THE PRAIRIE SCIENCE CLASSROOM: ORIGINAL OUTCOME DURABILITY AND IMPACT ON THE CONNECTION TO NATURE

A Thesis
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

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In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Biological Sciences

November 2016

Fargo, North Dakota

North Dakota State University
Graduate School

Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Environmental Education (EE) seeks to create an informed citizenry capable of taking action on environmental issues. Recent calls for more consistent evaluation of EE point to a need for more long-term evaluations as well as more qualitative evaluations if we are to understand if EE is actually meeting its stated goals. The current study evaluated long-term impacts of the Prairie Science Class (PSC), a formal EE partnership between the U.S. Fish and Wildlife Service and an independent school district. This study analyzed both quantitative and qualitative data to investigate outcome durability of the PSC, as well as the impact of the PSC on the connection to nature, a construct thought to be a predictor of future environmental behavior.

ACKNOWLEDGEMENTS

First I would like to thank my advisor, Lisa Montplaisir, for working with me on this project. I would like to thank Molly Stoddard of the U.S. Fish and Wildlife Service for her assistance with answering all of my questions about the Prairie Science Classroom throughout the course of my degree. I would also like to thank Julie Ernst, PhD (University of Minnesota Duluth) for her consultations with me on this research, Madison Milbrath and Laura Paulson for their assistance with the qualitative analysis, and Anqing Zhang for her assistance with the statistical analysis.

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INTRODUCTION

We live in a world increasingly altered by human activities. Although children are not responsible for the environmental damage that is currently taking place, they will surely inherit the consequences. We need to change our behavior toward the environment if we are to avoid increasingly severe environmental consequences, and environmental education plays a critical role in changing our beliefs, attitudes, and behavior related to environmental issues (Oskamp, 2000; Stapp, 1969). Although EE plays an important role in education, our current understanding of the effectiveness of EE is incomplete. While some research in the field tries to reveal what practices make EE effective, it is still unclear which aspects of EE curriculum lead to long-term impacts on students. If we are to continue to put effort into EE curriculum and programs in the hopes of better preparing future generations to deal with the environmental consequences of our actions, we must also continue to work towards understanding how to best achieve EE goals through consistent evaluation (Bergman, 2015; Carleton-Hug, 2010; Rickinson, 2001).

This study examines the long term outcomes of a formal EE partnership, called the Prairie Science Class, between the U.S. Fish and Wildlife Service and an independent Minnesota school district (PSC). The Prairie Science Class is a year-long immersive environmental education program for 4th and 5th graders. In this study, I had two main research goals: 1) to determine if an EE curriculum of long duration, such as the PSC, can lead to durable outcomes, and that 2) EE curriculum that includes consistent time spent in a pristine nature setting, such as the PSC, can lead to an increased connection to nature.

Environmental Education

Although roots certainly go back 100 years or more, increasing urbanization in the early part of the 20th century, an increased cultural awareness of environmental issues in the 1960s and

the first Earth Day in 1970 led to an increased interest in education for the environment and sustainability (Gough, 2013; Smyth, 2006). This increasing awareness of the importance of environmental literacy led to the Tbilisi Declaration, a result of the United Nations Educational, Scientific and Cultural Organization (UNESCO) first Intergovernmental Conference of Environmental Education in 1977. The Tbilisi Declaration included one of the first sets of goals and outcomes that helped to define the field of environmental education. While various attempts have been made to update or revise the original goals (Lee & Williams, 2001), they are still widely used in the literature (Chawla & Derr, 2012; Ernst & Theimer, 2011; Hungerford & Volk, 1990). The goals of fostering awareness of environmental issues, providing access to knowledge and skills needed to protect the environment, and creating behavioral change toward the environment were identified as critical to creating an environmentally responsible citizenry (UNESCO, 1978).

Evaluating Environmental Education

Common Approaches

Two common themes emerge in the literature for how EE is evaluated – short term evaluations and knowledge-based evaluations. In general, research on EE is primarily short-term, that is, outcomes for EE are evaluated a short time after implementation, and routinely lack a long-term or longitudinal follow up (Bergman, 2015; Carleton-Hug & Hug, 2010; Chawla, 2006; Chawla & Derr, 2007;). This is often due to practical constraints, such as the inability to track EE participants for a sustained period of time after the implementation, or the nature of the EE experience itself. In many cases, EE experiences can take the form of a field trip to a location away from the formal school environment, and environmental educators at the external site may not have access to students after the students leave the site, or the students were from several

different locations, making a follow-up evaluation more difficult. While some studies do not explicitly report the timeframe for collecting evaluation data, it is clear that a longitudinal analysis was not carried out. For example, in an evaluation of the Ferry Beach Ecology School (PEER, 2011), evaluation data for student science and ecology knowledge and attitudes about environmental stewardship are matched to the school year in which the programming was carried out. Similarly, while Cachelin, Paisley and Blanchard (2009) do not specify exactly when evaluation of student perceptions and knowledge of a wetland took place, it was clearly within a short time-frame of the EE programming described in the study. In an evaluation of connectedness to nature in seven EE programs, Ernst and Theimer (2011) collected pre and post-data as close as possible to the EE programming. Other example of short-term evaluations can be found in Bergman (2015), Leiflander et al. (2013), Sellman and Bogner (2013), and Zint et al. (2002).

Several studies have attempted a longitudinal evaluation, but none exceed a timeframe of one year. For example, a study by Bogner (1998) indicated that students who participated in a five-day outdoor camp showed an increased willingness to commit to positive environmental action six months later. Knapp and Benton (2006) found evidence for knowledge retention and positive emotional impacts in students at a residential outdoor education program for 5th grade students one year later. Although it was not a longitudinal study, Bergman (2015) found that in general, multiple years of EE programming had a cumulative effect on students' eco-appreciation and intentions of eco-behavior, lending some support to the idea that longer-term experiences lead to more lasting effects.

In addition to evaluations looking at short-term outcomes, previous research was primarily focused on outcomes related to environmental knowledge (Chawla, 2006; Hungerford & Volk, 1990). The emphasis on assessing environmental knowledge can be partially attributed to the misconception that knowledge alone is enough to encourage pro-environmental behavior, although it is now understood that knowledge alone does not lead individuals to act in an environmentally responsible way (Bamberg & Moser, 2007; Hungerford & Volk, 1990; Kempton et al., 1995 in Kollmuss & Agyeman, 2002).

Although EE research has begun to focus more on what leads individuals to act in environmentally friend ways, knowledge based evaluations are still common, particularly for evaluations of specific programs. In an evaluation of an environmental science and outdoor education program, Summerford (2015) used standardized test results to compare treatment and control groups. The previously cited evaluation of the Ferry Beach Ecology School (PEER, 2011) also used ecology and science knowledge as a primary component of evaluation, as well as the Cachelin, Paisley and Blanchard (2009) evaluation of a Nature Conservancy Wetland EE field trip.

Although some research does investigate other aspects of EE, the predominance of short-term and knowledge-based approaches have led to calls for increased evaluations focused on other EE outcomes, specifically long-term durability of outcomes and outcomes related to pro-environmental behaviors.

Recommendations for Evaluation

As a result of the primarily short-term and knowledge-based approaches to evaluating EE, reviewers have called for a more diverse and rigorous approach to evaluation. Environmental education experiences that are longer in duration are uncommon, so evaluations

of longer duration EE programs are critical for confirming the idea that longer duration EE experiences are more effective than short-term ones (Bergman, 2015; Chawla, 2006). Also important are evaluations focused on outcome durability – whether or not EE outcomes persist over a longer time frame, since most studies focus on outcomes either immediately following an EE experience, or within weeks or months (Chawla & Derr, 2007; Rickinson, 2001). In addition, research that facilitates understanding of how EE furthers the goal of creating citizens capable of acting on behalf of the environment is needed, and although recent research (for examples see Ernst & Theimer, 2011; Sivek, 2002; Tanner, 2010) has begun to investigate this aspect of EE, more work is needed (Chawla & Derr, 2007; Rickinson, 2001). And lastly, Carleton-Hug and Hug (2010) describe an overall lack of evaluation and a lack of evaluation consistency in the EE field in their review, yet it is clear that more evaluation of EE is needed. These recent calls to action provide guidance for EE researchers looking to contribute to the field.

The Significant Life Experiences Framework

Pro-environmental behavior, an explicit goal of the Tblisi Declaration, is thought to be related to our relationship with nature, or our sense of belonging to nature (Shultz, 2002; Shultz & Tabanico, 2007). Kollmuss and Agyeman (2002) describe pro-environmental behavior as "behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world (e.g. minimize resource and energy consumption, use of nontoxic substances, reduce waste production)."

One predictor of pro-environmental behavior is quantity and quality of time spent in nature as a child. Tanner (1980, 1998) noticed a pattern in the writings of notable naturalists and scientists, where the writers commonly described abundant time spent in nature during childhood, either alone, or with only a few other people. Tanner named this phenomenon the

Significant Life Experiences (SLE) Framework – significant time spent in nature as a child is a good predictor of adult interests and behavior. Chawla (1988) noticed a similar pattern among people working in conservation careers. Conservationists or others in related careers were more often motivated by time spent in nature than they were by the academic study of nature. Similarly, Wells and Lekies (2006) interviewed 2,000 adults found childhood experiences in wild natural settings to be predictive of adult environmental behaviors. This pattern of childhood experiences leading to adult behavior can inform the development and evaluation of EE curriculum with the goal of long-term behavioral change.

Environmental Sensitivity and Connection to Nature

Environmental sensitivity (ES) and connection to nature are similar terms related to an individual's feelings of connection to the natural world and both have been established as playing a role in shaping later pro-environmental behavior. Environmental sensitivity is often defined as "a set of affective characteristics that result in an individual viewing the environment from an empathetic perspective" (Ernst & Theimer, 2011) and is thought to be an entry-level variable in determining pro-environmental behavior. Similar to findings from previous SLE research, ES is thought to result from frequent early experiences in natural settings (Hungerford & Volk, 1990). Although related to ES, and playing a similar role in EE research, the connection to nature is defined as an "affective, experiential sense of oneness with the natural world" (Mayer & Frantz, 2004). Connection to nature was chosen for this study for several reasons. 'Connecting people to nature' is an explicit goal of the U.S. Fish and Wildlife Service (PWLC, 2015[c]), behavior change is an explicit goal of EE as described in the Tblisi Declaration, and several characteristics of the EE curriculum in this study are consistent with previous findings in

SLE research about what aspects of EE will most likely lead to long-term impacts and later pro-environmental behavior.

Research Goals

The overall goal of this study is to answer the recent calls for evaluations that focus on durability of EE outcomes and how EE affects precursors to pro-environmental behavior. Specifically I wanted to 1) assess the durability of the original PSC outcomes using original PSC evaluation tools and 2) assess the PSC's impact on connectedness to nature as a precursor to pro-environmental behavior.

Study Area: The Prairie Science Class

An example of EE that includes aspects of place-based and outdoor education is the Prairie Science Class (PSC). The PSC is an ideal study area, in that it immerses students in a long-duration environmental education experience that connects students to their local environment using a place-based and outdoor approach to curriculum.

The PSC is a formal partnership started in 2003 between Minnesota ISD 544 and The Prairie Wetlands Learning Center (PWLC), part of the Fergus Falls Wetland Management District of the U.S. Fish and Wildlife Service. The PWLC is located on the Townsend Waterfowl Production area, which encompasses 330 acres characteristic of the Prairie Pothole Region. The PSC provides interdisciplinary instruction in science, math and writing to 4th and 5th grade students using the Prairie Pothole ecosystem as an integrated learning context. Although the original PWLC building had room for only 2 classes of 5thth grade students, an additional classroom wing was built, made possible by a $2 million state appropriation and $500,000 from the Friends of the Prairie Wetlands Learning Center non-profit group. This expansion project was due to popularity of the PSC and general space constraints in the school district; starting in

2008, the expansion allowed the PSC to be offered to both 4th and 5th grade students (Garrahan, 2007).

For the entire year a student is in the PSC, they spend half of every school day at the PWLC. The PSC treats the outdoor environment as an extension of the classroom and part of each day is spent outside doing various field activities related to the school curriculum. Through their time in the PSC, students gain extensive knowledge and an intimate appreciation for the Prairie Pothole landscape. PSC goals include developing knowledge and skills in science, language arts, social studies, art, health, and applied math; increasing motivation toward learning; developing technology, problem solving, and communication skills; and fostering character skills and a stewardship ethic (PWLC, 2015[a]).

Original PSC Evaluation Outcomes

Formative evaluation reports for the 2003-2004 (Ernst, 2004), 2004-2005 (Stoddard et al., 2006[a]) and 2005-2006 (Stoddard et al., 2006[b]) school years were prepared to determine whether academic achievement for PSC students was either better or not significantly different than other ISD 544 students. The results for all three evaluations suggested positive affective and cognitive self-reported outcomes:

1. Increase in self-assessment of science process and problem solving skills.
2. Improvement in science, due to practicing observation skills and making discoveries in an outdoor setting.
3. Improvement in problem-solving, attributed to 'reading the land', learning in the outdoor classroom, and first-hand observation.
4. Increase in interest in school and learning.

5. Positive change in students' attitudes toward the prairie wetlands environment, a stronger stewardship ethic, and a stronger sense of civic responsibility.
6. Student interviews indicated that students felt the PSC positively influenced their actions in the environment.
7. Interviews also indicated exceptionally positive feedback from students and parents, many of whom suggested that the PSC be expanded to include more students.

Preliminary Durability of Outcomes

The 2005-2006 evaluation report also included a preliminary assessment for durability of PSC outcomes using the Ecosystem Experiences Project, an important component of the life sciences curriculum for all ISD 544 7th grade students since 1998. This year-long project consists of a classroom visit by a FWS employee, three field-trip visits to the PWLC to collect data for a scientific experiment and the use of ecosystem journals. Although this project is not new to the 7th grade curriculum, this was the first year that former PSC students completed the project and so was an opportunity to look at the possible durability effects of the PSC program. According to teacher interviews, former PSC students did not show a difference in science knowledge, although they were more comfortable asking questions to FWS staff and teachers, and self-reported using skills they felt they had learned in the PSC. They were also more enthusiastic on their field visits to the PWLC for the Ecosystem Experiences project, which was attributed to their having previously spent their 5th grade year in the PSC (Stoddard et al., 2006).

PSC Participation

The PWLC also provides day programming for other schools and other grades in ISD 544. All students in ISD 544 have some exposure to the PWLC and the staff there regardless of whether they are in the PSC class or not. Generally, students participate in multiple half-day field

trips to the PWLC most years through the 3rd grade, so all students have some experience with the Prairie Pothole environment and a small amount of exposure to what the students in the PSC do every day, as shown in Figure 1.

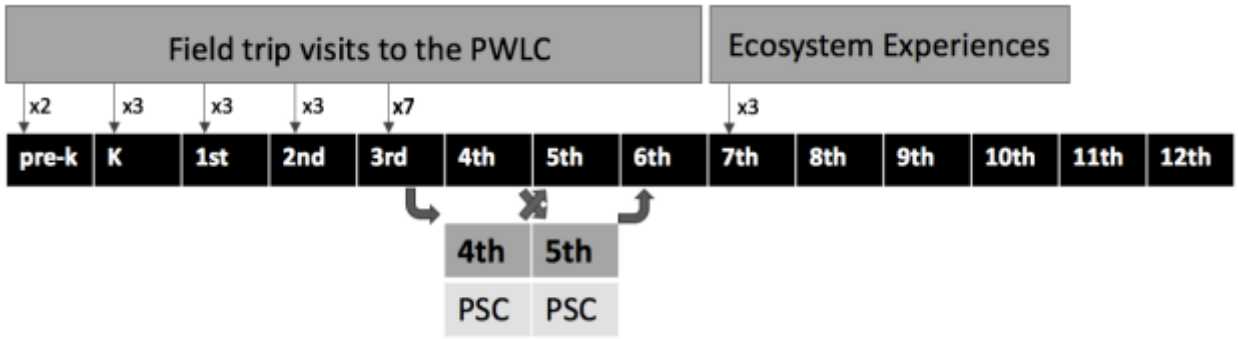

Figure 1. Timeline showing exposure to the PWLC learning environment across all grade levels. Approximately 64% of 4th and 5th grade students spend 2 ½ hours each day for the entire year at the PWLC for the PSC.

METHODS

Surveys

To assess the durability of the original PSC outcomes and assess the PSC's impact on connectedness to nature as a precursor to pro-environmental behavior, survey data were collected as a convenience sample from n=50 high school students from the graduating class of 2017, 64% of whom were previous PSC participants (Table 1). As not all students in ISD 544 participate in the PSC, the 36% of the class of 2017 who did not participate were used as a natural control group. Students were asked to volunteer to take a short survey during their study hall period, as it was highly desired by school administration that the activity not disrupt the normal school day. There were three different levels of participation in the PSC among the study participants: Participation of one year in the 4th or 5th grade, participation for two years in both 4th and 5th grade, and no participation.

Table 1

Number of students in each participation level of the convenience sample

Level of Participation	n
One year	11
Two years	21
None	18

I used four separate surveys to collect data: two surveys measuring the connection to nature and two original PSC evaluation instruments, as shown in Table 2. I chose to use the Mayer and Frantz (2004) connectedness to nature scale (CNS) because it was validated using college age participants, which were closer in age to my study population than another similar survey designed for children. In the original validation study, the connectedness to nature scale was found to be positively correlated with ecological behavior (Mayer & Frantz, 2004) and

although ecological behavior is not defined in the original validation study, pro-environmental behavior, a closely related phenomenon, has been described as "behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world" (Kollmuss & Agyeman, 2002). A second similar survey, the Nature Connectedness Inventory (NCI), was used to check internal validity of the study, similar to the approach used in Ernst & Theimer (2011). Ernst and Theimer designed the NCI to address the same areas as the Mayer and Frantz CNS, but it uses a response scale that allows the participant to identify with a particular view, rather than try to choose the answer they feel is more correct. To measure the durability of the original PSC outcomes, I used the same instruments as the original PSC evaluations, which are available through the FWS staff at the PWLC. All survey instruments were combined into one survey, in an effort to minimize the amount of participant confusion during the survey and to ensure that all participants completed all parts of the survey.

To determine durability of the original PSC outcomes and impact on the connection to nature, data from student surveys (n=50) were analyzed using a one-factor between-subjects ANOVA for each survey component (shown in Table 2), where each student was in one of three participation levels for the PSC (one year, two years, or none). The ANOVA was used to determine if significant differences exist between the PSC participation levels within the sample population. A Tukey test was used to determine any significant differences between participation levels for any of the survey components. A post-hoc power analysis was completed using G*Power (Faul et al., 2007).

Table 2

Surveys, survey question types, and use in previous PSC evaluations

Survey	Questions and response type	Analysis	Used in original PSC evaluations
The connectedness to nature scale (Mayer & Frantz, 2004)	14 items on a 5-point Likert scale	All questions used for an overall mean score	No
Student affective self-report (Ernst, 2004)	20 items on a 5-point Likert scale	3 composite scores: 1. Attitudes toward school and learning 2. Attitudes toward the prairie wetlands environment 3. Stewardship ethic and civic responsibility	Yes
Student skills self-report (Ernst 2004)	14 questions on a 4-point scale	1. Composite measuring science process skills 2. Individual items measuring communication skills and working cooperatively with others	Yes
The nature connectedness inventory (Ernst & Theimer, 2011)	11 two-part questions on a likert-type scale	All questions used for an overall mean score	No

Interviews

To further investigate durability of the original PSC outcomes, I conducted parent (n=5) and student (n=3) interviews. Interview protocols (Appendices A, B & C) were informed by interview protocols from the original PSC evaluations, as well as feedback from a meeting with PSC teachers about their observations of past PSC students and were designed to elicit responses to three a priori themes: PSC skills, family and social impacts, and academic impacts. Student and parent interview questions were similar, although rephrased to take into account the different

perspectives (Table 3). Parents received a letter requesting their participation in the study if their child was a former PSC student. Parent interviews were scheduled after school hours on the school grounds. Students who completed the survey instrument and were past PSC participants were asked to volunteer to take part in a brief interview after school hours on the school grounds.

All interviews were recorded using the Voice Record Pro application. Each interview was transcribed and stored as a de-identified interview transcript. Interview transcripts were coded and analyzed to identify responses to the a priori themes of PSC skills, family and social impacts, and academic impacts.

Table 3

Student and parent interview questions

Student Interview Questions	Parent Interview Questions
Tell me about your experience in the PSC.	Tell me a little bit about your child's experience in the PSC.
How often do you think about the PSC?	
If you do, describe some of the things you think about.	
How often do you talk about the PSC with our friends or family? If you do, what aspects do you talk about or share?	Does your child ever talk about the PSC with friends or family? If so, what aspects do they talk about or share?
Did the PSC influence your feelings about nature and how you treat nature? Does it still? How?	What influence, if any, do you feel the PSC had on your child's feelings about nature and how they treat nature? Does it still? How?
	What influence, if any, did your child's experience in the PSC have on your own feelings about nature and how you treat nature? Does it still? How?
What influence does the PSC have on your academic interests or career plans?	Do you feel your child's experience in the PSC has influenced their personal or academic interests? How so?
Can you give me an example of a skill that you did or learned during the PSC that you are still doing or using today?	Can you think of any skills or practices your child learned in the PSC that they still demonstrate or use today?
	Are there any other results of the PSC you have noticed that were not already mentioned?
Could you pick one thing that you experienced during the PSC that you hope students today will get to experience?	

RESULTS[1]

Survey Results

The ANOVA results indicated that there were no significant differences between the group means for the PSC participation levels for all of the survey components with one exception. The ANOVA results indicated that statistically significant differences exist among the means of the three participation levels for the survey component "Attitudes toward school and learning", shown in Figure 2 ($F(2,47)=6.41$, $p=0.0035$). A Tukey test showed that a significant difference exists between the means of the one-year participation level ($\bar{x}= 3.25$) and the 'none' participation level ($\bar{x}= 2.34$; $p<0.05$; Figure 2), and students in the one-year participation level had a 17% more positive response to the "Attitudes toward school and learning" survey component than students that were not in the PSC ($R^2=0.214$), with a moderately large effect size of 0.53. The power analysis indicated that with the present sample size, only moderate to large effect sizes could be detected, but more subtle effects could not be detected. For a full summary of the ANOVA results and power analysis, see Appendix D.[1]

[1] The material in this chapter was authored by Cedar Walters. Cedar Walters was solely responsible for data collection and interviewing participants. Madison Milbrath assisted with transcribing student and parent interviews. Laura Paulson assisted with coding of interview data. Anqing Zhang completed the ANOVA analysis and Tukey post-hoc procedures.

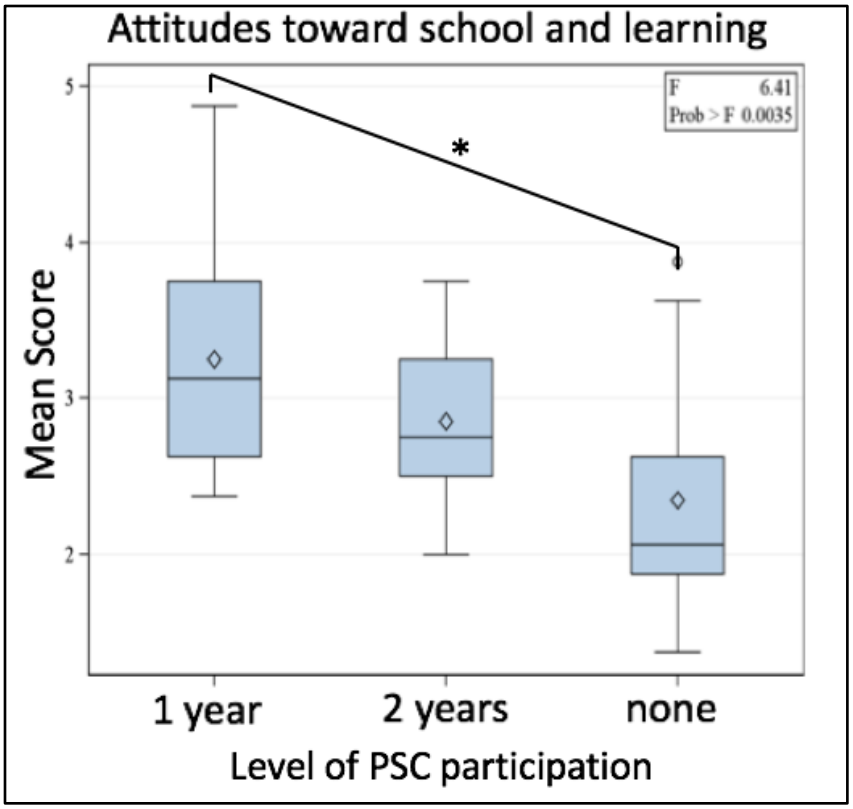

Figure 2. Attitudes toward school and learning. Significant differences exist among the means of the three participation levels F(2,47)=6.41, p=0.0035. A Tukey test showed a significant difference between the means of the one-year and none participation levels (p<0.05).

Interview Results

In contrast to the survey results, the interview results revealed more diverse long-term impacts on students. The majority of responses fell into four themes, the three a priori interview themes, given below, as well as a fourth theme, journaling, that emerged independent of interview prompt.

1. Prairie Science Class Skills
2. Family and social impacts
3. Academic impacts
4. Emergent theme: Journaling

Family and Social Impacts

In all parent and student interviews, the PSC was referenced in connection to either parent-student sharing or student-student sharing in the case of more than one child in a family participating in the PSC. One parent reported that their child shared more about their school experiences in the PSC than they did about their school experiences in the traditional classroom which was also a finding in the original PSC evaluations and several parents reported sharing memories of the PSC with their children on occasion in the intervening years. Both parents and students reported that having a sibling go through the PSC either before or after another child stimulated family discussion about the PSC, with siblings often comparing experiences, or if a sibling was younger, the younger sibling anticipating the experience in the future. Responses that included extended family members such as grandparents or cousins were mentioned fewer than three total times and are not listed in Table 4.

Table 4

Number of interview responses on family and social impacts

Responses related to:	# parent responses (/5)	# student responses (/3)
Parents	5	1
Siblings	2	3
Friends	3	1

Prairie Science Class Skills

This category of response included an array of skills that are intentionally included in the PSC curriculum (Stoddard, Molly (FSW), personal correspondence). Examples include general skills such as being observant, respectful, curious, prepared, or patient, as well as examples of specific behaviors such as ‘leave no trace’, photography skills, duck banding or skiing. All parent and student interviews included examples of one or more PSC specific skills and how

those skills impacted students beyond their time in the PSC. ‘Leave no trace’ was specifically mentioned by all student participants, suggesting that this practice has persisted over time. ‘Plant and animal ID’ was mentioned by all parent participants, suggesting that students are still using this skill years after completion of the PSC. A wide variety of other PSC skills were mentioned by parents and students, but did not display any consistent patterns, suggesting that different students may retain or use different skills according to preference or other unknown factors. Specific PSC skills mentioned fewer than three times are not listed in Table 5, but included being prepared, curious, patient, using photography, Seton watch, and building birdhouses or snowshelters.

Table 5

Number of interview responses on specific PSC skills

Responses related to:	# parent responses (/5)	# student responses (/3)
Plant and animal ID	5	2
Leave no trace	1	3
Respectful	2	2
Observation	2	2
Quiet	2	1

Academic Impacts

Positive academic impacts were referenced in all but one parent and student interviews. Often this took the form of an appreciation for applied skills that students would later use, such as a knowledge of real-life math skills and data collection, or knowledge about wildlife that informed later studies in biology. Interest or enjoyment of learning and science knowledge or process were mentioned the most frequently, followed by an appreciation of hands-on or applied

skills such as math. Academic impacts mentioned fewer than three times are not listed in the table, but included improvement in math skills and teamwork (Table 6).

Table 6

Number of interview responses on academic impacts

Responses related to:	# parent interviews (/5)	# student interviews (/3)
Interest/enjoyment in learning	3	2
Scientific method/science process/science knowledge	3	2
Hands-on/applied learning	3	1
General academics	2	1

Nature Journaling

Nature Journaling is emphasized in the PSC curriculum and therefore it is not surprising to find it was mentioned in most parent and student interviews, despite not being asked about specifically. Students in the PSC use nature journaling every day to record the weather, draw sketches, complete creative writing exercises and record other observations. Journaling was recalled across all but one parent and student interviews, and later writing skills were often attributed to the use of journaling in the PSC curriculum. In several instances parents or students recalled having saved their journals from their time in the PSC as meaningful mementos of the experience.

Table 7

Interview Categories and Representative Quotations

1. PSC Skills: PSC skills are recalled consistently across all interviews
"The first thing we would do when we would get to the prairie is you would stand on the railing and you just watch for a few minutes….so I think that definitely got ingrained into just observing what's around me." (student 2)
"Whenever we would go out in the field we used to always try to leave no trace, so whenever I go out I try to make sure I don't leave any huge impact wherever I went, or I would try to pick up whatever I see just lying on the ground…." (student 1)
2. Family and Social Impact: Family and social interactions had a reinforcing effect
"I think it was a real connecting tool…. for all 3 of them, but there are 7 years difference between my youngest and my oldest. So it was really good for them because all of a sudden she would be like - I have done something you have done." (parent 5)
"It comes up a little bit, only because like, my little brother might be going to the prairie soon…. I hope he likes it, because I liked it." (student 1)
3. Academic Impact: Appreciation for real-life application of skills was common
"I think it definitely helped, like, later in my biology class…. well, cause at the prairie we would look a lot at like animals and for example like birds we would look at like the kind of beaks they had, the kind of feet they had…" (student 2)
So they measured water temperature and took averages. So it gave him real-life math, not math that's out of a book." (parent 3)
4. Journaling Skills: Later writing skills were often attributed to PSC journaling
"Their writing skills grew exponentially with this program…. After that program he blew us out of the water. He sat down and started writing a book." (parent 1)
"It helped me with writing too especially. Because I had trouble with writing. The prairie kind of nudged me so I can do it not very well, but I can write competently…. We did a daily journal, and I kept mine for the longest time." (student 3)

DISCUSSION

Surveys

Durability of Original Outcomes

Out of the original PSC evaluation outcomes, an increase in attitudes towards school and learning was the only component to show any durability. It is somewhat unclear why this outcome persists when the others do not. This may be due to the hands-on nature of the PSC which is intended to engage students in authentic learning experiences, or some unknown characteristic of the students who are in the PSC. Although the results only indicated a statistically significant difference between the one-year and none participation levels, there is a discernable, although not statistically significant difference between the two-year and none participation levels as well. It is possible that as a result of the somewhat self-selective nature of enrollment in the PSC, students from families who emphasize the importance of education are more prevalent in the PSC, although this was not verified in the current study. The power analysis also indicated that with the current sample size, smaller effect sizes could not be detected. For example, students who participated in the PSC for one year did have a higher mean score for their self-reported ability to identify plants and animals in the prairie wetlands environment than students who did not participate in the PSC, but the difference was not statistically significant, due to low power as a result of a small sample size. So even if other effects were present, low power doesn't allow more subtle effects to be detected. Although it is encouraging to see the durability of one original outcome, it may be that six years is too long of a time to show durability more generally, a larger sample size would be needed to show more subtle effects, or that other assessments could better determine durability.

Connection to Nature

Impacts of the PSC on connection to nature are not clear in this study. Although it is reasonable to expect that the PSC would have an effect on the connection to nature due to many characteristics consistent with practices generally thought to increase ES or connection to nature, no difference between PSC and non-PSC students were found. This may be due to the consistent exposure to the PWLC environment for all ISD 544 students, in effect buffering any possible differences between PSC students and non-PSC students. It may also be that the experiences of the PSC alone are not enough to effect the connection to nature, as another similar study indicated. Ernst and Theimer (2011) also found the relationship between connection to nature and multiple EE programs to be unclear. Although in their study two programs did seem to increase connectedness to nature, they were not the programs the authors were expecting. Programs of longer duration are thought to lead to increased connectedness to nature, which was not consistent with their results and this led the authors to further question what aspects of EE contribute to an increase in connectedness to nature. Due to reasons previously stated, it is also possible that the instruments used in the current study were not able to capture differences between the participation levels.

Interviews

The student and parent interviews revealed a much more diverse range of impacts than the survey data, and did indicate some durability of the original PSC outcomes. Parent and student responses indicated that a variety of PSC skills still impacted the students in some way, either through current use of the skill, or that a particular activity was remembered more than others. A range of positive academic impacts were mentioned by students and parents, with comments related to interest or enjoyment of learning as a result of the PSC being mentioned the

most, along with comments about science process and knowledge. The pattern of responses related to interest or enjoyment of learning makes sense, considering that a positive attitude toward school and learning was the one significant result from the survey data. Most interviews also mentioned how the PSC impacted how students treat nature in a positive way, and some interviews mentioned a positive attitude toward the environment, both of which are similar to the original PSC outcomes. Interviews also indicated a variety of other impacts that although are not included in the original PSC outcomes, indicate long-term effects of the students' PSC experiences, such as increasing curiosity, seeking out nature for pleasure or stress-relief, or sharing PSC memories with family members or friends. The family and social impact theme was persistent across all interviews, and might indicate that sharing memories of the PSC serves an important reinforcing role in helping former PSC students remember and revisit their PSC experiences. It may be that the memories themselves might be important outcomes, as described by Liddicoat and Krasny in a 2014 study. Liddicoat and Krasny conducted interviews of residential outdoor environmental education (ROEE) participants, and proposed that memories of EE experiences have important functions, including *directive* (used to direct actions), *social* (allow people to converse and maintain relationships) and *self* (contribute to formation of identity and understanding of self) functions. The authors found that participants' ROEE memories did serve all of the functions they had expected by influencing later "environmental behavior, social interactions and personal reflections" (2014, p189). Interviews from the current study had similar qualities and example quotes as those described in the Liddicoat and Krasny study, indicating that memories of the PSC serve similar memory functions as those described by the authors. The use of memories to evaluate durability of outcomes or other lasting impacts of the PSC is a promising area for further investigation.

Recommendations

While the current study was somewhat limited in its ability to show durability of outcomes or connectedness to nature, the PSC curriculum includes many of the recommended aspects of EE that will create lasting effects in students, including an extended duration, place-based curriculum, positive experiences in a pristine natural setting, time in nature with positive role models, and the opportunity to practice action skills such as prairie restoration (Chawla & Cushing, 2007; Hungerford & Volk, 1990; Stern, Powell & Hill, 2013). Yet while the PSC curriculum is well-planned, it might be that further reinforcement through other grade levels would maintain the initial impacts over time. The 7th grade Ecosystem Experiences project field-trips are the last time students go to the PWLC. The PSC represents a substantial investment on the part of the school district and the FWS, and it would be worthwhile to make sure that the PSC has a lasting impact. So while the PSC curriculum itself is well-planned to create lasting impacts in students, reinforcement in later grades could extend the impacts of the PSC and further evaluations could lead to a better understanding of what those impacts are.

As the PSC is an ongoing partnership, it would be beneficial to all stakeholders to participate in periodic evaluations. For future evaluations, I recommend the use of interviews as the primary evaluation tool. Interviews best captured a variety of lasting impacts from student experiences in the PSC. Although a mixed methods approach would be valuable, I believe alternate assessments should be found or developed that would better capture durability of original PSC outcomes or impact of the PSC on ES or connection to nature.

Limitations

Survey Methods

There are several limitations for this study that need to be addressed. Student behavior while taking the survey, as well as one anecdotal report from a student parent, indicated that some of the survey questions were problematic due to the nature of the topics being covered. The survey packet may also have been too long. The additional non-validated survey (Ernst & Theimer, 2011) was probably not necessary, and was the most complicated to answer. Students may have begun to experience survey fatigue at some point while completing the survey packet, which contained over 70 questions. There is also the issue of selection bias or sampling error. Perhaps students who were in study hall periods shared other characteristics as well.

Interview Methods

Parent and student interviews were most likely influenced by selection bias. Parents were asked to volunteer to be interviewed, and it is likely that parents who had stronger feelings about the PSC would be more likely to volunteer to be interviewed than parents who were more neutral. This was also an issue with the student interviews, as it is likely that students with stronger feelings about the PSC would be more likely to be willing to be interviewed than students who were not impacted by the experience or had a negative experience.

Sample Sizes

In addition, small sample sizes for both data streams were a problem. The difficulties of collecting data from volunteers was compounded by school administrators not wanting to have any disruption in student school activities. Bergman (2015) found this to be a common problem in her review on assessing environmental education impacts – although it is critical to evaluate

EE programs and curriculum to find out what is effective, it can be difficult to find administrators willing to work fully with researchers to collect the data they need.

Conclusion

Although the connection to nature as a result of the PSC was not established with this evaluation, past PSC students had a more positive attitude toward school and learning, indicating some durability of the original PSC outcome of increased interest in school and learning. The interview data showed a much more diverse range of long-term impacts than the survey data, and indicated some durability of the original PSC outcomes in addition to responses to the a priori and emergent interview themes. This study also reinforced the previous finding that increased administrator participation in EE evaluation is essential for meaningful evaluation and while I recommend further evaluation of the PSC in the future, this issue should be addressed before further evaluation takes place. However, the current evaluation does indicate durability of some aspects of the PSC, which is promising for future evaluations of the PSC, as well as more general research looking at long-term impacts of EE curriculum.

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APPENDIX A. IRB APPROVAL LETTER

NDSU NORTH DAKOTA STATE UNIVERSITY

February 16, 2016

Dr. Lisa Montplaisir
Biological Sciences

Re: IRB Certification of Exempt Human Subjects Research:
Protocol #SM16156, "Longitudinal Effects of the Prairie Science Classroom"

Co-investigator(s) and research team: Cedar Walters

Certification Date: 2/16/2016 Expiration Date: 2/15/2019
Study site(s): Kennedy Secondary School, Fergus Falls, MN
Sponsor: n/a

The above referenced human subjects research project has been certified as exempt (category # 1) in accordance with federal regulations (Code of Federal Regulations, Title 45, Part 46, Protection of Human Subjects). This determination is based on the revised protocol submission with revised parent notification, youth assent and teacher/parent consent forms (received 2/10/2016).

Please also note the following:
• If you wish to continue the research after the expiration, submit a request for recertification several weeks prior to the expiration.
• The study must be conducted as described in the approved protocol. Changes to this protocol must be approved prior to initiating, unless the changes are necessary to eliminate an immediate hazard to subjects.
• Notify the IRB promptly of any adverse events, complaints, or unanticipated problems involving risks to subjects or others related to this project.
• Report any significant new findings that may affect the risks and benefits to the participants and the IRB.

Research records may be subject to a random or directed audit at any time to verify compliance with IRB standard operating procedures.

Thank you for your cooperation with NDSU IRB procedures. Best wishes for a successful study.
Sincerely,

Kristy Shirley

Kristy Shirley, CIP, Research Compliance Administrator

For more information regarding IRB Office submissions and guidelines, please consult http://www.ndsu.edu/research/integrity_compliance/irb/. This Institution has an approved FederalWide Assurance with the Department of Health and Human Services: FWA00002439.

INSTITUTIONAL REVIEW BOARD
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APPENDIX B. STUDENT INTERVIEW PROTOCOL

1) Tell me about your experience in the PSC.

2) Do you still think about the PSC? If so, what do you think about?

3) Do you ever talk about the PSC with our friends or family? What aspects do you talk about or share?

4) Did the PSC influence your feelings about nature and how you treat nature? Does it still? How?

5) What influence, if any, does the PSC have on your academic interests or career plans?

6) Can you give me an example of a skill that you learned during the PSC that you are still doing or using today?

7) Could you pick one thing that you experienced in the PSC that you hope students today get to experience?

APPENDIX C. PARENT INTERVIEW PROTOCOL

1) Tell me a little bit about your child's experience in the PSC?

2) Does your child ever talk about the PSC with friends or family? If so, what aspects do they talk about or share?

3) What influence, if any, do you feel the PSC had on your child's feelings about nature and how they treat nature? Does it still? How?

4) What influence, if any, did your child's experience in the PSC have on your own feelings about nature and how you treat nature? Does it still? How?

5) Do you feel your child's experience in the PSC has influenced their personal or academic interests? How so?

6) Can you think of any skills or practices your child learned in the PSC that they still demonstrate or use today?

7) Are there any other results of the PSC you have noticed that were not already mentioned?

APPENDIX D. HIGH SCHOOL PRINCIPAL QUESTION GUIDE

- From your perspective as the High School Principal, how do you see the value of the program at the secondary level, as opposed to the elementary level when it started?
- Are there positive or negative outcomes that at the high school level occurred as a direct result of the PSC? If so, what?
- Where do you see this program fitting within the context of national education reform?
- Has the PSC helped the PWLC carry out the School District's mission? If so, how?
- Do you feel the credibility of the school has changed within the formal education community and/or the community in general as a result of the PSC?
- Do you think this program has the potential to be adapted or replicated in other grade levels or at other schools?
- Do you think the PSC has the potential to be extended to the high school level for a follow up course on site? Or other expansion/extension curriculum?
- How else could the PSC experience be carried on to other grade levels, beyond the 7th grade Ecosystem Experiences Project?
- Is there anything else you'd like to add?

APPENDIX E. ANOVA SUMMARY

Survey Component	Participation	Means (LS)	*p*	SD	Effect size	Power
1. Connectedness to Nature (Mayer & Frantz 2004). 5-pt Likert scale.	1. One year	2.77	0.55	0.483	0.151	0.140
	2. Two years	2.58				
	3. None	2.61				
2. Nature Connectedness Inventory (Ernst & Theimer 2011) 6-pt scale.	1. One year	4.26	0.15	0.702	0.289	0.407
	2. Two years	4.12				
	3. None	4.57				
3. Attitudes toward school and learning. 5-pt Likert scale.	1. One year	3.25*	0.00*	0.677	0.530	0.911
	2. Two years	2.85				
	3. None	2.34*				
4. Attitude toward prairie environment and nature. 5-pt Likert scale.	1. One year	2.41	0.26	0.499	0.240	0.293
	2. Two years	2.39				
	3. None	2.64				
5. Stewardship. 5-pt Likert scale.	1. One year	2.44	0.55	0.633	0.148	0.136
	2. Two years	2.69				
	3. None	2.56				
6. Science Process 4-pt. scale.	1. One year	2.66	0.28	0.601	0.235	0.282
	2. Two years	2.97				
	3. None	3.02				
Individual Questions: How well can you do each of the following?						
7. Make observations about the environment. 4-pt scale.	1. One year	2.64	0.71	0.968	0.118	0.103
	2. Two years	2.86				
	3. None	2.94				
8. Read the landscape. 4-pt scale.	1. One year	2.45	0.85	1.051	0.086	0.077
	2. Two years	2.52				
	3. None	2.67				
9. Make a reasonable guess about why something happens in the environment. 4-pt scale.	1. One year	2.64	0.34	0.745	0.217	0.246
	2. Two years	2.86				
	3. None	3.06				
10. Work with others in a team or in small groups. 4-pt scale.	1. One year	2.63	0.68	0.960	0.127	0.112
	2. Two years	2.90				
	3. None	2.94				
11. Identify plants and animals that live in the prairie wetlands. 4-pt scale.	4. One year	2.82	0.23	0.964	0.255	0.327
	5. Two years	2.62				
	6. None	2.22				
12. Share my ideas with others through speaking. 4-pt scale.	1. One year	3.18	0.69	0.981	0.125	0.109
	2. Two years	3.10				
	3. None	2.89				
13. Share my ideas with others through writing. 4-pt scale.	1. One year	3.09	0.23	0.849	0.236	0.284
	2. Two years	2.62				
	3. None	3.00				

* significant at $p<0.005$.