within their science method courses. Evident in the study of Swennen et al. (2008), and reiterated within this study, was the difficulty many teacher educators have in translating practice into theoretical constructs which their students can understand. If science educators face challenges with understanding their own theoretical basis for particular instruction, why would we assume that preservice teachers would be different? Without dialogue occurring to help the preservice science teacher understand the transition and how that influences instruction, different approaches are often meaningless.

In this study, challenges were obviously felt by both the instructor and preservice teachers in determining the most appropriate way in which to conceptualize instruction. By considering the tension between theory and practice, both Morgan and the preservice teachers were encouraged to develop a philosophical "stance" they wanted to implement within their own teaching. Morgan's attempt to help the preservice teachers internalize philosophical beliefs was often a challenge, one that was enhanced by a departmental culture whose primary guidelines for science teacher preparation were the National Science Teacher Association standards and other science teacher preparation accreditation organizations. While guidelines are necessary for accreditation purposes, they carry with them an unspoken lack of flexibility as to the strategies deemed appropriate for accomplishing the goals of NSTA Science Teacher

Preparation standards. Morgan appeared to have conflicting beliefs throughout the course as to whether he should teach strategies for the preservice teachers to use in their future classrooms or adhere to helping them develop a deeper philosophical understanding of teaching and learning. The preservice teachers in this study expressed value in learning about citizen science and appreciated the opportunity to discuss actual classroom situations; yet, they failed to make the connection to acceptance of ecojustice philosophy and citizen science as a framework for their own teaching. The internal debate of effective science teacher preparation, whether it is theoretical, practical, or philosophical, is not uncommon for teacher educators. However, it often serves as a point of contention and an opening for future discussion, for both preservice teachers and teacher educators, as to how they can modify their own instruction to more seamlessly integrate practice and theory without apparent dissention.

How do we create practice-theory-practice as a cycle rather than maintaining a dichotomy between theory and practice? Practice and theory are often intertwined throughout teacher education in ways that make the transition to actual teaching more fluid. Preservice teachers respond well to thinking theoretically while maintaining a desire to have practical experience that better enables them to handle classroom situations. It is evident that both approaches are used, expected, and valued within science teacher education. The concern is in how we as science teacher educators help preservice teachers make sense of what an actual classroom looks like and assist them in being prepared for using the knowledge they have gained so they may be more effective teachers. Introducing personal philosophy is, arguably, why many educators chose to enter the profession; this research serves as a representation of how one could share their approach to education and addresses some of the challenges experienced by participants when neither expectations nor agendas are clearly defined. Creating opportunities for explicit dialogue about the processes which are being used can go far in helping preservice teachers understand and internalize ideas presented in teacher preparation courses. We, as science teacher educators, must help them identify the relationships which exist between their years of learning educational theory/philosophy and the experience of applying this knowledge to the real world.

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