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Elementary Science Education in Classrooms and Outdoors: Stakeholder views, gender, ethnicity, and testing

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In this article, we present a mixed-methods study of 2 schools' elementary science programs including outdoor instruction specific to each school's culture. We explore fifth-grade students in measures of science knowledge, environmental attitudes, and outdoor comfort levels including gender and ethnic differences. We further examine students' science and outdoor views and activity choices along with those of adults (teachers, parents, and principals). Significant differences were found between pre- and posttest measures along with gender and ethnic differences with respect to students' science knowledge and environmental attitudes. Interview data exposed limitations of outdoor learning at both schools including standardized test pressures, teachers' views of science instruction, and desultory connections of alternative learning settings to 'school' science.

Keywords: *Elementary school; Environmental education; Teacher beliefs*

Elementary science education continues to challenge educators and policy-makers despite reform efforts and national policies aimed at achieving scientific literacy (American Association for the Advancement of Science, 1993; National Research Council [NRC], 1996). The percentage of scientifically literate citizens in the USA is lower than in many European and Asian nations (Gonzales et al., 2000), with students'

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performance on ecological portions of science assessments identified as poor (Carrier, Tugurian, & Thomson, 2013; Institute of Education Science, 2006). Science literacy has been defined in a variety of contexts (Millar, 2006; Norris & Phillips, 2003; Tytler, 2007), including the ability to use and interpret the language of science and to apply data to personal and collective decision-making. Despite educators' goals to prepare scientifically literate citizens, elementary students tend to be shortchanged in science, with less instruction in science than other disciplines (Tilgner, 1990). This unfortunate marginalization of science for young students persists despite the fact that students' potential to develop science habits of mind and to learn rich science content at a young age has been clearly identified (Gelman & Lucariello, 2002; Gopnik, Sobel, Schulz, & Glymour, 2001; Inagaki & Hatano, 2006; Keil, 2003; NRC, 2007).

One aspect of science literacy, ecological literacy, focuses on the relationship between natural processes on earth and related human interactions. In building a framework for ecological literacy, teams of ecologists emphasized a key scientific perspective for ecological literacy with scientific habits of mind that include modeling and issues of scale (Jordan, Singer, Vaughn, & Berkowitz, 2008). Knowledge of ecological systems is a necessary foundation for conservation and resource management decisions (Berkowitz, Ford, & Brewer, 2005). Ecological literacy has been classified as a subset of environmental literacy (EL) (Hollweg et al., 2011) and is critical to understanding the natural world and the relationships between humans and natural systems (Berkowitz et al., 2005; Slobodkin, 2003; Speth, 2004). These understandings are particularly relevant in light of today's complex environmental challenges, such as climate change. Furthermore, as today's students are the future decision-makers who will be faced with these environmental challenges, early building of students' science and environmental literacy is imperative (Jordan et al., 2008; NRC, 2007). In this article, we use the term EL to include attitudes and behaviors that Hollweg et al. (2011) identified as interactive and developmental. We chose this term to offer a broad umbrella, encompassing ecological literacy's knowledge of patterns and systems and recognizing the multiple dispositions that contribute to EL. The mixed-methods study presented in this article describes two US schools' science education programs and their attempts to build elementary students' scientific and EL through outdoor learning. We include voices of key stakeholders who can influence the entire education experience: students, teachers, principals, and parents.

One key strategy for building EL is outdoor learning, as it may contribute to students' rich analyses of environmental issues. Research on outdoor learning (Dillon et al., 2006; Eaton, 2000; State of Education and Environment Roundtable, 2000) has shown that outdoor experiences are effective for developing cognitive skills that enhance classroom-based learning. In addition, researchers have documented both academic and personal benefits related to outdoor experiences, such as improved academic knowledge and skill acquisition (Malone, 2008), improved environmental attitudes (Cheng & Monroe, 2010), and improved outdoor comfort levels (Carrier, 2009). Unfortunately, elementary students spend little of their school time in the outdoors (Coyle, 2010). Affective components of EL (e.g. environmental attitudes and outdoor comfort levels) have the potential to promote engagement in environmental problem-solving and behaviors (Hungerford & Volk, 1990).

Although the inclusion of EL topics and outdoor learning can contribute to students' science literacy, significant influences are associated with the implementation of both. These factors include teacher beliefs about science teaching and environmental education, teachers' self-efficacy in teaching science, outdoor fears, and school cultures that include perspectives of principals and parents. Additionally, student gender and ethnicity are associated with differences in EL levels, suggesting that other contextual factors can inhibit the goal of achieving EL among all students.

Teacher Beliefs

Teachers' Beliefs about Science Teaching

Research studies have found that teachers' beliefs have a strong impact on their classroom actions and attitudes toward students and instruction (Cannon & Scharmann, 1996; Dixon & Wilke, 2007; Pajares, 1992). In a review of literature on teachers' beliefs about teaching and learning science, Calderhead (1996) places teachers' beliefs into two categories, suggesting that some teachers view science teaching as a process of knowledge transmission while others see it as a process of facilitating students' learning. Research examining teachers' beliefs about science teaching (Levitt, 2002; Lumpe, Haney, & Czerniak, 2000; Sampson & Benton, 2006) reports that most teachers adopt a traditional science teaching approach (i.e. knowledge transmission/teacher centered) because they believe this is an effective teaching method. Studies show that teachers generally avoid using inquiry-based instruction (i.e. student-centered), as many teachers perceived this approach as unstructured, and therefore more difficult to effectively implement in science teaching (Lumpe et al., 2000; Smith & Southerland, 2007). This preference suggests that many teachers see science teaching as a knowledge transmission process and may shy away from outdoor learning, as outdoor experiences are often associated with unstructured, student-centered learning (Estes, 2004).

Teachers' Beliefs about Environmental Education

Many teachers believe that environmental education should be included in the science curriculum (Forbes & Davis, 2008; Kim & Fortner, 2006), and elementary classrooms have the potential to offer cross-disciplinary instruction characteristic of environmental education (Forbes & Zint, 2011). Additionally, teachers with positive attitudes and feelings of responsibility toward the environment have more positive attitudes about including lessons about the environment in their science classes (Ko & Lee, 2003). Yet many elementary teachers feel unprepared to effectively teach environmental science due to lack of instructional expertise, curriculum materials, and time for environmental education instruction (Ekborg, 2003; Forbes & Davis, 2008; Ko & Lee, 2003; Tal & Argaman, 2005). This lack of time and expertise may help explain why many elementary teachers fail to include environmental education in their classrooms, despite their intentions to do so.

Teachers' Self-efficacy of Teaching Science

Although the elementary grades represent a critical period for developing students' basic scientific literacy and attitudes toward science (Smith & Southerland, 2007), most elementary teachers perceive science teaching to be challenging, and oftentimes choose to avoid teaching it in favor of other subjects (Sampson & Benton, 2006). A survey of elementary teachers in California determined that 90% of teachers felt prepared to teach language arts and mathematics, but only about one-third felt prepared to teach science (Dorph, Shields, & Tiffany-Morales, 2011). Most elementary teachers report low teaching efficacy beliefs about science teaching because they are not sufficiently prepared to teach science or to implement calls for reform that require complex science domain knowledge and pedagogical skills (Abell, Bryan, & Anderson, 1998; Appleton & Kindt, 2002; Tilgner, 1990). Therefore, science teacher educators are constantly striving to increase elementary teachers' self-efficacy beliefs about science teaching in order to change their approaches to science teaching altogether (Mansour, 2009).

School Culture

In addition to teacher beliefs about science teaching and environmental education, school cultures (as shaped in part by administrators and parents) can influence the type and quantity of science instruction available to the students. Ernst (2009) identified administrator support as a key factor in determining whether or not teachers include environmental education in their curriculums. Ernst found lack of support from parents to be an obstacle for some teachers. However, Tal (2004) found that parental involvement in environmental education can support student learning.

Other Contextual Factors

In a review of a decade of research, Zelezny, Chua, and Aldrich (2000) explored gender differences and found that women showed more environmental concern than men in 9 of the 14 countries studied, while Ellis and Korzenny (2012) identified strong environmental connections with Hispanic students. The differences in ecological knowledge associated with gender and ethnicity may reflect the 'culture of power' as described by Calabrese Barton and Yang (2000). These authors identify tiers of people within society who are unfairly elevated, thereby depressing certain groups within institutions, including schools. This culture of power limits access to science classrooms for all students by emphasizing colloquial language and rituals that are specific to certain classrooms and labs, and not always representative of how scientists work (Eisenhart, Finkel, & Marion, 1996). These cultural misrepresentations and the stereotypical image of scientists as white males all serve to alienate ethnic minorities and women, and may prevent them from seeing a future career in science, including environmental science. This culture of power, found in some traditional schooling, may discourage female or minority students from envisioning themselves as scientists, despite their documented environmental connections.

Study Objectives

The present study examines two elementary schools' science programs with a focus on each school's efforts to include outdoor learning experiences. One school in this study had a reputation for a high emphasis on science and outdoor learning, and the other school did not. This mixed-methods exploratory investigation compared students' science knowledge using the state's grade 5 objectives linked to ecological concepts, environmental attitudes, and outdoor comfort level both within and between the two schools, developing a representative snapshot of how outdoor learning interfaces with elementary science education practice.

We further considered stakeholder beliefs and attitudes about science teaching and outdoor learning as well as student gender and ethnicity to identify factors that impact students' science experiences and relationships with the natural world. Using interviews and observations, we investigated teacher, administrator, student, and parent views of science education and environmental education both in and out of school. Quantitative data included students' pre- and posttest measures of science knowledge, environmental attitudes, and outdoor comfort levels; qualitative research findings are based on classroom observations and interviews with 7 teachers, 30 students, 2 administrators, and 18 parents from 2 schools. Research questions addressed include the following:

(1) What changes can be identified in fifth-grade students' science knowledge, environmental attitudes, and comfort levels in the outdoors following their science instruction for one academic year?
(2) Are there differences between the two schools in the study in terms of students' science knowledge, environmental attitudes, and comfort levels in the outdoors?
(3) What are key stakeholder (teachers, students, parents, principals) views about science instruction and science teaching practices, including using the outdoors as a setting for instruction?
(4) Are other contextual factors beyond school culture (i.e. student gender and ethnicity) associated with differences in fifth-grade students' science knowledge, environmental attitudes, and outdoor comfort levels?

Method

Participants and Context

Seven grade 5 teachers, 30 students, 18 parents, and both principals from 2 elementary schools in the southeastern USA consented to inclusion in the study. The two participating schools, Frasier and Caswell (pseudonyms), were selected for their rich ethnic and socioeconomic demographic populations (both schools are Title 1 schools), and were identified by the district's science supervisor as having similar but distinct approaches to teaching science. According to the district's science supervisor, Caswell's teachers' approach to science instruction is traditional and follows the district guidelines and schedule, which is strictly aligned with the state's standards-based content objectives. Frasier teachers also follow the district's science schedule, but the school-wide culture emphasizes expanding instruction beyond the classroom to incorporate outdoor instruction. Both schools incorporated district-distributed science kits that had consumable materials supplemented with support from a local museum. The present research focused on fifth-grade teachers and students because science is assessed at grade 5, encouraging science instruction. In addition, the fifth-grade state objectives include content related to environmental science (e.g. weather, ecosystems, and landforms).

Data Sources and Procedures

The present study was conducted in three phases: (1) collecting students' pretest quantitative data, (2) classroom observations and interviews with stakeholders (principals, teachers, students, and parents), and (3) collecting posttest quantitative data. In the first phase of the study, the students completed surveys in the beginning of the school year, assessing science knowledge using the ClassScape (CS) science test, outdoor comfort levels using the Comfort Level Scale (CLS), and environmental attitudes using the Children's Attitudes Toward the Environment Scale (CATES).

CS is a science content knowledge test designed for this study. It uses questions from an existing bank of multiple choice test items to measure objectives from four instructional fifth-grade state science content areas: ecosystems (CS1), weather (CS2), landforms (CS3), and force and motion (CS4). The CLS (Carrier Martin, 2003) consists of 11 open-ended questions that measure students' comfort levels in the outdoors. Example questions ask students to respond in writing to prompts such as describing how they feel about bird or insect sounds. The CATES (Musser & Malkus, 1994) consists of 25 belief, affective, or behavioral statements that measure the environmental attitudes of grade-school children. Students were asked to circle which statement they most closely aligned with. Psychometric properties of the instruments have been previously established and discussed in the literature (Carrier Martin, 2003; ClassScape Assessment System, n.d.; Musser & Malkus, 1994).

In the second phase of the study, we conducted in-depth, semi-structured interviews (see the appendix for sample questions) with the principals, fifth-grade teachers, students, and parents. The interviews were audio recorded and were either face-to-face or over the phone. Following a grounded theory approach (Creswell, 2007), interviews were transcribed verbatim and coded and organized by three researchers to find common themes related to science instruction, the outdoors, and environmental science. Additionally, the first author conducted thirty 50–90-minute science classroom observations, with approximately three per classroom (13 from

Frasier and 17 from Caswell). Detailed field notes were recorded, organized into categories, and interpreted with the qualitative data from interviews.

In the third phase of the study, students completed posttest surveys at the end of the school year. The same measures used in the pretest session were used in the posttest session. The present study describes quantitative data along with bounded case studies of both schools' science instruction (Creswell, 2007).

Data Analyses

Data analysis of the quantitative data collected from students ($N = 114$) included descriptive analyses (e.g. counts, percentages, and means), and comparative analyses (t-tests, ANOVA) of students' pre- and posttest measures of their science knowledge, environmental attitudes, and comfort levels in the outdoors as well as students' demographic characteristics such as gender and ethnicity. Qualitative data analysis included transcribed interviews and notes from field observations of science lessons inside and outside of the classroom, as well as a review of classroom artifacts. Qualitative data were coded by three coders using coding procedures borrowed from grounded theory (open, axial, and selective coding; see Creswell, 2007). Researchers reviewed interview data, discussed themes, and 100% agreement was reached on the coding themes reported in the following section.

Results

Students' Science Knowledge, Attitudes, and Comfort Levels: Pre- and posttest measures

Comparative analysis (paired t-tests) on the pretest and posttest student scores indicated significant changes in two of the three measured constructs. There were no significant differences between the two schools' scores; however, we did find several notable differences associated with gender and ethnicity.

Student Science Knowledge, Environmental Attitudes, and Outdoor Comfort Level

Overall, pretest and posttest results for all students revealed growth in *science knowledge*. Comparative analyses showed significant differences between students' pre- and posttest results on all four CS measures. A comparative analysis of the CATES measure indicated significant changes in students' *environmental attitudes* from pre- to posttest. The comparative analysis of pre- and posttest results for CLS showed no significant differences between students' *outdoor comfort* levels. Table 1 presents a summary of student scores.

Gender Differences: Pre- and posttest measures

Of the three measures, gender differences were indicated only in *environmental attitudes* (CATES). Female students scored significantly higher than males on both pretest and

Table 1. Pre- and posttest results for CS, CATES, and CLS measures ($N = 114$)

Test	Pretest M (SD)	Posttest M (SD)	t	$p <$
CS science test (ecosystems, CS1)	65.70 (19.9)	74.35 (17.9)	6.41	.00**
CS science test (weather, CS2)	41.66 (1.6)	54.47 (17.1)	6.39	.00**
CS science test (landforms, CS3)	54.62 (20.4)	70.56 (21.2)	8.27	.00**
CS science test (force and motion, CS4)	36.99 (21.24)	61.04 (23.0)	10.67	.00**
CATES	66.66 (25.2)	72.8 (18.3)	2.16	.032*
CLS	12.32 (4.95)	12.16 (5.0)	0.43	.66

*$p < .05$.

**$p < .01$ (paired samples t-test).

posttest CATES measures. Additionally, female students made significant changes from pretest to posttest scores in their environmental attitudes, but male students did not.

In the measure of *science knowledge* (CS), there were no significant gender differences on pre- or posttest scores. Comparative analysis for all students' *outdoor comfort* (CLS) also showed no significant differences with respect to gender. Neither female nor male students made significant changes to their comfort levels. Table 2 presents a summary of the pre- and posttest results for female and male students for the CLS, CATES, and CS measures.

Ethnic Differences: Pretest and posttest measures

Students' ethnicities were identified from school documents as reported by parents. An overall comparative analysis (ANOVA) indicated significant differences with respect to

Table 2. Pre- and posttest measures on gender differences ($N = 114$)

	Female ($N = 55$)	Male ($N = 59$)			Female ($N = 55$)	Male ($N = 59$)		
Test/demographics	Pretest M (SD)	Pretest M (SD)	t	$p <$	Posttest M (SD)	Posttest M (SD)	t	$p <$
CS science test (ecosystems, CS1)	64.14 (21.3)	65.5 (18.9)	0.36	.48	71.68 (17.8)	74.4 (17.0)	0.81	.36
CS science test (weather, CS2)	38.92 (16.4)	43.6 (18.7)	1.36	.72	37.33 (15.3)	58.1 (18.3)	2.74	.48
CS science test (landforms, CS3)	51.69 (19.8)	56.06 (21.3)	1.07	.94	67.40 (22.6)	71.37 (22.0)	0.93	.55
CS science test (force and motion, CS4)	34.39 (21.8)	38.89 (20.5)	1.08	.52	55.70 (23.4)	64.32 (24.1)	1.88	.86
CATES	68.22 (22.0)	65.08 (28.1)	0.65	.05*	74.89 (13.4)	70.98 (21.9)	1.12	.02*
CLS	12.38 (4.9)	12.39 (4.9)	0.04	.82	12.70 (5.1)	11.86 (4.7)	0.89	.25

*$p < .05$ (ANOVA).

Table 3. Pretest measures scores on ethnic differences ($N = 111$)

Test/demographics	Caucasian ($N = 48$) M (SD)	African-American ($N = 26$) M (SD)	Hispanic ($N = 19$) M (SD)	Asian ($N = 9$) M (SD)	F	$p <$
CS science test (ecosystems, CS1)	$71.79\ (16.3)_a$	59.50 (21.6)	$53.47\ (19.4)_b$	68.30 (19.1)	5.35	.002*
CS science test (weather, CS2)	$47.73\ (18.3)_a$	$34.36\ (16.7)_b$	35.58 (15.6)	38.5 (10.5)	4.36	.006*
CS science test (landforms, CS3)	$63.21\ (19.3)_a$	$45.00\ (18.8)_b$	42.26 (19.7)	51.60 (14.0)	7.96	.000**
CS science test (force and motion, CS4)	$43.71\ (21.8)_a$	31.74 (21.3)	$24.58\ (12.1)_b$	40.30 (21.8)	4.74	.004*
CATES	66.42 (28.2)	62.19 (21.6)	64.10 (28.9)	79.30 (5.7)	1.13	.338
CLS	$13.75\ (3.9)_a$	$9.62\ (5.1)_b$	12.74 (4.5)	11.44 (4.6)	5.03	.003*

Note: Means with different subscripts are significantly different.

*$p < .05$.

**$p < .01$ (ANOVA).

student ethnic characteristics on both pretest and posttest for CS, CATES, and CLS. Tables 3 and 4 summarize students' scores on all measures by ethnic categories.

Significant differences in student pretest and posttest *science knowledge* scores were found between Caucasian, African-American, and Hispanic students, with Caucasian

Table 4. Posttest measures scores on ethnic differences ($N = 111$)

Test/demographics	Caucasian ($N = 48$) M (SD)	African-American ($N = 26$) M (SD)	Hispanic ($N = 19$) M (SD)	Asian ($N = 9$) M (SD)	F	$p <$
CS science test (ecosystems, CS1)	$81.18\ (12.1)_a$	$65.50\ (16.6)_b$	$59.80\ (16.2)_b$	80.70 (17.2)	13.92	.000**
CS science test (weather, CS2)	$61.08\ (18.5)_a$	$46.54\ (14.5)_b$	$44.25\ (14.1)_b$	55.70 (18.95)	6.89	.000**
CS science test (landforms, CS3)	$78.12\ (19.3)_a$	$59.42\ (24.2)_b$	$59.25\ (18.6)_b$	74.30 (24.3)	6.64	.000**
CS science test (force and motion, CS4)	$67.20\ (23.6)_a$	$50.32\ (19.7)_b$	$50.85\ (21.6)_b$	67.60 (25.6)	4.70	.004*
CATES	$77.50\ (9.1)_a$	$66.22\ (21.0)_b$	72.95 (20.0)	$81.00\ (8.2)_a$	4.03	.009*
CLS	13.14 (4.4)	10.30 (5.4)	13.32 (4.4)	10.60 (4.4)	2.86	.040*

Note: Means with different subscripts are significantly different.

*$p < .05$.

**$p < .01$ (ANOVA).

students scoring significantly higher than African-American and Hispanic students for CS1, CS3, and CS4.

Additional comparative analyses on students' pretest to posttest growth in CS indicated that Caucasian, African-American, and Asian students made significant changes on all four objectives measuring science knowledge. Hispanic students made significant growth on objectives CS3 and CS4.

The comparative analysis (ANOVA) results for *environmental attitudes* found significant ethnic differences with respect to students' scores on CATES posttests. Both Caucasian students and Asian students scored significantly higher than African-American students.

With respect to students' posttest *outdoor comfort* scores on the CLS, Hispanic students obtained the highest score (although not statistically significant), followed by Caucasian, Asian, and African-American students. A comparative pre- and posttest analysis on student outdoor comfort level indicated that none of the four ethnic groups made significant changes.

Stakeholder Interviews

A thematic analysis (Creswell, 2007) of the interview data revealed multiple participant views regarding (1) memories and perceptions of elementary school science, (2) challenges to science instruction, (3) impressions of the outdoors (both in school and out), and (4) awareness of environmental issues. The following statements situated within the interview groups of each school's teachers, principals, students, and parents were selected as representative of common views held by the respective groups.

Teachers

Teachers' initial interviews revealed intentions and enthusiasm for including outdoor learning. In discussions at the start of the school year, Frasier's teachers expressed clear and enthusiastic intentions to situate much of their science instruction in the outdoors. Caswell's teachers recognized that there could be some opportunities to provide outdoor experiences closely aligned with standards. As the year progressed, several teacher beliefs surfaced during interviews that identified teachers' inclination to include EL concepts or outdoor learning in their science program. However, these beliefs did not differ substantially between the two schools and are reported below.

The number of outdoor experiences varied by teacher and, according to field notes and interviews, we documented three outdoor events at Caswell and six at Frasier. Both schools participated in an outdoor field trip to a nature center, which they identified as supporting their study of ecosystems. Two Caswell teachers reported using the playground to illustrate landform features and three Caswell teachers asked students to collect materials such as leaves in the schoolyard to use in their model ecosystem boxes. Frasier students also participated in the field trip to the nature center. All Frasier students spent the majority of at least one school day outdoors at a nearby nature preserve, participating in activities spanning multiple disciplines and led by various guest speakers or teachers at the school. This school-wide event involved students from each grade level and spanned a total of four days. One Frasier teacher sent selected students outdoors to collect data from a weather station in the schoolyard, and another Frasier teacher took his class on a walking field trip to a nearby farm, as well as on a schoolyard observation walk. In the following interviews, teachers describe their impressions of the strengths and challenges of presenting science instruction for their students, acknowledging their personal experiences and the school's resources.

Memories and perceptions of elementary school science. Teachers at Caswell described little interest in or exposure to science when they were in elementary school. 'I can't even remember a science lesson. I had to learn 5th grade science when I started teaching it.' The teachers related their obstacles to becoming effective teachers of science as lacking the models for elementary science instruction when they were in school. Frasier teachers also had few memories of science in elementary school. 'I don't remember having a lot of science instruction that was given. I don't remember it being fun. I remember a couple of teachers that were just really dry and they just weren't engaging.'

Challenges to school science. All teachers described science as an important subject, but most of their descriptions included perceived challenges they faced. Challenges included testing pressures, limited resources including time to teach science, and their self-efficacy in teaching science. One Caswell teacher did not identify herself as a science teacher and explained, 'I'm a language arts teacher by nature. A lot of my time goes in to making sure I learn the curriculum for language arts.' She acknowledged the state-mandated science standards but felt ill qualified to teach science compared to other subjects. 'They expect the students to master those areas when the teachers really haven't mastered them.' She recommended teachers specialize in content areas ' . . . have some teachers that have specialties, you know, specialize in science'. Caswell teachers talked about the difficulties they faced as they tried to incorporate district-mandated kit-based science programs while maintaining student interest. 'Truthfully in my opinion I think the kits that we get don't necessarily have the type of equipment in them to accurately and effectively teach the content that we have to teach the kids for the most part.'

The Frasier teachers also felt science kit instruction was limiting. 'There is a lot that the kits do not cover that I need to do before, during, and after to make the kit fit the curriculum.' While some described supplementing kits, teachers varied in their views of extending science to the outdoors as a setting for learning and in their personal identity as an outdoor person.

Impressions of outdoors—in and out of school. Most teachers describing their personal memories of the outdoors considered themselves 'outdoorsy', and described fond memories of camping, hiking, or exploring. One Caswell teacher's only memories of school science were of outdoor instruction, 'Anything we ever did outside I can remember, versus being in the classroom because I'm an outdoorsy person.'

Many teachers felt that the four science topics in fifth grade (ecosystems, landforms, force and motion, and weather) are suited to include outdoor experiences; however, one teacher from Frasier felt the outdoors is an ineffective setting for instruction: 'The hands-on things are fun, however, they don't end up getting as much of the information they need to know when they are outside looking at things.' Interestingly, this teacher identified as an indoor person growing up. 'I wasn't very outdoorsy. I much preferred to be inside playing or watching TV.'

Generally, interview results highlighted the discord between teachers' intentions to include outdoor learning with science instruction, and their actual practices. Questions designed to identify teachers' impressions of the outdoors in general led to their thoughts on environmental issues.

Environmental awareness. Some Caswell teachers' views of the environment and environmental issues were local to the schoolyard and lacked global relevance, just like their students' views; these teachers identified schoolyard litter as the most important environmental issue. Another teacher's response to the question about a key environmental issue was,

> Do they want me to say global warming? Because I don't think it's the biggest one. I would just say the biggest environmental issue is the overuse of natural resources ... you don't have to turn a corner before you see trees being knocked down and buildings being put up.

The Frasier teachers talked about modeling recycling behaviors and reducing paper use. 'We talk a lot about the damage humans have done to the earth and how we could prevent damage and how we could try to reverse it all. We talk about cause and effect.'

Principals

As with the teachers, there were minimal differences between the responses of the principals of the two study schools. Both principals affirmed the value of science and acknowledged the limiting influence of testing. Caswell's principal described his support for a greater emphasis on science teaching:

> There is such an emphasis on literacy and math and ... a lot of the emphasis gets put on areas which are tested. High stakes testing. Literacy and math are foundational for sure ... Science is a good combination of both ... They're all kind of important and interrelated but I think that really explicit exploration in science really activates a different part of your brain.

Caswell's principal felt that science testing would encourage science teaching. 'Now it's a tested area in 5th grade, but for me I think it [science] is important because it does a lot of helping kids begin to develop that natural curiosity, questioning, discovery, testing and finding out what happens.' He expressed expectations that teachers devote time to science.

Frasier's principal acknowledged the importance of science and credited the school's teachers and the community support for school-wide science emphasis. 'At Frasier I think we are just blessed to have so many who are passionate about science and who tie it into outdoor learning and engaging activities.' Field notes about Frasier confirmed this outdoor culture (e.g. school's website, outdoor gardens, outdoor bird blinds, and outdoor-related bulletin boards), yet were not as apparent from classroom observations in grade 5.

Memories and perceptions of elementary school science. Neither principal remembered much about science from elementary school. Caswell's principal explained:

> Gosh, in elementary school? Isn't that interesting how you don't really have any [science memories] ... the textbook ... that's all I can remember. I can kind of see the logo. I can remember the textbooks. I don't have an overwhelming amount of memories.

Frasier's principal mused, 'The one [science] memory that stands out to me was in 6^{th} grade ... They took us out and we spent time collecting things in streams, learning about bugs.'

Challenges to school science. Both principals echoed the teachers' frustrations with trying to fit science into a busy day. Caswell's principal explained:

> Time, time, time. We always want more time and we always try to look at ways in which science is taught through reading and writing and how we can incorporate that into some of the larger chunks of time that we have to do for literacy and math.

The principals acknowledged pressure from the district for each school's students to perform well on the tested subjects of literacy and mathematics throughout the grade levels, contributing to the challenges teachers described when trying to fit science into their very full school days.

Impressions of outdoors in and out of school. Both principals had outdoor memories as children, but Caswell's principal said he would not describe himself as outdoorsy. 'I'm not one to go on hikes or bike rides ... ' Caswell's principal clearly felt that outdoor instruction should have a well-defined purpose. When asked about outdoor science instruction, he said, 'It can't just be going outside for the sake of getting fresh air outside; it needs to be meaningful ... not just for the sake of being outside.'

Students at both schools participate in outdoor field trips and both principals expressed support for science lessons and outdoor activities in their schools. Frasier's principal identified himself as an outdoor person, saying, 'I just love being in the outdoors, so as an adult if I can be outdoors, that's where I am.' He acknowledged the importance of outdoor experiences for students and concurred with Caswell's principal's support for teachers' intentional learning goals.

Environmental awareness. Caswell's principal feels that reliance on non-renewable energy resources is the most important environmental issue facing the present generation. 'All the discussions we've been having about energy and looking at alternative energy sources . . . a general cleaner energy would be great to have.'

Frasier's principal talked about the pollution of water, air, and natural resources. He compared US and Canadian recycling programs, saying, 'We are so behind.' He feels that the best way to prepare children for today's environmental issues is 'being outdoors'.

Students

Memories and perceptions of elementary school science. Many of the students were enthusiastic about science. Students liked the activities, projects, and 'fun' of science. 'You get to do a lot of projects and stuff with groups and communicate with people in your class more. When I learn stuff, I have to touch it.' One Caswell student credited a former teacher from an earlier grade's enthusiasm for her love of science. 'I love science because my old teacher, she loved bugs and everything and she made it so much fun.' Some negative comments about science described a lack of learning. 'Right now we're learning about clouds, but sometimes the teacher doesn't teach us anything at all . . . so not everybody really likes science.'

Frasier students also appreciated the active and collaborative nature of science, with statements such as, 'I think working as a group is better than working by yourself because you have more options to ask people and see stuff, see what's going on instead of being by yourself.'

Challenges to school science. Even the students recognized that the limited time for science was an issue. A Frasier student wanted to increase the time spent on science. 'I'd probably make it longer, longer in the day.' Another student's challenge to embracing science at school related to a fear of assessments. 'I'm really scared when we take our [tests]. I'm really scared what I'm going to get, if I did a good job or not.'

Impressions of outdoors in and out of school. Many Caswell students said they enjoy being outdoors. 'I like going out in nature and exploring, finding animals and building. It's just fun.' Similarly, many Frasier students enjoy spending their personal time outdoors, though some prefer indoor activities. 'I try to spend most of my time outside because I really like to be outside instead of inside doing homework or video games. Sometimes we try to climb the trees.'

With regard to outdoor experiences at school, one student described lost opportunities. 'I would tell them [the teachers] that if we're learning about weather instruments like the thermometer ... instead of telling how they work, instead of just looking at them, actually using them outside.' Few students recalled outdoor experiences at school. 'In science [we go outside] once in a blue moon, not a lot.' While many teachers claimed to use the schoolyard for science instruction, only 1 of the 30 students interviewed recollected outdoor activities directly identified as 'science'.

Environmental awareness. Students from Caswell expressed concern about their local environment when asked to discuss environmental issues. 'I'm afraid that if we don't care about the Earth that it's going to come to an ending because some people really don't.' Most of the students from Frasier identified pollution as litter. 'Probably the pollution [concerns me the most] because I want the earth to be healthy and not polluted and have trash and stuff.' A few students were able to describe broader systems:

> We are being taught in science that fertilizer isn't good because say a farmer lives on a hill, even if he is ecofriendly, when it rains the fertilizer can run down the hill and say there's a lake down there, all the plants in the lake might overgrow and the fish can't get around.

In addition to teachers and principals, parents are key stakeholders who influence students' lives and school decisions. We felt it important to include their voices in our study.

Parents

Memories and perceptions of elementary school science. As with other adults interviewed, parents valued science but had few memories of science in elementary school. One parent said, 'Science was very often presented as something you were told, not something we did.' Many parents felt that their child was having a good science experience, yet some parents felt there is not enough science. 'There's so little time in the day. It seems there is such a huge block of time that is focused on ... It seems like science and social studies have been pushed aside to spend three hour blocks on literacy.'

Challenges to school science. While many parents were generally supportive of science instruction and of their school's programs, they seemed to have mixed feelings about the fifth-grade science assessments as a motive for including science. One parent explained the testing dilemma that teachers and principals discussed:

> I'm very grateful that science is important in 5th grade, but I fear that it's only important in 5th grade because the state mandates and tests it in 5th grade, and I worry if for whatever reason the state decides not to test it anymore that the importance of science will go away for 5th graders.

Impressions of outdoors in and out of school. Many parents described their children's love of time spent outdoors. '[My child] loves to play in the dirt ... he was always the outside type of person.' Some parents worry about their children's safety outside. 'I worry about him outside because there are bad kids who live in the neighborhood . . . I also worry about insects because there are some bad ones.'

Environmental awareness. Several parents expressed the desire for their children to learn about environmental issues. One parent explained:

> I think environmental science is a really important topic to teach kids very early, because of the fact that we are all on this earth with limited resources and we need to teach them about the environment and about our limited resources.

Many parents described the importance of recycling, composting, water conservation, and keeping water clean and expressed an interest in their children learning some basic knowledge. 'I think a basic understanding of how people broadly impact, both positively and negatively, the natural world.' One parent of a student at Frasier said that her devotion to recycling came from her child's insistence.

The presentation of these key stakeholders' views on elementary science, environmental science, and images of the outdoors for both recreation and learning are intended to unpack the various influences on the current state of elementary science and environmental education. While many of the adults supported including environmental education in elementary science, they also recognized the impact of testing policies that steer emphasis away from science and toward mathematics and literacy. In addition, fifth-grade testing of science skills influenced teachers who more strictly adhered to the tested curriculum. This focus on testing was also reflected in student responses, and most often elicited fear and stress in relation to science. In the following section, we discuss the implications of this elementary science snapshot at two schools to tease out some of the implications for science education.

Study Limitations

Results and interpretations of this study are grounded in the sample size. We make no attempt to generalize these findings. All results and discussions of such results should be carefully interpreted (specifically, all comparative analyses regarding ethnic differences) due to the fact that we had small sample sizes for Hispanic students ($N = 19$) and Asian students ($N = 9$). While both schools in this study had rich outdoor spaces, it is important to note that many opportunities exist in urban settings to provide students with schoolyard and outdoor field trip experiences (Lopez, Campbell, & Jennings, 2008).

Discussion and Implications

Similarities Between Student Scores, Outdoor Learning Experiences, Stakeholder Beliefs, and Emphasis on Testing

Years of science reform efforts have met with mixed results (Hughes & Byers, 2010; Tytler, 2010), and the overwhelming absence of elementary science memories of adults in this study suggests that a paucity of meaningful science experiences and content for learners persists.

Further, environmental education, while supported by many stakeholders, has not been effectively implemented in the USA (Aikenhead, 2003; Pederson & Totten, 2001). The surprising lack of difference in scores between the two schools may be explained by the apparent resemblance between the schools. Interviews and observations revealed distinct similarities between outdoor experiences, perceptions of teaching science and environmental science, and an emphasis on testing. While the principal and teachers at Frasier believe that their school is unique in its 'outdoor culture' there was not much difference from Caswell in the actual outdoor experiences of the fifth-grade students. Frasier's teachers expressed a greater commitment to providing outdoor instruction early in the school year, but field notes and student interviews revealed that the expectation that Frasier's students would have significantly more outdoor instruction compared to Caswell's students did not materialize. Students in both schools attended outdoor field trips and participated in some schoolyard experiences (e.g. collecting materials for indoor microhabitats or observing landforms), but they failed to identify those experiences during interviews as school science and rather saw them as separate from organized science learning.

Though teachers, parents, and administrators in the present study recognize the value in outdoor experiences in relation to science instruction, only parents seemed to identify it as an essential part of elementary school science. Teachers and administrators (especially at Frasier) tended to express high levels of enthusiasm for outdoor instruction, yet interview responses revealed that they saw it as peripheral to classroom-based lessons as opposed to identifying aspects of science instruction that were most appropriately taught in the outdoors. Although many students wanted to go outside during science, they tended to be surprised by the idea that some science lessons could be most appropriately taught outdoors, associating outdoor experiences with lower grades. This decrease in outdoor education in upper elementary grades has also been documented in England (Kendell, Murfield, Dillon, & Wilkin, 2006; O'Donnell, Morris, & Wilson, 2006). Students in the present study often viewed school science instruction in fifth grade as bounded by the classroom walls, and while science at school included hands-on activities, many students connected science with copying vocabulary words, note-taking, and tests. Teachers in this study saw outdoor settings as peripheral to science instruction in general, and they clearly articulated a relationship between the science they were teaching and the world around them. Yet while the teachers felt these real-world connections were clear to the students, the students saw science as occurring in school and failed to make connections beyond the classroom. This disconnect between teachers and students' views in the present study may be addressed by making purposeful connections for students, linking outdoor experiences to science in the natural world and science habits of mind.

Though teachers and principals seem to de-emphasize outdoor learning in science instruction, their memories of science point to its importance. Adults shared limited memories of elementary school science in general, suggesting that their science instruction lacked luster or emphasis in their elementary schooling. Interestingly, the few school science and other childhood memories related to science seemed tied to the adults' childhood experiences in the natural world. As Frasier's principal described, his only memory of elementary science was spending a day outdoors. Given the limited memories of elementary science in general in this study, these findings suggest that learning in and about the natural world has the potential to build memories of elementary science for students. Such memories can be powerful influences in adult life. Several naturalists and environmentalists recall experiences as children that they tie to their lifelong interest in science (Chawla, 1998; Feynman, 1999; Palmer, Suggate, Rothbottom, & Hart, 1999; Tanner, 1980; Wilson, 1994). Experiences in the natural world can generate lasting memories of science instruction, having the potential to impact learners into their adult lives. The adults in this study who described themselves as 'outdoorsy' related their identity to childhood experiences in the natural world (Duerden, Taniguchi, & Widmer, 2010; King, 2010), offering further contributions that may support environmental stewardship.

The similarity of outdoor experiences between the two schools may reflect a shared view on teaching science. Teachers' context beliefs (Ford, 1992) about science instruction were illustrated in their complaints about the lack of delegated time for science. These views also suggest that teachers in this study approached science teaching as knowledge transmission (Calderhead, 1996), which can be incongruent with outdoor learning (Estes, 2004). Teachers described their feelings that science instruction lacked support (i.e. time), and that they were underprepared to adequately address science based on weak preparation. The teachers' antecedent capability beliefs (Ford, 1992) were perhaps formed by the absence of elementary science models when they were students, ineffective science teaching at higher levels, and their described lack of science teacher preparation in science methods coursework. Hawkins (1990) described the 'loop in history' of teachers who were taught little science and taught poorly, then become teachers themselves and continue the pattern (p. 97). Many elementary teacher preparation programs require five or fewer science courses (Blank, Kim, & Smithson, 2000; Weiss, Banilower, McMahon, & Smith, 2001), and Ball (1988) explained that despite teacher preparation, many teachers tend to fall back on teaching how they were taught.

In addition to all the stakeholder influences explored in this study, acknowledgement of the testing and curricular constraints imposed on environmental and outdoor learning also surfaced as a significant factor that influenced ecological and outdoor learning. Some teachers' focus on helping students perform well on science assessments revealed their personal beliefs and view of science as a body of knowledge, and of their role as teachers of bounded facts. Furthermore, they seemed to identify their professional effectiveness with student performance on standardized tests. This view of the role of school science as test preparation situates outdoor and environmental science as challenges to instruction time, although most teachers expressed a willingness to dedicate class time to discussion of related environmental issues.

The testing culture of fifth grade means the two schools face the same district obligations to prepare students for the high-stakes measures of the four key content areas. In many states, elementary science progress is assessed only in the fifth grade, the same general stage when students begin to lose interest in science (Archer et al., 2010). Tests measure a limited range of learning outcomes, and science is allotted little time in a typical school day (Cocke, Buckley, & Scott, 2011) compared to other subjects, specifically mathematics and reading. While the content areas addressed in this study had potential connections to outdoor learning (weather, ecosystems, landforms, and force and motion), the teachers' efforts to efficiently meet objectives within a limited timeframe seemed to overwhelm their intentions to extend outdoor connections to the content, the natural world, and students' lives. While the interviews revealed overall support and intentions for outdoor experiences and environmental education, even the teachers initially committed to teaching science in the outdoors failed to include significant science and outdoor experiences, in a large part because of the emphasis on tested science knowledge. We question the degree to which the emphasis on testing and narrowing of the curriculum impact students' impressions and interest in science and teachers' attitudes toward teaching science (Pringle & Carrier Martin, 2005; Jones et al., 1999). Answers to these questions are beyond the scope of this study, but given the documented decline of interest in science at the end of elementary school, this topic deserves continued attention (Osborne, Simon, & Collins, 2003; Yager & Penick, 1986).

We failed to detect a difference in student scores between the two schools, but we did find score gains in measures by both groups. The CS measures of science knowledge in this study were directly related to the learning objectives for fifth grade. As all stakeholders expressed concern in meeting state testing requirements, it is not surprising that we found an increase in student scores on these state objective-aligned measures. In this study, one parent described her attention to recycling because of her child's influence. This potential for students to influence home practice has been found in other research (Evans, Gill, & Marchant, 1996; Vaughan, Gack, & Solorazano, 2003).

The encouraging gains in students' environmental attitudes may reflect teacher efforts or parental support. Though teachers in general failed to link outdoor experiences directly with science instruction, they did take students outside, if only for supplemental instruction or recreation. Outdoor experiences have been repeatedly linked to gains in environmental attitudes (Carrier Martin, 2003; Carrier et al., 2013; Cheng & Monroe, 2010), and these experiences may explain the gains in environmental attitudes in our study. Further, though some parents expressed concerns about safety in the outdoors, many parents described support for environmental issues, so gains in environmental attitudes may be attributed to factors at home. Although outdoor experiences may have impacted environmental attitudes, they appear to have failed to influence outdoor comfort levels. As stated before, the number of outdoor experiences was limited at both schools, and it may be that students lacked sufficient exposure to the outdoors to impact this measure. Another explanation could be that students' pretest scores were initially solid, therefore failing to identify significant changes from pre- to posttest. Many students responded to a CLS question about bird or insect sounds as 'music to my ears' and stated that being in nature was 'peaceful' in both pretest and posttest measures.

Differences Associated with Student Gender and Ethnicity

With respect to gender differences, our study found gender differences only regarding environmental attitudes. Namely, girls scored significantly higher than boys on both pretest and posttest measures regarding pro-environmental attitudes. Additionally, girls made significant growth on their environmental attitudes from pre- to posttest, while boys did not. These findings are consistent with other research that suggests girls are more aware of environmental issues and are more proactive environmentally in general (Carrier, 2007, 2009; Cavas, Cavas, Tekkaya, Cakiroglu, & Kesercioglu, 2009; Uitto, Juuti, Lavonen, Byman, Meisalo, 2011), suggesting that more effort should be made to establish emotional connections with the environment among boys.

The substantial ethnicity-related differences on all student measures suggest that special attention should be paid to ensure that science and outdoor instruction are culturally responsive. Supporting previous research on environmental knowledge (Carrier et al., 2013), Caucasian students' scores were the highest on all science knowledge measures followed by Asian, African-American, and Hispanic students. Further, Hispanic students did not display significant knowledge changes on each objective's pretest and posttest scores. Given the changing populations of US schools (Fry, 2007; Perez & Hirschman, 2009), this particular issue is timely and relevant. These results may reflect a lack of English proficiency for Hispanic students, given the fact that all tests were administered in English. Looking beyond language barriers may help explain score differences associated with African-American students, such as expectation bias (de Boer, Bosker, & Van der Werf, 2010) or cultural views of schooling (Ogbu & Simons, 1998), including a 'culture of power' (Calabrese Barton, & Yang, 2000). While observational data from this study do not directly indicate unbalanced treatment toward any group of students, it is important to consider the possibility that students of multiple cultural backgrounds may struggle to see themselves as 'scientists'. Madaus and Clarke (2001) clearly identify high-stakes testing as an inequitable way to assess students who differ in race, culture, native language, or gender. Furthermore, assessments that fail to accurately measure student knowledge and learning but instead identify language or cultural differences fail in intent. Science experiences that occur outside traditional classroom walls have the potential to connect students who may not feel a direct 'fit' with traditional science instruction, providing an avenue for communicating science to students of broad backgrounds (Bowen & Roth, 2007).

In addition to finding science knowledge gaps associated with ethnicity, the differences related to environmental attitudes and outdoor comfort levels point to a need to engage diverse groups of students in outdoor learning. Our results are informed by previous research (Ellis & Korzenny, 2012) that found Spanish-speaking Hispanics had the greatest pro-environmental behaviors. While not statistically significant, Hispanic students in this study scored highest on measures of outdoor comfort. This connection may lend further support to the bias associated with language or school culture. Time outdoors may be especially important for English language learners. When a child has language challenges, whether native or academic, multi-sensory experiences can provide a foundation for learning. Furthermore, in at least a few studies, outdoor experiences were shown to disproportionally improve environmental attitudes among African-American and Hispanic students over Caucasian students (Carrier et al., 2013; Larson, Whiting & Green, 2011), suggesting that outdoor learning could be a promising strategy to engage these students in science, the outdoors, and environmental learning in general.

Conclusions

The lack of outdoor instruction in this study, despite the best of intentions of teachers at Frasier, points to both the pervasiveness of the testing culture as well as the acute need for professional development to train teachers on how to effectively use the outdoors to enrich student learning. Although the scientific topics in this study lent themselves well to outdoor instruction, there was no clear evidence of the teachers' ability to effectively incorporate the outdoors for instruction. None of the teachers in this study reported teacher preparation for outdoor instruction, nor did they have many models of outdoor instruction as students. The findings from this study support other researchers' calls for combining efforts of policy-makers, universities, schools, and curriculum developers in supporting professional development experiences designed to increase teachers' capacity to bring environmental and science literacy to all students within the elementary science curriculum (Forbes & Zint, 2011; Lock & Glackin, 2009; Shepardson et al., 2003).

In this time of changing climate and global initiatives, elementary students of today will face complex decisions that require not only science literacy but also EL. Elementary educators' contributions toward these goals can have powerful implications and benefits impacting future generations. Though outdoor instruction offers promise for building both the cognitive (i.e. ecological knowledge) and affective (i.e. environmental attitudes and outdoor comfort) domains of EL, this study highlights how a pervasive testing culture can overcome even the best of intentions to include outdoor instruction, potentially diminishing benefits to students. Our results suggest that even the most well-intended school outdoor learning initiatives will fail to achieve EL among students without more effective integration of outdoor instruction with science instruction (Gough, 2002). Efforts must be made to ensure students of all backgrounds are prepared to fully engage in emerging environmental challenges.

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Appendix. Sample teacher interview questions

1. Thanks for your time and for agreeing to the interview. These are just some questions about science and your background and about science and environmental issues. So first of all I want to start off with where did you grow up?
2. And are you board certified?
3. How many years have you been teaching?
4. How do you view the role of science instruction in elementary schools today?
5. What are your personal memories of science in elementary school?
6. What do you think your students are going to remember about science in your classroom?
7. How do you balance the pressures related to science content objectives with the goals to include hands-on activities?
8. Is there anything you do beyond the kits?
9. How do you feel about the role of learning environments indoors and out and are there situations where you take the students outdoors?
10. Regarding your personal activity choices would you consider yourself an outdoorsy person or do you feel more comfortable with indoor activities?
11. Do you have any personal memories about your outdoor experiences when you were growing up?
12. As an educator, can you share any special memories of children learning science either indoors or out?
13. What do you feel is the most important environmental issue today?
14. Do you incorporate environmental issues or concerns into the classroom and if so, how?
15. What's your favorite subject?
16. As a teacher, what would best support your science instruction?
17. Do you have anything else you'd like to add?